CONCURRENT GROWING OF GREEN MANURE CROPS IN DRY AND WET SEEDED RICE

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled **"CONCURRENT GROWING OF GREEN MANURE CROPS IN DRY AND WET SEEDED RICE"** is a bonafide record of research work done by me during the course research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society

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CERTIFICATE

Certified that this thesis entitled **"CONCURRENT GROWING OF GREEN MANURE CROPS IN DRY AND WET SEEDED RICE"** is a record of research work done independently by Ms. ANITHA, S. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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Anitha, S.

Dedicated
to
my loving parents

CONTENTS

LIST OF ABBREVIATIONS

N	-	Nitrogen
P	-	Phosphorus
K	-	Potassium
FYM	-	Farm yard manure
DAS	-	Days after sowing
DAP	-	Days after planting
DAI	-	Days after incorporation
BI	-	Before incorporation
AT	-	Active tillering
PI	-	Panicle initiation
HG	-	Horse gram
CP	-	Cowpea
LAI	-	Leaf area index
HI	-	Harvest index
SI	-	Stage of incorporation
RBD	-	Randomised Block Design
NS	-	Not significant
CD	-	Critical difference
BC	-	Benefit: cost

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Introduction

INTRODUCTION

Rice is the most unique crop with a very wide adaptability and is the main food of Keralites. Rice production and productivity face a critical decline today and the rice farming in Kerala is now under serious threat. The rice area which is fast shrinking, witnessed a sharp fall from 8.0 lakh ha in 1980-81 to 2.8 lakh ha in 2003-04 (Balachandran, 2007). The rate of conversion of paddy field is at the rate of 60 ha per day. If such a situation persists, paddy cultivation will disappear from Kerala with in decades. The major constraint pertaining to rice farming in Kerala is high production cost and low productivity. Rice production system is a labour intensive enterprise and the labour charges alone accounts 65 per cent of the cost of production (Satheeshbabu *et al.*, 2006). In recent years there is an acute shortage of labour and high increase in labour wages. Scarcity of labour during critical stages of farm operations leads to low productivity. The productivity of paddy field is further affected due to the non application of organic manures in view of their high cost and limited availability. As a result there is a decline in the nutrient use efficiency. This situation necessitates the introduction of agronomically efficient technologies to increase the yield and lower the cost by optimum use of nutrients, and labour and thus make the rice farming remunerative.

Direct seeding is a way to cut down the cost of cultivation sizably. In Kerala, direct seeding of rice is done either by dry seeding in semi-dry system or by wet seeding in puddle condition. The dry sown (semi-dry) system of rice cultivation is a unique and extensively adopted rainfed rice ecosystem in Kerala, which constitute more than 60 per cent of the area under rice during *Kharif* season. In this system, the early growth of rice, upto 30-40 days is in a dry soil environment and thereafter comes under submergence with the onset of south west monsoon. The absence of stagnant water during the initial 4-6 weeks cause serious problems in dry sown low land rice with regard to application of organic manures and weed management affecting its productivity adversely. Wet sowing is a system of crop establishment in rice cultivation where pre-germinated seed is broadcast into puddle soil in areas with effective water control in the initial period. Profuse weed growth is a major constraint in wet seeded rice.

In Kerala, rice production is exclusively depending on chemical fertilizers for the supply of plant nutrients with little or no application of organic manures. This is mainly due to the non-availability and high cost incurred for the application of required quantity of organic manures. Hence it is high time to identify some cheaper organic manure sources to meet the organic matter requirement of the rice production system. Evolving a suitable system for fitting green manures without sacrificing any of the economic crops in the rice based cropping system mooted the strategy of growing green manure crops along with rice as a dual culture. There is a greater possibility of intercropping green manure crops during the early stage of rice crop with less interference on rice growth (Mathew *et al.*, 1991). Intercropping a green manure crop in rice and its incorporation later obviates the need for separate land, labour, inputs and time for a green manure crop.

In dry seeded system, this situation can effectively be capitalized by sowing green manure crops along with rice crop and allowing self incorporation due to flooding at the onset of monsoon. In wet seeded rice, the system involves raising daincha as a green manure crop concurrently with wet seeded rice using rice-cum-green manure seeder and subsequent incorporation of daincha using a cono weeder. But these systems require major refinement for large scale field adoption due to certain constraints. An undue delay in the onset of monsoon may cause problem in the incorporation of green manure crop in dry seeded system. Alternatively intense rainfall immediately after sowing adversely affects the establishment of green manure crop in lines in the wet seeded system causing problems in its incorporation by cono weeder. There is lack of information on the optimum stage and correct method of incorporation of green manure crops to get the maximum benefit from green manure crops to the rice crop. The extent of nutrient saving by concurrent growing of green manure crop to the current and residual crop has also not been worked out for both the dry and wet seeded systems. Understanding the nitrogen release pattern after the incorporation of concurrently grown green manure crops is important in formulating an efficient nitrogen management schedule for both dry and wet seeded lowland rice. It will be an added advantage, if the leguminous crop grown for the green manuring purpose can yield some economic produce and not much work has been done in this line. The present study was proposed in this background to further refine the technology of concurrent growing of green manure crops in direct seeded rice so as to improve the adoptability of the technology and to make rice cultivation more profitable through reduced production cost and enhanced productivity.

The research project 'Concurrent growing of green manure crops in dry and wet seeded rice' was intended

to find out effective methods and optimum stage of incorporation of green manure crops in dry and wet seeded rice,

to study the nitrogen release pattern of incorporated green manure crops,

to monitor the soil fertility changes,

to work out the nutrient saving to the current and residual crops

to study the economics of concurrent growing of green manure crops in dry and wet seeded rice.

Review of literature

REVIEW OF LITERATURE

Direct seeding of rice, either dry sown or wet sown, in low lands is a cost effective method of crop establishment followed by farmers in many rice growing areas including Kerala. Excessive weed growth is a major constraint in direct seeded rice, leading to high production cost and low productivity. The productivity is further adversely affected due to the non application of organic manures in view of their high cost and limited availability. Many studies have indicated that concurrent growing of green manure crops and its subsequent incorporation in dry and wet seeded rice is very effective in supplying the required quantity of organic manures to rice with minimum investment and this practice has the additional benefit of weed suppression.

Research results available on concurrent growing of green manure crops and its subsequent incorporation in dry and wet seeded rice, its effect on biomass addition, weed suppression, nutrient release pattern, nutrient saving, crop growth, productivity and nutrient uptake of rice, soil fertility changes, residual effect and economics are reviewed in this chapter.

2.1. CONCURRENT GROWING OF GREEN MANURE CROPS IN DRY SEEDED RICE

In dry seeded system, green manure crops are sown along with rice in a dry soil environment and are allowed for self incorporation by flooding with the onset of monsoon. John *et al.* (1992) cited loss of a season with out food or cash value as the main reason for the reluctance of farmers to grow and incorporate green manures. But experimental evidences indicated that beneficial effects of green manures shall be obtained by concurrent cropping. The system of growing green manure crop as an intercrop in semi-dry rice has been found to be an effective technology for supplying the required quantity of green manure with yield advantages in rice (Mathew *et al.*, 1991; Bridgit *et al.*, 1994; Mathew *et al.*, 1996 and Musthafa, 1995). Increased biomass and nitrogen addition, reduced the loss of nutrients, improvd the soil properties, increased availability of nutrients and weed control are the direct benefits attributed to green manuring.

2.1.1. Green matter addition and nutrient contribution

Direct beneficial effects of green manuring are increased biomass addition, nitrogen contribution, nutrient saving and higher nutrient use efficiency. According to Morris *et al.* (1986) a fast growing tropical legume can accumulate more than 80 kg N ha^{-1} in 45 days. They observed that cowpea and green gram showed a linear relationship between N accumulation and dry weight. Cowpea accumulated 44 to 83 kg N ha^{-1} in 30 to 45 days growth (Morris *et al.*, 1986). Studies on biomass production and N accumulation of green manures have shown that 60 days old cowpea produced 6.9 t ha $^{-1}$ of dry matter and the corresponding N addition was 113 kg ha $^{-1}$ (Beri *et al.*, 1989). John *et al.* (1989) found that N equivalent of cowpea green manure varied between 34 to 54 kg N ha^{-1}. Maskina *et al.* (1989) reported 3.8 t ha^{-1} of dry matter production and 76 kg ha^{-1} of N accumulation of cowpea in 50 days of incorporation. Mathew *et al.* (1991) compared the different green manure crops for dual culture in rice at Regional Agricultural Research Station, Pattambi and found that cowpea is the best from the point of view of rice yield whereas *Sesbania aculeata* was unsuitable. According to Vargheese and Kumari (1993) cowpea and sunnhemp are good for dual culture when incorporated on 30^{th} day after sowing (DAS). Bridgit *et al.* (1994) compared the performance of cowpea and sunnhemp and found that cowpea has a distinct edge over sunnhemp as it produces 80 per cent more green matter in unit time. Accoring to Bhuiyan and Zaman (1996) cowpea was shown to be superior to daincha as a green manure crop with respect to mineral composition and yield for lowland rice. *Sesbania rostrata* was proved to be more efficient green manure crop for intercropping in the semi- dry rice (Kalpana *et al.*, 2002). Resmy (2003) has reported the advantages of horse gram over cowpea for growing in the early stages of semi-dry rice for green manure purpose.

2.1.2. Weed management

Reduction in weed growth by intercropping due to the smothering effect of intercrop has been reported by many workers (Prusty *et al.*, 1990; Tiwari *et al.*, 1992; Kar *et al.*, 1993). Thakur (1993) found a reduction in weed growth to the extent of 35-40 per cent due to intercropping. Bridgit *et al.* (1994) compared the performance of cowpea and sunnhemp and found that cowpea has a distinct edge over sunnhemp for simultaneous in situ green manuring and also observed a significant reduction in weed biomass through concurrent cropping of cowpea in semi-dry rice. Of the cowpea intercropping treatments, weed control in terms of weed population density and weed dry weight, was best, if the crop was harvested at 45 DAS which gave the highest net return owing to additional returns from green fodder yield as well as the cost involved in weed management (Dutta *et al.*, 1994). Simultaneous raising of cowpea for *in situ* green manuring had reduced the weed growth and the weed biomass by 45 per cent Musthafa, 1995). He opined that the reduction in weed growth evidently had been due to the successful smothering effect of cowpea (. He reported a differential influence of cowpea on different groups of weeds in rice and noticed that cowpea tended to increase sedges and reduce dicot weeds while it had virtually little effect on grassy weeds. Resmy (2003) observed that intercropping rice with cowpea and horsegram reduced the weed count to the extent of 42.8 to 56.8 per cent up to 60 DAS.

2.1.3. Growth and yield of rice

Yield improvement in rice due to green manuring has been established beyond doubt by several workers. Varghese and Kumari (1993) reported that maximum yield of dry sown rice could be obtained when cowpea and sunnhemp were raised as intercrops with rice and incorporated on 30 DAS by light hoeing. Mathew *et al.* (1991) and Bridgit *et al.* (1994) had recorded a yield increase to the tune of 500 kg ha^{-1} by concurrent cropping of cowpea. Musthafa (1995) reported a significant increase in grain and straw yield of rice due to the increase in yield attributes viz., productive tillers and 1000 grain weight brought about by the interacting influences of fertilizer N and cowpea intercropping. In this system the green manure gets incorporated only after 50 days of sowing. The high yield obtained from such a system suggested that in crop production system, where application of green manure is not possible at the time of crop commencement, they can be supplied with advantage even subsequently. Jayachandran and Veerabadran (1996) reported an increase in plant height, leaf area index and total tillers of semi-dry rice as a result of incorporation of intercrops.

Decrease in grain yield of rice due to intercropping was reported by Ramakrishna and Ong (1994). Mathew *et al.* (1991) reported decreased tiller count by intercropping green manure in rice. Clement *et al.* (1998) found highest rice total dry matter production with the growing of green manure crops like *Vigna unguiculata* and *Sesbania emerus*. Over growth of green manure crops and their over stay in the field due to delayed monsoon has caused severe competition to the rice crop leading to poor growth and yield of rice when intercropped with cowpea and horse gram (Resmy, 2003). She observed that intercropping rice with horse gram invariably out yielded (both grain and straw) those with cowpea. It was attributed to the lesser vegetative growth of horse gram, compared to cowpea and suggested horsegram as a better choice for concurrent growing in semi-dry situations, wherever delay in the onset of monsoon is anticipated.

2.1.4. Nitrogen release pattern from green manure crops

Understanding the nitrogen release pattern after the incorporation of concurrently grown green manure crops is important in formulating an efficient nitrogen management schedule for direct seeded lowland rice. The pattern of release of ammonium and nitrate nitrogen during decomposition of glyricidia, sunflower, centrosema, calapagonium and crotalaria was more rapid in the early stages of incubation (Weeraratna, 1979). Swarup (1988) found that substantial N content in green manure was released within a decomposition period of one week. Under flooded soil conditions, the N released from legume residue accumulates as ammoniacal N, but in aerobic soil, the ammoniacal N formed by mineralization of legume N readily oxidized to nitrate (Beri *et al.*, 1989). After incorporating 60 days old cowpea, sunnhemp,Sesbania and clusterbean, all green manures decomposed rapidly and a peak in the formation of KCl extractable NH_4^+-N from the soils amended with different green manures was observed between 7-15 days period and there was not much difference in the mineralization of N among different green manures (Beri *et al.*, 1989). Diekmann *et al.* (1991) found that peak period of mineralization from green manures is within 10 days of incorporation. According to Johnkutty (1996) incorporation of green manures increased soil NH_4^+-N content and the effect was pronounced during the peak period. The peak period occurred between the second and fourth week after transplanting rice. Studies on nitrogen dynamics and balance in intensively cultivated low land rice based cropping system at IRRI (1996) revealed that soil NH_4^+-N ranged from 20 - 40kg ha^{-1} in wet season to less than 10 kg ha^{-1} during non-rice season. NH_4^+-N peaked 45 days after rice transplanting, most probably due to incorporation of weeds and crop residue into the soil just prior to transplanting. NO_3^--N declined sharply due to flooding of rice and NO_3^--N increased after harvest (IRRI, 1996). Green house experiments to study the influence of three green manure crops viz. cowpea, daincha and guar on organic nitrogen fraction showed that hydrolysed and amino acid N fraction registered a decline at the harvest of both rice and wheat crop. Reduction of hydrolysed NH_4^+-N and amino acid N fraction indicated that these fractions play an important role in N nutrition (IARI, 1997). Clement *et al.* (1998) suggested that green manures like

Indigofera tinctoria and *Vigna unguiculata* released N rapidly and the soil NH_4^+-N with rice increased until about 20 DAT, followed by a decline caused by N uptake. Joseph *et al.* (2002) reported significant gain in soil NH_4^+-N content and NO_3^--N content with the incorporation of intercropped green manure and the mineralization of N from green manure biomass was rapid and its availability was prolonged over an extended period.

2.1.5. Soil fertility changes

Green manuring, apart from fixing and making available nitrogen to the companion and successor crops, is known to influence crop growth in other ways also. One of the early reported effects is Lohin's (1926) priming action which stated that addition of easily decomposable organic matter will lead to decomposition of native organic matter thus liberating more nutrients for crop growth. Broadbent and Norman (1946), Chapman and Liebig (1947) and Furoc and Morris (1982) have confirmed this. Increased organic matter status of soil due to incorporation of green manures in a crop sequence had been reported by many workers (Swarup, 1987; Sharma and Mittra, 1988; Meelu *et al.*, 1992a; Watanabe and Ventura, 1992; Kolar *et al.*, 1993). Green manures not only supply N to rice but also improves physical and chemical properties of soil (Buresh and De Datta, 1991). According to Gill *et al.* (1994), green manure can be used as a supplement or substitute for mineral N. In water logged soil, green manure increased the availability of P through the mechanisms of reduction, chelation and favourable changes in soil pH (Hundal *et al.*, 1988). The increased P, K and trace elements due to green manuring have been attributed to the solubilising effect of decomposing organic matter (Shrikhande, 1948). Many workers had reported increased availability of K in soil due to green manuring. (Debnath and Hajra, 1972; Tiwari *et al.* 1980; Nagarajah *et al.*, 1986; Swarup 1987). Tiwari *et al.* (1980), Swarup (1987) and Sharma and Mittra (1988) found increased NPK content of soil through green manuring. Cowpea intercropping in the early stages of semi-dry rice for *in situ* green manuring appears to have contributed at least in part by limiting weed growth and there by conserving more of K and Mg (Musthafa, 1995). A substantial build up of soil fertility, with respect to NPK status, was noticed after the incorporation of intercropped green manure crops like cowpea and horsegram and the contribution of N, P and K by cowpea was almost double than that of horsegram (Resmy, 2003). Bridigit *et al.* (1994) explained it as a clear reflection of increased production of biomass by cowpea, over horsegram that has contributed to its quick growth rate in the early stages. Bharat and Niranjan (2003) reported higher available N, P and K in green manure applied plots.

2.1.6. Concurrent growing of green manure crops on nutrient uptake of rice

Favourable effects of green manuring and nitrogen fertilization on the uptake of nitrogen has been reported by Debnath and Hajra (1972) and Tiwari *et al.* (1980). Musthafa and Potty (1998) reported that simultaneous *in situ* green manuring significantly increased the uptake of certain elements by rice, but reduced the uptake by weeds. By reducing the nutrient removal by weeds, *in situ* green manuring made the nutrients more available and absorbed by the rice which would otherwise have been absorbed by the weeds. Clement *et al.* (1998) reported higher N uptake rates by rice with green manures like *Vigna unguiculata* and *Sesbania emerus* than with urea from 52 to 69 days after transplanting indicate a better synchrony between green manure N availability and rice N uptake. The uptake of N, P and K was found to be higher in rice intercropped with horse gram compared to cowpea (Resmy, 2003).

2.1.7. Residual effect of concurrent growing of green manure crops

Many studies have shown that grain legumes residues, remaining after harvesting the grain, increased the yield of subsequent low land rice crop substantially. According to Faroda and Singh (1983), inclusion of grain and fodder legumes in cropping systems reduced the need of fertilizer N in associated and succeeding cereals. Morris *et al.* (1986), with *V. radiata* (L.) Wilczek and *V. unguiculata* as green manure, did not measure any effect on a second rice crop. Nitrogen not mineralized during the first season is probably lost due to favourable conditions for mineralization after a rice crop, such as alternate wet-dry conditions. The N benefit is due to lower uptake of soil N by legumes relative to cereals and a carry over of N from the legume residue, both leading to a greater uptake of soil N by the subsequent crop compared to crops grown after non legumes (Danso and Papastylianou, 1992). According to Tiwari *et al.* (1995), soil N decreased in all treatments after two cycles of rice-wheat cropping except in the green manured plots fertilized with 120 kg N ha^{-1}. John *et al.* (1989) concluded from a study that cowpea residue increased the yield of succeeding rice by 0.7 t ha^{-1}, which was equivalent to 47 kg N ha^{-1}. Silsbury (1990) observed that incorporating the residues of legumes added about 26 kg N ha^{-1} and increased the yield of succeeding rice by 10 per cent.

Siddeswaran (1992) on comparing grain legumes cowpea, black gram and soybean, cowpea incorporation resulted in an yield increase of 10.4 per cent of the following rice.

2.1.8. Economics

Growing legume as intercrop in cereal has been found economical and beneficial (Mandal *et al.* 1986 and Chatterjee, 1989). Introduction of legumes in cropping systems has been advocated as a source of nutrient economy (Balyan and Seth, 1991). Ramamoorthy *et al.*, (1994) observed that intercropping of black gram in rice gave the highest gross return per hectare as compared to sole crop of rice. Of the cowpea intercropping treatments, weed control in terms of weed population density and weed dry weight, was best, if the crop was harvested 45 DAS which gave the highest net return owing to additional returns from green fodder yield as well as the cost involved in weed management (Dutta *et al.*, 1994). Quayyam and Maniruzzadin (1995) conducted studies on intercropping of black gram with upland rice. Rice (67%) and black gram (33%) combination gave higher net return hectare^{-1}and higher net return rupee^{-1} invested (0.97) compared with pure crop of rice (0.65). Rice +black gram increased the net return by 32 per cent compared with rice (Ramamoorthy *et al.*, 1997). Mandal *et al.* (2000) reported that intercropping of black gram with rice gave the highest rice equivalent yield and the highest net return over the respective sole crops. It was concluded that growing of green gram, black gram and pigeon pea between rice rows was profitable as the values of relative net returns of rice exceeded unity in all intercropping systems.

2.2. CONCURRENT GROWING OF DAINCHA WET SEEDED RICE

In wet seeded rice, the system involves growing of rice and daincha simultaneously into the puddled soil in alternate rows using a green manure cum rice seeder and then subsequent incorporation of daincha using a cono weeder. Sesbania species were well adapted for use as a green manure because of their ability to withstand waterlogging and flooding (Evans and Rotar, 1987). Concurrent growing of daincha and rice using rice cum green manure seeder and the subsequent incorporation of daincha using cono weeder is a low cost technology because it avoids exclusive cultivation of green manure crop, and avoided the raising of nursery and transplanting thus saves considerable labour and cost (Rajendran *et al.*, 2002). Cono weeder can be used for uprooting and burying weeds and green manure crops in between standing rows in wet lands of Kerala (Suseela *et al.*, 2002).

2.2.1. Green matter addition and nutrient contribution

Many studies have shown the beneficial effect of concurrent growing of daincha and rice using rice cum green manure seeder and the subsequent incorporation of daincha on biomass addition by trampling the green manure crop in between the standing rows of paddy by using conoweeder within four to five weeks. Bhardwaj and Dev (1985) correlated the green matter production potential and N accumulation of *Sesbania cannabina* and found that it produced 18,28 and 37 t ha^{-1} of green matter and accumulated 98,147 and 165 kg N ha^{-1} at 45,55,65 days of growth respectively. Even though the dry matter production and N accumulation vary at these stages, the rice grain yield immediately after turning under the green manure, irrespective of its stage of growth was, equivalent to 100-120 kg N ha^{-1}. *S. rostrata* under flooded condition produced 2.5 and 7.2 t ha^{-1} of dry matter with N accumulation of 89 and 176kg N ha^{-1} in 49 and 62 days respectively (Furoc *et al.*, 1985). Combination of inorganic and organic such as *Sesbania aculeata* / FYM can substitute inorganic fertilizers to an extent of 33 per cent (DRR, 1986). Studies on biomass production and N accumulation of green manures have shown that 60 days old *Sesbania* produced 5 t ha^{-1} of dry matter and the corresponding N addition was 108 kg ha^{-1} (Beri *et al.* 1989). Maskina *et al.* (1989) reported 4.9 t ha^{-1} of dry matter production and 97 kg ha^{-1} of N accumulation of *Sesbania* in 50 days of incorporation. The biomass production and N accumulation of *Sesbania* were mainly controlled by age factor (Singh *et al.*, 1991a). Incorporation of *Sesbania rostrata* provided N continuously to rice even after45 DAT (Buresh *et al.*, 1993a). Similar observation has made by Anilakumar *et al.* (1989) on incorporation of *Sesbania aculeate* in laterite soila at Pattambi, Kerala. The saving of nitrogenous fertilizers for the 1st crop of rice was 25% (38 kg N ha^{-1}) due to green manuring of *Sesbania rostrata* and 50% for the residual crop (MSSRF,1995). Joseph (1998) stated that intercropping green manure crop and incorporating it at early stages (35 DAS) was found beneficial in terms of rice growth and yield, returns, soil fertility dynamics etc., compared to green manuring of daincha at 6.25 t ha^{-1} and full dose of N to rice. Conversely, belated incorporation of green manure at 50 to 65 days coupled with reduction in

N dose to rice adversely affected rice growth, yield and its returns. Combined application of green manure and urea at different levels revealed that green manure is easily decomposible and the N applied through green manuring is as efficient as chemical sources and 50 per cent of the applied N was substituted with green manure (CRRI, 1998). Tajuddin and Doraiswamy (2000a) reported that nitrogen input can be reduced by 25 to 50 per cent by adopting the paddy cum daincha seeder. Sharma and Ghosh (2000) stated that green manuring of direct seeded rice with intercropped daincha is beneficial for substituting urea fertilizer up to 40kg N ha^{-1} and augmenting crop productivity under flood-prone lowland conditions. Intercropping *Sesbania* in wet seeded rice added higher biomass, thereby supplementing the N need for rice crop and imparting a synergistic effect between organic source of N and fertilizer N (Anbumani *et al.,* 2002). Nadanassababady *et al.* (2002) reported that as inter cropped daincha in between the rice rows were trampled at 40 to 70cm height, the biomass production ranged from 7.58 t ha^{-1} to 29 t ha^{-1}. But biomass production in the range of 20 to 29 t ha^{-1} (60 to 70 cm height) would hamper the associated rice due to temporary lock-up of N and related problems. Allowing daincha to grow up to 60 or 70 cm height was thus found disadvantageous. Incorporating daincha at 40 cm height (young tender stage) using IRRI conoweeder recorded higher biomass and was found optimum for nutrient addition and mineralization to the associated rice (Nadanassababady *et al.,* 2002). Rajendran *et al.* (2002) opined that concurrent growing of daincha and rice using rice cum green manure seeder and the subsequent incorporation of daincha using conoweeder, yielded seven to nine tones of biomass per hectare within four to five weeks. Selvi *et al.* (2002a) reported that the use of rice cum green manure seeder reduce the nitrogen requirement of rice by 50 percent. Incorporation of 40 to 60 days old *Sesbania aculeata* added 18-22 t ha^{-1} green matter, saved about 50 kg N ha^{-1} (Yadav *et al.,* 2006). Studies on the impact of organic / *in situ* daincha green manuring before rice in conjunction with inorganic fertilizer for 10 years on the productivity of rice-wheat system showed that, highest yield of both the crop was obtained with 100 per cent N, P and K combined with green manure or FYM. The results further showed that rice and wheat yields could be maintained even with the application of 50 per cent of the N, P and K dose with green manure or FYM (Yaduvanshi and Swarup, 2006).

2.2.2. Weed management

Weerakoon *et al.* (1992) reported that higher density of Sesbania diminished the weed biomass. Sowing with drum seeder in lines enable a significant reduction in weed dry matter production (1587 kg ha^{-1}) compared to 2363 kg ha^{-1} in broadcast method of sowing (Venkatachalapathy, 1997). Rajendran *et al.* (2002) reported that weeds were substantially controlled by the adoption of concurrent growing of daincha and rice using rice cum green manure seeder and the subsequent incorporation of daincha using conoweeder. Summer ploughing followed by rice + intercropping with green manure crop in kharif and rabi season registered highest weed control efficiency (TNAU, 2002). Dual culture of green manure in wet seeded system by drum seeding could add about 2000 kg of biomass through incorporation (Johnkutty and Prasanna, 2002). Conjoint cropping of rice+daincha and incorporation of daincha on 37 DAS using cono weeder proved better in terms of reducing total weed density over sole rice (Sankar *et al.*, 2003). Gupta *et al.* (2006) reported that co-culture of *Sesbania* in rice and its subsequent knock down by 2, 4-D ester reduced the weed population by nearly half with out any adverse effect on rice yield. Subhaiah *et al.* (2006) opined that the weed problem in direct sown crop (broadcasting of pre germinated seeds) can be over come through the use of paddy row seeder.

2.2.3. Growth and yield of rice

A great deal of literature is available on direct effect of green manuring on the grain yield of wet land rice. Increased yields with addition of green matter have been reported by Mandal and Bharati (1983), Morris *et al.* (1986) and Mahapatra *et al.* (1987). Antil *et al.* (1989) reported an increase in rice yield due to daincha and green gram. Furoc and Morris (1989) compared three Sesbania species and reported that the yield of low land rice was a direct function of soil extractable ammonium at 10 days after green manure incorporation. Manguiat *et al.* (1992) obtained a yield increase of 1.8 t ha^{-1} by green manuring with *S rostrata* alone and this increase was equivalent to that of applying 60 kg N ha^{-1}. Saravanapandian and Perumal (1994) stated that green manure had a notable effect in improving the yield attributes of rice viz., productive tillers plant $^{-1}$, filled grains $panicle^{-1}$ and 1000 grain weight as compared to FYM. *In situ* green manuring effectively minimized the production and decline of non productive tillers in the post flowering phase and contributed to the increased yield (Musthafa, 1995). Raising *Sesbania rostrata* as intercrop in two rows all around rice plot at 2.5 m interval and incorporation at pre flowering stage yielded on par with basal incorporation of 12.5 tonnes of *Sesbania rostrata* or *Sesbania speciosa* (Veerabadran *et al.*, 1999). Tajuddin and Doraiswamy (2000a) reported that there was a definite increase in yield of rice up to 20 per cent by using drum seeder due to good population, profuse tillering and early vigour and the age of paddy crop was reduced by 10 days because the establishment shock of seedling was avoided. According to Sharma and Ghosh (2000), panicle number was lower but the panicle weight was higher with daincha green manuring than with recommended level of 40 kg N ha^{-1}. Intercropping daincha, exclusively for in situ green manuring promoted growth factors of rice viz., plant height, number of tillers m^{-2}, LAI, DMP and yield attributes viz., number of panicles m^{-2}, number of filled grains $panicle^{-1}$, and panicle length with low percent of ill filled grains which in turn reflected positively on the grain and straw yield of rice than sole rice (Anbumani, 2001). Higher values of yield attributes and yield could be secured by growing daincha up to 40 cm height as an intercrop in rice and incorporated it with recommended dose of fertilizer N (Selvi, 2001)Incorporation of daincha at 40 cm height +100 per cent recommended dose of nutrients to rice had grain yield comparable to that of sole rice + basal incorporation of green manure obviating the need for exclusive cultivation of green manure, basal green or green leaf manuring (Nadanassababady *et al.*, 2002). Rajendran *et al.* (2002) observed an increased paddy yield of 800 kg ha^{-1} by adopting concurrent growing of daincha and rice using rice cum green manure seeder and the subsequent incorporation of daincha by using conoweeder. Bhuiya and Salam (2002) reported significant yield increase in rice due to the incorporation of green biomass of *Sesbania.* Intercropping daincha, exclusively for *in situ* green manuring, promoted growth and yield attributes which in turn reflected positively on the grain and straw yield of rice than sole rice (TNAU, 2002). Selvi *et al.* (2002 b) reported significantly higher rice grain and straw yield when green manure was applied with the recommended N and K followed by green manure with 75 per cent of recommended N and K. Green manure plus half of the recommended N and K was able to produce comparable economic yield with 100 per cent recommended N and K alone. Drum seeding of hybrid rice CoRH-2 along with daincha and incorporating daincha at 45 DAS registered highest grain yield of 6660 and 6421 kg ha^{-1} during 1999- 2001 (TNAU, 2002). Intercropping daincha exclusively for *in situ* green manuring recorded a higher grain yield of rice (with green manure) than sole rice (Anbumani *et al.*, 2003). Conjoint cropping of rice+daincha and incorporation of daincha on 37 DAS using cono weeder improved rice productivity by 26 per cent over sole rice (Sankar *et al.*, 2003). Inter cropping of daincha in drum seeded rice for *in situ* incorporation at 30 DAS and application of 100 per cent recommended N recorded significantly higher yield due to effective biomass incorporation into the soil (Jayadeva *et al.*, 2004). Ramasamy *et al.* (2006) reported direct planting system exhibited superiority in plant stand, tillering, panicle weight, number of filled grains per panicle and grain yield compared to dual establishment of rice and green manure through rice cum green drum seeder and incorporating the green manure at 28 DAS. Increase in productive tillers, panicle weight and filled grains per panicle compared with drum seeding were 15.1per cent 38.8 per cent and 30 per cent respectively.

2.2.4. Nitrogen release pattern of daincha

Knowledge on the process of mineralization of green manure nitrogen and the amount and duration of release of nitrogen is of primary importance for efficient management of nitrogen nutrition to rice. When incorporated, 70 per cent of N content of *S. rostrata* became available within 20 days, sufficient to meet the N needs of rice plant at early stages (Ventura *et al.*, 1987). Following incorporation of *S. rostrata* in tropical low land rice fields, the accumulation of soil ammonium peaked at 7 to 20 days after rice transplanting and then gradually declined (Becker *et al.*, 1990). For *S. aculeate* the peak ammonium occurred during the first 10-14 days of green manure incorporation (Sur *et al.*, 1993). Buresh *et al.* (1993b) observed that ammonium-N after *S. rostrata* reached a maximum by 36 days after incorporation which correlated with N accumulation by rice at 45 days after transplanting. During the peak period, soil NH_4^+-N content was 7.9 to 21.89 ppm higher in green manure plots than that in non- green manure plots (Johnkutty, 1996). Periodical analysis of wet soil sample for amide, NH_4^+-N and NO_3^- -N content at CRRI indicated that there was a relatively faster release of N with a greater N availability during the crop reproductive stage in case of green manuring supplemented with urea top dressing than with other biological sources like azolla or blue green algae (CRRI, 1998). A separate study on pattern of N mineralized from daincha, azolla and blue green algae in unplanted submerged soils at the low land sites of CRRI revealed that 6-13, 5-15, 5-9, 11-26, and 9-20 per cent of N from these sources were recovered in mineral form during 8, 15, 30, 45 and 75 days respectively after their incorporation into soil. The N availability was always higher with daincha than the other two sources (CRRI, 1998). Beena *et al.* (1999) found higher ammonium N accumulation in soils incorporated with cowpea and *Sesbania* green manures up to 15 days after transplanting and then started declining. Joseph *et al.* (2002) reported significant gain in soil NH_4^+-N content and NO_3^- -N content with the incorporation of intercropped daincha. They reported that at any stage of estimation of soil NH_4^+-N content was much higher in green manure intercropped plots than sole rice cropped plots. The soil NH_4^+-N content increased from 38-39 kg ha^{-1} on first day of incorporation to 57-58 kg ha^{-1} on 5^{th} day of incorporation of daincha. The peak NH_4^+-N content reached a high level of 159-167 kg ha^{-1} at three weeks after green manure incorporation and reduced to 74-77 kg ha^{-1} at seven weeks after incorporation. Intercropping and incorporation of *Sesbania aculeata* in wet seeded hybrid rice exerted a positive influence on NO_3^--N content of soil and the soil NO_3^--N content registered a steady and significant increase (Joseph *et al.*, 2002). In green manure incorporated plots, soil NO_3^--N content increased from 18-19 kg ha^{-1} on the first day of incorporation to 26-28 kg ha^{-1} on five days later, recording peak values at five weeks after incorporation.

2.2.5. Soil fertility changes

Improvement in soil fertility due to green manuring and intercropping of green manure crops was reported by many authors (Tiwari *et al.*, 1980; Swarup,1987; Meelu *et al.*, 1992b; Duban and Singh, 1994; Sharma, 1995 and Somasundaram *et al.*, 1996, Chapale and Badole, 1999 and Sharma *et al.*, 2000). Sharma *et al.* (2000) stated that green manuring with Sesbania interacted positively with inorganic fertilizer in building up soil N. Improvement of soil fertility in terms of soil organic carbon, available N and P was observed when daincha was intercropped in wet seeded rice (Anbumani, 2001). Selvi (2001) reported that intercropping daincha in wet seeded rice was an effective alternative to basal incorporation in maintaining higher status of organic carbon, available N and Pin the soil at the crucial stage of rice flowering provided it is buried at tender stage of 40 cm height. Joseph *et* al. (2002) reported that incorporation of green manure *Sesbania aculeate* in wet seeded hybrid rice and its incorporation at 45 DAS enormously improved the soil N status. They opined that in wet seeded hybrid rice, green manure intercropping and incorporation makes adequate N available at the critical stage of 58-80 DAS enabling better nutrient uptake and higher yield. The combination of chemical fertilizers with FYM and green manures registered more increase in available N and P content of the soil. Bhuiya and Salam (2002) observed an increased organic matter content and N of post harvest soil due to incorporation of *Sesbania* biomass but slightly decreased in control. The build up in N and P is attributed to the solubilization of nutrients from their native sources during decomposition process and mineralization of organic manures (Yadav *et al.*, 2006). Incorporation of daincha or FYM resulted in build up of soil organic carbon and available N, P, K and greater nutrient uptake by the crop (Yaduvanshi and Swarup, 2006).

2.2.6. Concurrent growing of daincha on nutrient uptake of rice

Increased N uptake by rice, by the incorporation of *Sesbania canabina* has been reported by Bhardwaj and Dev (1985). Green manure decomposition enhanced the uptake of N by the crop and there by increased the grain yield of rice (Kundu *et al.*, 1991). Meelu *et al.* (1992b) reported an increased N uptake by rice by green manuring with sesbania, crotalaria, soybean and indigo. Nitrogen uptake of rice varied from 37.32 kg ha-1 without green manuring to 57.23 with daincha green manuring. The N content in grain and straw were in the range of 1.022-1.283 and 0.527-0.625 percent respectively (CRRI, 1998). Application of *Sesbania aculeate* to flooded rice significantly enhanced the dry matter yield and N uptake of rice (Ashraf *et al.*, 2004).

2.2.7. Residual effect of concurrent growing of green manure crops

Green manures have not only increased grain yield but also enhanced the sustainability of the soil due to higher residual recoveries (Medhi and De Datta, 1996). *Sesbania rostrata* incorporation significantly increased the grain yield of succeeding rice (Ventura *et al.*, 1987; Kalidurai and Kannaiyan, 1989; Ladha *et al.*, 1989; Manguiat *et al.*, 1992). Ladha *et al.* (1989) reported that green manuring minimized the loss of nitrogen and 80 per cent of the N is made available to the two succeeding crops. In China incorporating a winter crop of beans, after harvesting pods, gave 19 per cent increase in yield of subsequent rice crop (Singh *et al.*, 1991b). Increase in yield and net income of 1st crop of rice due to green manuring of *Sesbania rostrata* were 6 and 16 per cent, in the residual crop the respective figures were 95 and 22 per cent. The saving of nitrogenous fertilizers were 25 per cent (38 kg N ha^{-1}) and 50 per cent respectively (MSSRF, 1995). *Sesbania* green manure residue substituted for 43 kg urea-N ha^{-1} in rice and subsequently gave a beneficial effect in spring wheat equal to the residual effect of 89 kg urea-N ha^{-1} applied to rice (Sharma *et al.*, 1995). They also reported that *Sesbania* green manuring increased grain yield of rice by 0.4 t ha^{-1} and of spring wheat by 0.6 t ha^{-1} when no urea-N was applied to rice and 40 kg urea-N ha^{-1} as a basal starter dose was applied to wheat. According to Solaiappan *et al.* (1996) various green manures raised during pre-season rice gave higher yield of succeeding rice than rice following pre-season fallow by increasing the values of yield determinants viz., grains panicle^{-1} and 1000 grain weight. Studies on the impact of using organic / *in situ* green manuring (daincha) before rice in conjunction with inorganic fertilizer for 10 years on the productivity of rice-wheat system showed highest yield of both crops obtained with 100 per cent NPK combined with green manure/FYM. The results further showed that rice and wheat yields could be maintained even at 50 per cent of NPK with green manure or FYM (Yaduvanshi and Swarup, 2006).

2.2.8. Economics

Cost effectiveness of concurrent growing of daincha and rice using rice cum green manure seeder and the subsequent incorporation of daincha using cono weeder has been reported by many workers. Tajuddin and Doraiswamy (2000a) reported 14.4 per cent reduction in the cost of cultivation by adopting the paddy seeder compared to transplanting. Tajuddin and Doraiswamy (2000b) reported that cost of operation of cono weeder was only Rs. 1400 ha^{-1} compared to 75 women labourers required to weed one hectare of rice in a day. The dual purpose of raising daincha (both for green manuring and seed production) in rice with daincha seed row at farther interval (every 20^{th} row) proved to be more remunerative with high net income and benefit: cost ratio (Anbumani, 2001). Direct wet – seeding of rice with intercropping of daincha using the single wheel rice cum green manure seeder was found advantageous, besides reducing the labour cost to a greater extent (Nadanassababady *et al.*, 2002). Johnkutty and Prasanna (2002) reported that drum seeding of rice and green manure seeds and incorporation of weeds and green manures by cono weeder resulted in a saving of Rs. 2490/ha over broadcasting and hand weeding and Rs.4490/ha over transplanting. Drum seeding of hybrid rice CoRH-2 along with daincha and incorporating daincha at 45 DAS and recommended level of N (150kg ha^{-1}) registered highest net return of Rs.29597 and BCR of 3.25 during 1999-00 and Rs. 27329 and 3.08 during 2000-01 (TNAU, 2002). Concurrent growing of daincha and rice using rice cum green manure seeder and the subsequent incorporation of daincha using cono weeder is a low cost technology because it avoids exclusive cultivation of green manure crop, and avoided the raising of nursery and transplanting thus saves considerable labour and cost (Rajendran *et al.*, 2002). Subhaiah *et al.* (2006) reported a labour saving to the tune of 33% can be achieved through the use of paddy row seeder. The drum seeding recorded highest net return with a BC ratio of 1.23 compared to broadcasting (0.83).

Materials and methods

MATERIALS AND METHODS

The investigation on 'Concurrent growing of green manure crops in dry and wet seeded rice' was carried out to study the various aspects of the system of concurrent growing of green manure crops in direct seeded rice and to develop a complete technology package for the system. The details of materials used and methods adopted for the study are briefly described below.

3.1. LOCATION

The experiment was conducted at the Agricultural Research Station, Mannuthy, Thrissur. The station is geographically situated at 10^0 31'N latitude, 76^0 13' E longitude and at an altitude of 40.3m above mean sea level. It is located six kilometers away from Thrissur on the southern side of NH 47.

3.1.1. Soil

Soil of the experimental site is texturally classified as sandy loam, belonging to the taxonomical order oxisol. The soil is acidic in reaction with a pH of 5.6. Field capacity of the soil was 19.7 per cent and the permanent wilting point was 11.3 per cent. The basic physico-chemical properties of the soil are presented Table 3.1.

Table 3.1. Basic physico-chemical properties of soil

Parameters	Value	Method used	Reference
a)Mechanical composition			
Sand (%)	51.0	Robinson's International Pipette method	Piper, 1966
Silt (%)	22.6		
Clay (%)	26.4		
b)Physical characteristics			
Bulk density (g cc^{-1})	1.52	Core sampler method	Piper, 1966
Water holding capacity (%)	49.1		
c) Chemical properties			
Organic carbon (%)	0.48	Walkley and Black method	Piper, 1966

Available nitrogen (kg ha^{-1})	232	Alkaline permanganate distillation	Subbiah and Asija, 1956
Available phophorus (kg ha^{-1})	59.8	Bray extractant-Ascorbic acid reductant method	Jackson, 1973
Available potassium (kg ha^{-1})	112	Neutral normal ammonium acetate extractant flame photometry	Jackson, 1973

3.1.2. Weather condition during the cropping period

The area of the experimental site enjoys a typical humid tropical climate. The meteorological parameters recorded are rainfall, maximum and minimum temperatures, relative humidity and number of rainy days. The average weekly weather values prevailed during experimental period were collected from the observatory attached to the College of Horticulture and presented in Appendix I and Appendix II and illustrated graphically in Fig. 1 and Fig 2.

The mean annual rainfall of the area is 2669 mm with 75 per cent received during south west monsoon, 16.6 per cent during north east monsoon and the rest being distributed in the summer months.

The weather prevailed during the experimental period was normal. During the cropping period, the mean maximum and minimum temperatures were 31.37 and 22.72°C respectively. The average relative humidity recorded was 71.78 per cent. A total of 5370.3 mm rainfall was received distributed over 272 rainy days

3.1.3. Season

The field trial on 'Concurrent growing of green manure crops in dry seeded rice' was conducted during the early virippu (first crop) season from April to August 2004 and 2005. The 'Residual effect of concurrent growing of green manure crops in dry seeded rice' was conducted on the same plots during mundakan (second crop) season from September 2004 and 2005 to January 2005 and 2006.

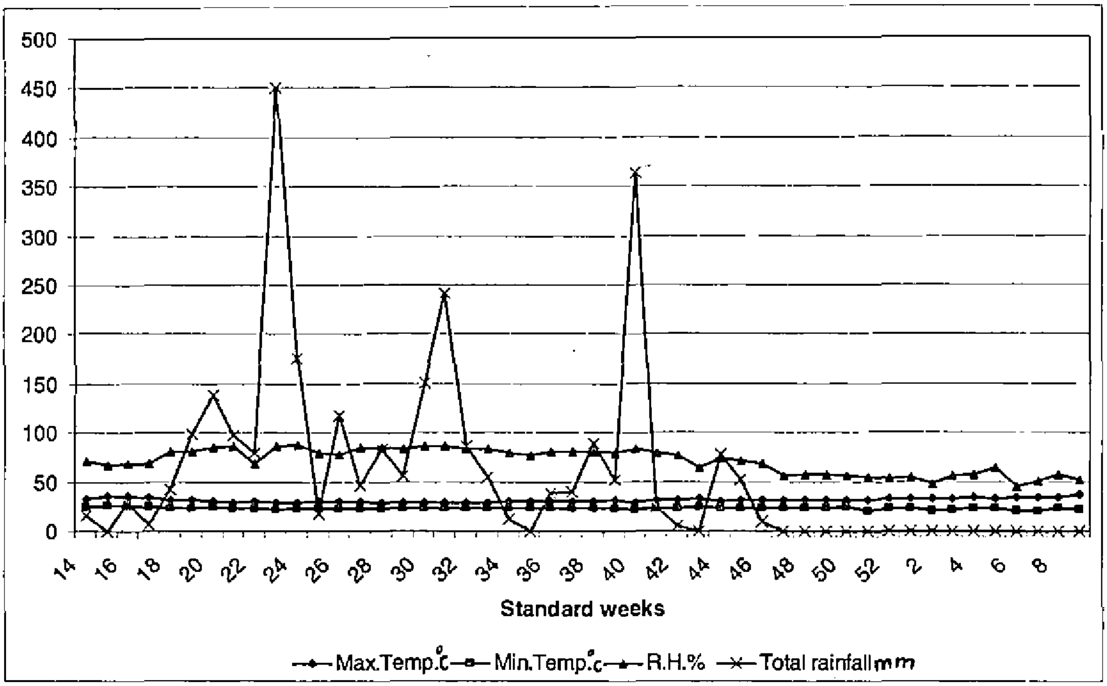


Fig. 1. Weather data during the 1st year of study (April 2004 - February 2005)

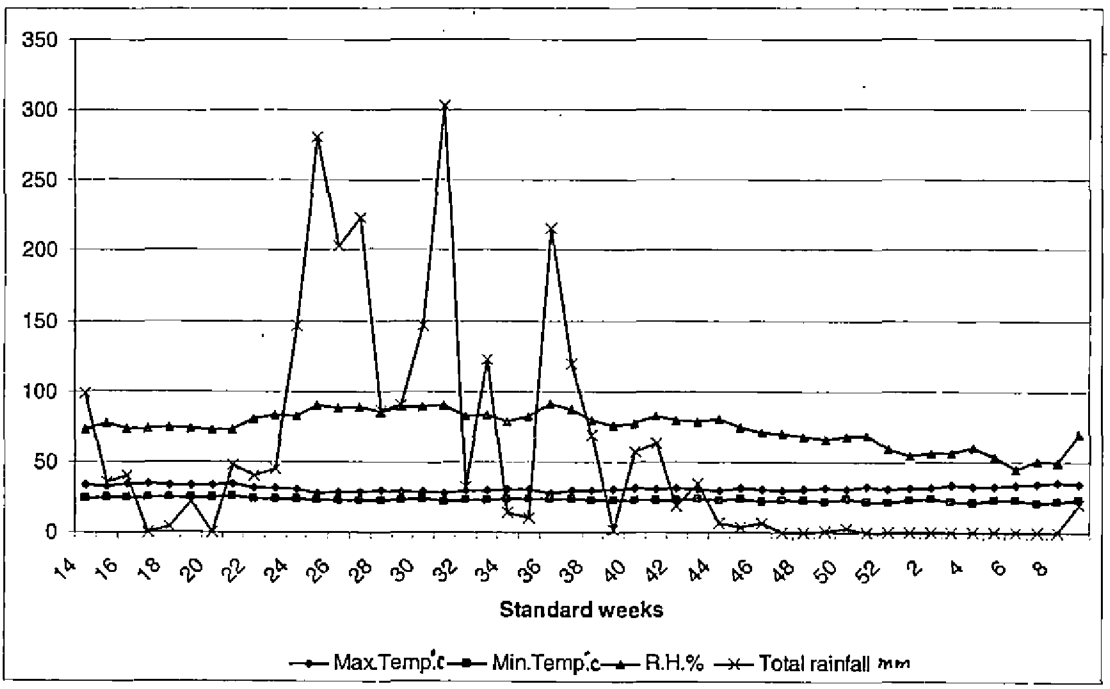


Fig. 2. Weather data during the 2nd year of study (April 2005 - February 2006)

The field trial on 'Concurrent growing of daincha in wet seeded rice' was conducted during the late viruppu season from July to September 2004 and 2005. The 'Residual effect of concurrent growing of daincha in wet seeded rice' was conducted on the same plots during mundakan season from October 2004 and 2005 to February 2005 and 2006.

3.1.3. Cropping history

The experimental site is a double crop paddy wetland, where a semi-dry crop is taken during April-May to August- September and a transplanted crop during September- October to December- January every year. The land for the 1st year of study was left fallow during the summer season. The land for the 2nd year of study was cultivated with bitter gourd during the summer season.

3.2. MATERIALS USED

3.2.1. Seeds

3.2.1.1. Rice

The rice variety Aiswarya was used for the experiments involving concurrent growing of green manure crops in dry and wet seeded rice during virippu season. Aiswarya is a medium duration variety of 120-125 days duration. Aiswarya is suitable for direct seeding during first and second crop seasons. The grains are red kernelled, long and bold. The variety is resistant to blast and blight diseases and to BPH.

The rice variety Kanchana was used for the experiments to study the residual effect of concurrent growing of green manure crops in dry and wet seeded rice during mundakan season. Kanchana is a short duration variety of 105-110 days duration. Kanchana is suitable for cultivation in all the three crop seasons. The grains are red kernelled, long and bold. The variety is resistant to blast and blight diseases and to stem borer and gall midge.

3.2.1.2. Cowpea

Short duration bush type vegetable cowpea, Pusa Komal was used as one of the green manure crop for concurrent growing in dry seeded rice.

3.2.1.3. Horse gram

Local variety of horse gram was used as the other green manure crop for concurrent growing in dry seeded rice.

3.2.1.4. Daincha

Local variety of daincha was used as the green manure crop for concurrent growing in wet seeded rice.

3.2.2. Herbicides

2,4 –D

Chemical name	2, 4-Dichlorophenoxy acetic acid
Chemical family	Phenoxy carboxylic herbicide
Mode of action	selective systemic post emergence herbicide

Almix

Chemical name	Chlorimuron ethyl + metsulfuron methyl
Chemical family	Sulfonylurea group
Mode of action	selective contact post emergence herbicide

Algrip

Chemical name:	Metsulfuron methyl
Chemical family	Sulfonylurea group
Mode of action	selective contact post emergence herbicide

3.2.3. Fertilizer

Fertilizers analyzing the following nutrient contents were used.

Urea	-	46.1% N
Mussorie Rock Phosphate	-	20% P_2O_5
Muriate of Potash	-	60% K_2O

3.2.4. Implements

3.2.4.2. Rice cum green manure seeder

Rice cum green manure seeder consists of two aluminium drums of 50 cm circumference with circular holes, for holding and dropping the seed and it has one ground wheel in the centre with 60 cm diameter. Two floats are provided to facilitate smooth sliding of the seeder on soft puddle soil. It has a handle of 70 cm length. Each drum is divided into three hoppers to hold the rice and green manure seeds alternately. The paddy seed hoppers are provided with large holes and green manure hoppers with small holes. The holes can be adjusted to regulate the flow of seeds. On pulling the seeder, paddy seeds are placed in three rows with spacing of 25 cm and at about 6-8 cm between plants and one row of green manure in the middle of the paddy rows. It is light and easy to pull manually by one person.

3.2.4.3. Conoweeder

Cono weeder is a hand operated mechanical weeder used for uprooting and burying weeds or green manure crops in between the standing rows of rice in wet lands. Cono weeder consisted of two conic rollers with serrated blades rotating in the opposite direction. A float provided in the front portion prevents the unit from sinking into the puddled soil. It has a long handle made of mild steel tube. It can be pulled by a single person very easily, through the space in between the rows. On moving the cono weeder through the field, the weeds/green manures get cut and trampled into the soil. At the time of cono weeding the soil should be soaked and there should be a small level of standing water.

3.3. METHOD

3.3.1. Treatments

The research project consisted of four experiments. Each experiment was repeated for two seasons during 2004-2005 and 2005-2006. The details of the experiments are furnished below.

Experiment Ia. Concurrent growing of green manure crops in dry seeded rice

A. <u>Green manure crops</u> - 2

1 – Horse gram

2 – Short duration bush type vegetable cowpea

B. Incorporation methods – 3

1 – Incorporation by cono weeder

2 – Desiccation by 2,4 - D spray @1.0 kg ha^{-1}

3 – Allowing for self decomposition

C. Levels of nitrogen – 2

1- 100 % of recommended N

2- 75 % of recommended N

Control- Rice alone as per POP

Experiment Ib. Residual effect of concurrent growing of green manure crops in dry seeded rice

Rice was raised during the second crop season in the same plots after dividing the plots equally into two sub plots to study the residual effect of the treatments imposed during the first season. The sub plot received differential nitrogen doses of 100 and 75 per cent of the recommended dose.

Experiment IIa. Concurrent growing of daincha in wet seeded rice

A. Stages of incorporation - 2

1 – 20 DAS

2 – 30 DAS

B. Methods of incorporation - 3

1 – Incorporation by cono weeder

2 – Desiccation by 2, 4-D spray @1.0 kg ha^{-1}

3 – Desiccation by Chlorimuron ethyl + Metsulfuron methyl (Almix) spray @ 4.0 g ha^{-1}
or Metsulfuron methyl (Algrip) spray @ 5 .0 g ha^{-1}.

C. Levels of nitrogen - 2

1- 100% of recommended N

2- 75% of recommended N

Control - Rice alone, as per POP

Experiment IIb. Residual effect of concurrent growing of daincha in wet seeded rice

Rice was raised during the second crop season in the same plots after dividing the plots equally into two sub plots to study the residual effect of the treatments imposed during the first season. The sub plot received differential nitrogen doses of 100 and 75 per cent of the recommended dose.

3.3.2. Design and layout

The lay out plan is given in Fig. 3 and Fig. 4.

3.3.2.1. For the Experiment Ia and Experiment IIa (Fig. 3)

Design	– Factorial experiment in RBD
No. of treatments	–12 +1
Replications	– 3

3.3.2.2. For the Experiment Ib and Experiment IIb (Fig. 4)

Design	– Split plot				
Main plot	–13	Sub plot	–2	No. of treatments	–13 x 2
Replications	– 3				

3.3.2.3. Plot size

The gross plot size for Experiment Ia and Experiment IIa was 5 m x 4.5 m. For green manure intercropped treatments the net plot size was calculated after leaving one row of rice and green manure crop all around the plot. In pure crop of rice, the net plot size was calculated after leaving two rows of rice all around the plot. For residual crops, such as Experiment Ib and Experiment IIb, the gross plot size was 5 m x 2.1 m. The net plot size was calculated after leaving two rows of rice all around the plot. A strip of 1.0 m width was left along the 5m side as the sampling area.

3.4. FIELD EXPERIMENT

3.4.1. Crop husbandary

Fig. 3. Lay out plan of Experiment Ia & IIa

5 m

4.5 m

R_1T_3	R_1T_8	R_1T_{10}	R_1T_5
R_1T_{12}	R_1T_1	R_1T_{13}	R_1T_9
R_1T_4	R_1T_6	R_1T_{11}	R_1T_2
R_1T_7	R_2T_3	R_2T_{12}	R_2T_4
R_2T_8	R_2T_{13}	R_2T_2	R_2T_{10}
R_2T_9	R_2T_1	R_2T_5	R_2T_7
R_2T_6	R_2T_{11}	R_3T_3	R_3T_8
R_3T_{10}	R_3T_5	R_3T_{12}	R_3T_1
R_3T_{13}	R_3T_9	R_3T_4	R_3T_6
R_3T_{11}	R_3T_2	R_3T_7	

Experiment Ia

T_1 Horse gram+Cono+100%N
T_2 Horse gram+Cono+75%N
T_3 Horse gram+2,4-D+100%N
T_4 Horse gram+2,4-D+75%N
T_5 Horse gram+Self+100%N
T_6 Horse gram+Self+75%N
T_7 Cowpea+Cono+100%N
T_8 Cowpea+Cono+75%N
T_9 Cowpea+2,4-D+100%N
T_{10} Cowpea+2,4-D+75%N
T_{11} Cowpea+Self+100%N
T_{12} Cowpea+Self+75%N
T_{13} Rice alone+ 100%N

Experiment IIa

T_1 Daincha 20days+Cono+100%N
T_2 Daincha 20days+Cono+75%N
T_3 Daincha 20days+2,4-D+100%N
T_4 Daincha 20days+2,4-D+75%N
T_5 Daincha 20days+almix/algrip+100%N
T_6 Daincha 20days+almix/algrip+75%N
T_7 Daincha 30days+Cono+100%N
T_8 Daincha 30days+Cono+75%N
T_9 Daincha 30days+2,4-D+100%N
T_{10} Daincha 30days+2,4-D+75%N
T_{11} Daincha 30days+almix/algrip+100%N
T_{12} Daincha 30days+almix/algrip+75%N
T_{13} Rice alone+ 100%N

Fig. 4. Lay out plan of Experiment Ib & IIb

5 m

2.1 m

R_IT_{3A}	R_IT_{8A}	R_IT_{10A}	R_IT_{5A}
R_IT_{3B}	R_IT_{8B}	R_IT_{10B}	R_IT_{5B}
R_IT_{12A}	R_IT_{1A}	R_IT_{13A}	R_IT_{9A}
R_IT_{12B}	R_IT_{1B}	R_IT_{13B}	R_IT_{9B}
R_IT_{4A}	R_IT_{6A}	R_IT_{11A}	R_IT_{2A}
R_IT_{4B}	R_IT_{6B}	R_IT_{11B}	R_IT_{2B}
R_IT_{7A}	R_2T_{3A}	R_2T_{12A}	R_2T_{4A}
R_IT_{7B}	R_2T_{3B}	R_2T_{12B}	R_2T_{4B}
R_2T_{8A}	R_2T_{13A}	R_2T_{2A}	R_2T_{10A}
R_2T_{8B}	R_2T_{13B}	R_2T_{2B}	R_2T_{10B}
R_2T_{9A}	R_2T_{1A}	R_2T_{5A}	R_2T_{7A}
R_2T_{9B}	R_2T_{1B}	R_2T_{5B}	R_2T_{7B}
R_2T_{6A}	R_2T_{11A}	R_3T_{3A}	R_3T8_A
R_2T_{6B}	R_2T_{11B}	R_3T_{3B}	R_3T8_B
R_3T_{10A}	R_3T_{5A}	R_3T_{12A}	R_3T_{1A}
R_3T_{10B}	R_3T_{5B}	R_3T_{12B}	R_3T1_B
R_3T_{13A}	R_3T_{9A}	R_3T_{4A}	R_3T_{6A}
R_3T_{13B}	R_3T_{9B}	R_3T_{4B}	R_3T_{6B}
R_3T_{11A}	R_3T_{2A}	R_3T_{7A}	
R_3T_{11B}	R_3T_{2B}	R_3T_{7B}	

Sub plot A 100% N

Sub plot B 75% N

3.4.1.1. Land preparation

The experimental field for dry sowing was prepared by two ploughings using a tractor drawn disc plough and pulverized using rotavator. The field was laid out into three blocks and the blocks were subdivided into 13 plots. The plots were formed by taking ridges and furrows of 30 cm width around the plots. The individual plots were thoroughly dug and perfectly leveled manually before sowing.

The experimental field for wet sowing was prepared by puddling using a tractor drawn plough and leveled. The field was laid out into three blocks and the blocks were subdivided into 13 plots. The plots were formed by taking ridges and furrows of 30 cm width around the plots. The individual plots were perfectly leveled and the field was flooded for one day and then drained out. This was to allow the deflocculated soil particles to settle. Drum seeding was done after settling of the puddled soil with no standing water in the field.

For transplanting the residual crops, the same plots of dry and wet seeded crop raised during the first crop season were divided into two equal subplots by taking ridges of 30 cm. The individual subplots were thoroughly dug and leveled.

3.4.1.2. Sowing

Sowing/planting dates of the four experiments during 2004-2005 and 2005-2006 are presented in Table 3.2.

Table 3.2. Sowing / planting dates of the experiments

Experiment	2004-2005	2005-2006
Experiment I a (Dry sowing)	23-04-04	23-04-05
Experiment I b (Transplanting)	21-09-04	29-09-05
Experiment II a (Wet sowing)	02-07-04	14-07-05
Experiment II b (Transplanting)	29-10-04	15-11-05

For concurrent growing of green manure crops in dry seeded rice, one row of cowpea/horse gram was sown in between two rows of rice in finely prepared soil by dibbling (Plate 1a to

1c). It was ensured that the soil moisture was optimum at the time of sowing with the receipt of pre-monsoon showers.

For concurrent growing of daincha in wet seeded rice, the sowing of rice and daincha was done simultaneously into puddled soil using the rice-cum-green manure seeder (Plate 2a and 2c). Paddy seeds, with radicle just emerging were used for sowing with the seeder. For this, seeds were soaked in water for 24 hours and incubated for 12 hours. The pre-germinated seed with radicle just emerging was then filled in the paddy seed hoppers of rice-cum-green manure seeder to about ¾ volumes to allow free flow of seeds through the holes. Simultaneously, un-sprouted green manure seeds were filled in the green manure seed hoppers of rice-cum-green manure seeder. When drawn, the rice-cum-green manure seeder placed sprouted paddy seeds and un-sprouted green manure seeds in alternate rows. Sowing was done with no standing water in the field.

The residual crops were raised by transplanting 20 days old seedlings in puddled soil.

The details of seed rate and spacing are furnished in Table 3.3.

Table 3.3. Seed rate and spacing

Crop establishment system	Seed rate (kg ha^{-1})	Spacing
Dry sowing		
Rice (dibbling)	60	20cm x 15cm
Cowpea(dibbling)	20	20cm x 15cm
Horse gram(dibbling)	20	20cm x 15cm
Residual rice (transplanting)	60	15cm x 10cm
Wet sowing		
Rice (drum seeding)	60	25cm x 6-8cm
Daincha (drum seeding)	25	25cm x 6-8cm
Rice (broad casting)	80	-
Residual rice (transplanting)	60	15cm x 10cm

Plate 1. Concurrent growing of green manure crops in dry seeded rice

10 DAS **30 DAS** **45 DAS**

Plate 1a. Rice + Horse gram

Plate 1b. Rice + Cowpea

Plate 1c. Rice alone

Plate 2. Equipments used for wet seeding in rice

Plate 2a. Rice cum green manure seeder

Plate 2b. Conoweeder

Plate 2c. Simultaneous sowing of rice and daincha using rice cum green manure seeder

3.4.1.3. Manures and fertilizer application

FYM @ 5 t ha^{-1} was applied to control plots and incorporated by digging before sowing. No FYM was applied in treatments where green manure crops were grown concurrently. The residual crops in both the experiments did not receive FYM.

Nitrogen fertilizer at the rate of 100 % and 75 % of the recommended dose were applied according to the treatment schedule. Fertilizers P and K were applied uniformly to all the treatments as per the Package of Practices recommendations: crops of Kerala Agricultural University (KAU, 2002). Recommended fertilizer doses and schedule of fertilizer application are given in Table 3.4.

Table 3.4. Fertilizer recommendation and schedule of fertilizer application

Experiment	Recommendation (kg ha^{-1})			Schedule of fertilizer application
	N	P	K	
Ia. Dry sown rice (Aiswarya)	90	45	45	$^1/_3$rd N, Full P& ½ K Basal $^1/_3$rd N 45 DAS $^1/_3$rd N & ½ K 75DAS
Ib. Residual crop (transplanting) (Kanchana)	70	35	35	$^2/_3$rd N, Full P& ½ K Basal $^1/_3$rd N & ½ K 30DAP
IIa. Wet sown rice (Aiswarya)	90	45	45	$^1/_3$rd N, Full P& ½ K Basal $^1/_3$rd N 45 DAS $^1/_3$rd N & ½ K 75DAS
IIb. Residual rice (transplanting) (Kanchana)	70	35	35	$^2/_3$rd N, Full P& ½ K Basal $^1/_3$rd N & ½ K 30DAP

DAS – Days after sowing; DAP – Days after planting

3.4.1.4. Incorporation of green manure crops

The concurrently grown green manure crops, horse gram (*Macrotyloma uniflorum* (Lam) Verdc) and cowpea [*Vigna unguiculata* (L.) Walp.], were incorporated in dry seeded rice at 45 days after sowing by three methods of incorporation viz., using cono weeder, spraying

2,4-D @1.0 kg ha^{-1} and allowing self decomposition by flooding at the onset of monsoon (Plates 3a to 3c).

The concurrently grown daincha (*Sesbania aculeata*), in wet seeded rice was incorporated either at 20 days or 30 days after sowing (Plates 4a to 4c) by using one of the three methods of incorporation viz., using cono weeder, spraying 2, 4-D @1.0 kg ha^{-1}or spraying chlorimuron ethyl + metsulfuron methyl spray @ 4.0 g ha^{-1} ***or*** metsulfuron methyl spray @ 5 .0 g ha^{-1} (Plates 5a to 5c).

Chlorimuron ethyl + met sulfuron methyl spray @ 4.0 g ha^{-1} was used during the 1st year of the study to incorporate the daincha. But the effectiveness of Chlorimuron ethyl + met sulfuron methyl spray @ 4.0 g ha^{-1} in desiccating daincha was poor. Hence a micro plot study was conducted to find out a more effective herbicide for the desiccation of daincha.

The micro plot study was conducted by raising daincha in micro plots of one m^2 area. The treatments for the micro plot study are furnished below

T_1- Chlorimuron ethyl + met sulfuron methyl spray @ 4.0 g ha-1

T_2- Chlorimuron ethyl + met sulfuron methyl spray @ 4.0 g ha^{-1} + urea 2 %

T_3- Chlorimuron ethyl + met sulfuron methyl spray @ 6.0 g ha-1

T_4- Chlorimuron ethyl + met sulfuron methyl spray @ 6.0 g ha^{-1} + urea 2 %

T_5- Met sulfuron methyl spray @ 4.0 g ha-1

T_6- Met sulfuron methyl spray @ 4.0 g ha^{-1} + urea 2 %

T_7- Met sulfuron methyl spray @ 5.0 g ha-1

T_8- Met sulfuron methyl spray @ 5.0 g ha^{-1} + urea 2 %

From the micro plot study (Plates 6a to 6j), Metsulfuron methyl spray @ 5 .0 g ha^{-1} was found more effective in desiccating the daincha. Hence in the 2nd year, Metsulfuron methyl spray @ 5 .0 g ha^{-1} was used instead of Chlorimuron ethyl + met sulfuron methyl spray @ 4.0 g ha^{-1}.

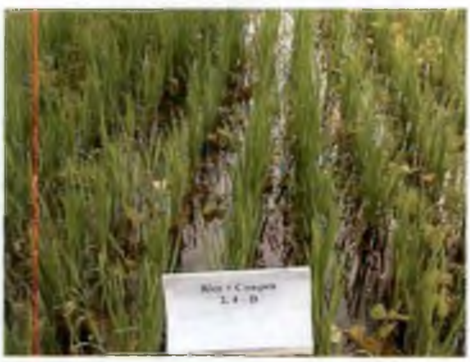
3.4.1.5. Weeding

Two hand weeding were given at 30 and 50 days after sowing uniformly to all the treatments of dry seeded rice. One hand weeding at 45 days after sowing was given uniformly to all the

Plate 3. Methods of incorporation of green manure crops in dry seeded rice

Rice + Cowpea | Rice + Horse gram

Plate 3a. Conoweeding



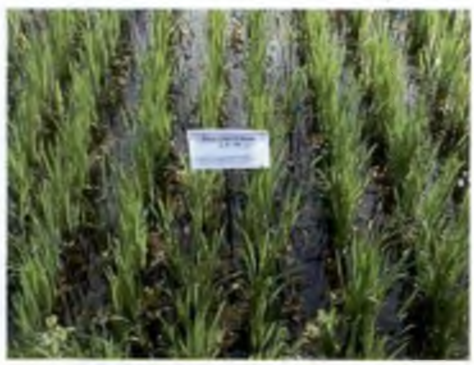


Plate 3b. Desiccation by 2, 4-D

Plate 3c. Self decomposition

Plate 4. Concurrent growing of daincha in wet seeded rice

Plate 4a. Rice + Daincha at 20 DAS

Plate 4b. Rice + Daincha at 30 DAS

Plate 4c. Rice alone

Plate 5. Methods of incorporation of daincha in wet seeded rice

Rice + Daincha 20DAS | **Rice + Daincha 30DAS**

Plate 5a. Conoweeding

Plate 5b. Desiccation by 2, 4-D

Plate 5c. Desiccation by Metsulfuron methyl

Plate 6. Effect of almix and algrip on daincha in Micro plot study

Plate 6a. Almix 4g

Plate 6b. Almix 4g + urea

Plate 6c. Almix 6g

Plate 6d. Almix 6g + urea

Plate 6e. No change by almix application

Plate 6 f. Algrip 4g

Plate 6g. Algrip 4g +urea

Plate 6h. Algrip 5g

Plate 6i. Algrip 5g+urea

treatments of wet seeded rice. For residual crops one hand weeding at 30 days after planting was given uniformly to all the treatments.

3.4.1.6. Harvesting of rice

Harvesting dates and duration of crops of the four experiments during 2004-2005 and 2005-2006 are presented in Table 3.5.

Table 3.5. Harvesting dates and duration of different experiment

Experiment	2004-2005		2005-2006	
	Harvesting date	duration	Harvesting date	duration
Experiment I a (Dry sowing)	23-08-04	122	20-08-05	119
Experiment I b (Transplanting)	17-12-04	109	26-12-05	109
Experiment II a (Wet sowing)	16-10-04	107	27-10-05	106
Experiment II b (Transplanting)	28-01-05	110	14-02-06	110

Two border rows all around the plots were harvested first and removed. Ten panicles were collected at random from each plot for observations on panicle characteristics. Remaining crop was harvested and threshed. The grain and straw were sun dried for two days and the weight recorded.

3.4.1.7. Harvesting of cowpea pods

Cowpea pods (Plate 7a and 7b) were harvested by plucking it just before the incorporation of cowpea plants.

3.5. Observations

Six hills were randomly selected from each plot as suggested by Gomez (1972) for recording the growth and yield observations except number of tillers m^{-2} and number of panicles m^{-2}. The following observations were recorded at different growth stages.

Plate7. Flowering and pod stages of cowpea in dry seeded rice

Plate 7a. Cowpea at flowering stage

Plate 7b. Cowpea at pod stage

3.5.1. Observation on growth characters

3.5.1.1. Rice

Growth characters were recorded at important growth stages viz., active tillering (AT), panicle initiation (PI) and harvest

3.5.1.1.1. Plant height

Plant height of 5 plants was measured from the base to the tip of the top most leaf at active tillering (AT) and panicle initiation (PI) stage. At harvest, the height was recorded from the base of the plant to the tip of the longest panicle. The mean height was computed and expressed in cm.

3.5.1.1.2. Number of tillers hill^{-1}

Number of tillers was counted from 5 hills and the average was taken.

3.5.1.1.3. Number of tillers m^{-2}

The number of tillers was counted from a quadrat of 0.25 m^2 selected at random and expressed as number of tillers m^{-2}.

3.5.1.1.4. Number of leaves plant^{-1}

Total number of green leaves produced was recorded from 5 plants and the average was taken and furnished.

3.5.1.1.5. Leaf area plant^{-1}

Length of the leaf was measured from base to tip of 5 leaves and the breadth was measured from the middle portion of 5 leaves and the average was taken. Leaf area per plant was calculated by length x breadth x number of leaves x factor method and expressed as cm^2.

Factor : 0.75 (Yoshida, 1981)

3.5.1.1.6. Leaf Area Index

Leaf Area Index (LAI) was calculated from the leaf area considering the land area occupied by the plants.

3.5.1.1.7. Dry matter production

Five sample hills were up rooted, washed free of soil, air dried and oven dried at 70-80°C to constant weight. Dry matter production was computed and expressed in kg ha^{-1}.

3.5.1.2. Green manure crops

Growth characters were recorded at the stage of incorporation.

3.5.1.2.1. Plant height

Height of the plant was measured from the base of the plant to the tip of the growing point and expressed in cm.

3.5.1.2.2. Nodule count

The plants were uprooted carefully, washed the roots free of soil particles and nodules on the tap root and lateral roots were counted and expressed as number of nodules $plant^{-1}$.

3.5.1. 2.3. Leaf area

Total number of leaves produced was recorded from 5 plants, the length of the leaf was measured from base to tip of 5 leaves and the breadth was measured from the middle portion of 5 leaves and the average was taken.

Leaf area per plant was calculated by length x breadth x number of leaves x factor method and expressed as cm^2.

Factor for horse gram: 0.63

Factor for cowpea: 0.72

Factor for daincha: 0.71

3.5.1.2.4. Leaf Area Index

Leaf Area Index (LAI) was calculated from the leaf area considering the land area occupied by the plants.

3.5.1.2.5. Biomass production

Five sample plants were uprooted washed free of soil and the fresh weight was taken and the green matter production was computed and expressed in kg ha^{-1}. The sample plants were then air dried and oven dried at 70-80°C to constant weight and the dry matter production was computed and expressed in kg ha^{-1}.

3.5.2. Observations on yield and yield attribute

3.5.2.1. Days to 50% flowering

Number of days taken by 50 per cent of the plants to flowering from the date of sowing was recorded from each plot.

3.5.2.2. Number of panicles m^{-2}

At harvest, number of panicles were counted from a randomly selected quadrat of 0.25 m^2 from each plot and expressed as number of panicles m^{-2}.

3.5.2.3. Number of panicles $hill^{-1}$

Total number of panicles from 5 hills was counted and the average was taken

3.5.2.4. Panicle weight

Ten main panicles were collected from each plot at random, mean weight worked out and expressed in g.

3.5.2.5. Number of filled grains $panicle^{-1}$

The filled grains from ten randomly selected panicles were counted and average worked out.

3.5.2.6. Percentage of filled grains

The grains from the randomly selected panicles from each plot were separated to filled and unfilled grains and counted to workout the percentage of filled grains.

3.5.2.7. 1000 grain weight

Thousand grains were collected from the randomly selected panicles from each plot and the weight recorded in grams.

3.5.2.8. Grain yield

Grains from each plot were sun dried, cleaned, winnowed, weighed and expressed in kg ha^{-1}.

3.5.2.9. Straw yield

Straw from the net plot was dried in sun uniformly, weighed and expressed in kg ha^{-1}.

3.5.2.10. Harvest Index

Harvest index (HI) was calculated using the data on grain yield and straw yield as per the following formula.

$$\text{Harvest index} = \frac{\text{Grain yield (kg ha}^{-1}\text{)}}{\text{Grain + straw yield (kg ha}^{-1}\text{)}}$$

3.5.2.11. Yield attributes of cowpea

Pods from ten randomly selected plants were counted and average number of pods worked out. Length of ten randomly selected pods was measured and average worked out. Pods harvested from each plot were weighed and expressed in kg ha^{-1}.

3.5.3. Observations on weed incidence

The observations on weeds were taken from the sampling strip from each plot using a 50 cm x 50 cm (0.25 m^2) quadrat. The following observations were recorded.

3.5.3.1. Weed count

The count of major weeds such as grasses, sedges and broad leaved weeds were recorded from the sampling unit in each plot and recorded as number m^{-2}.

3.5.3.2. Weed dry matter production

The weeds from the sampling area in each plot were uprooted, dried initially in shade and then in a hot air oven at 70°C and the weed dry weight was recorded in g m^{-2}.

3.5.4. Plant analysis

Sample plants collected from each plot at AT, PI and harvest was sun dried, oven dried at 70°C to constant weight. The samples were then ground to pass through a 0.5 mm mesh sieve. Then 0.5 g of samples were weighed out, digested and nutrient content was estimated as per standard procedure.

3.5.4.1. NPK content

Nitrogen content was estimated by modified microkjeldhal method (Jackson, 1973). Phosphorus content was estimated colorimetrically (Jackson, 1973) by developing colour by vanado molybdophosphoric acid method. The yellow colour developed was read using spectrophotometer. Potassium content in the plants was estimated by flame photometric method. NPK contents were expressed as percentage. Similarly NPK contents of green manure crops at incorporation stage and residual crop of rice at harvest were estimated.

3.5.4.2. NPK uptake

Uptake of N, P and K were calculated by multiplying the respective values of N, P and K with total dry weight of the plant. The uptake values were expressed in kg ha^{-1}. Uptake values were calculated for rice at different stages, green manure crops at incorporation stage and residual crop of rice at harvest.

3.5.5. Soil analysis

Soil samples were collected from the experimental area before the start of the experiment and after the experiment from each plot, dried in shade, sieved through 2 mm sieve and analysed.

Soil organic matter content was estimated using Walkley and Black method (Piper, 1966). Available nitrogen status of the soil was estimated using alkaline potassium permanganate method (Subbiah and Asija, 1956), available phosphorus by Bray colorimetric method (Jackson, 1973) and available potassium by ammonium acetate method (Jackson, 1973). The content of organic carbon was expressed as percentage and that of available N, P and K as kg ha^{-1}.

3.5.6. Nitrogen mineralization pattern

Wet soil samples were collected from the experimental area before and at five days interval after the incorporation of green manure crops till harvest of rice for the determination of ammoniacal and nitrate nitrogen release pattern. KCl extract of wet soil samples was used for steam distillation in a macrokjeldhal apparatus (Hesse, 1971). The values are expressed either in percentage or kg ha^{-1} by using the formula.

NH_4^+/ NO_3^-N in dry soil (%) = NH_4^+/ NO_3^- N in wet soil (%) x Moisture factor

Ten gram of wet soil was taken and oven dried at 70°C to a constant weight and weighed the dry soil and calculated the moisture factor.

$$\text{Moisture factor} = \frac{\text{Weight of moist soil (g)}}{\text{Weight of dry soil (g)}}$$

3.5.7. Economics

The labour charges of the locality, cost of inputs and extra treatment costs were taken together to compute the gross expenditure and expressed in Rupees ha^{-1}. The gross return was calculated based on the local market prices of paddy and straw and expressed on per hectare basis. Net return was calculated by subtracting total cost of cultivation from gross return. The Benefit: Cost ratio was worked out by dividing the gross return with the gross expenditure per hectare.

3.5.8. Statistical analysis

Data relating to different characters were compiled, tabulated and analysed statistically by applying the technique of analysis of variance, and significance was tested by F test (Panse and Sukhatme, 1978).

Results

RESULTS

The investigation entitled 'Concurrent growing of green manure crops in dry and wet seeded rice' was carried out at the Agricultural Research Station, Mannuthy with the objective to refine the technology of concurrent growing of green manure crops in direct seeded rice. The experimental data collected were statistically analysed and the results obtained are presented under the following sections.

4.1. CONCURRENT GROWING OF GREEN MANURE CROPS IN DRY SEEDED RICE

4.1.1. Growth characters of dry seeded rice

4.1.1.1. Height of plants

As revealed from pooled analysis, different green manure crops, methods of incorporation and levels of nitrogen had no significant influence on the height of rice in the system of concurrent growing of green manure crops at any growth stages except for nitrogen levels at panicle initiation stage (Table 4.1.1). However pure crop of rice recorded the lowest height at all growth stages with significantly lower values at active tillering and panicle initiation stages than that of intercropped rice. None of the interaction effects showed significant influence on the height of dry sown rice.

4.1.1.2. Number of tillers hill^{-1}

The pooled results showed that different green manure crops, methods of incorporation and levels of nitrogen had no significant influence on the number of tillers hill^{-1} of rice at different growth stages (Table 4.1.2). The number of tillers hill^{-1} of pure crop of rice was marginally higher at active tillering stage but at later growth stages tiller production was found less in pure crop. None of the interaction effects had significant influence on this character at any of the growth stages.

4.1.1.3. Number of tillers m^{-2}

The data showed that during 1st year, the number of tillers m^{-2} in cowpea intercropped rice at active tillering stage was significantly higher. However different treatments had no significant influence on the number of tillers m^{-2} at later growth stages during

Table 4.1.1. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on height (cm) of dry sown rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Green manure crops									
Horsegram	55.9	67.8	61.9	67.4	96.7	82.0	106.0	105.1	105.7
Cowpea	55.5	71.2	63.4	69.7	100.6	85.1	105.0	107.2	106.2
CD (0.05)	NS	2.6	NS	NS	NS	NS	NS	NS	NS
Methods of incorporation									
Conoweeding	56.8	68.0	62.4	69.8	97.9	83.9	106.0	105.8	105.9
2,4-D spray	55.9	71.4	63.6	66.7	97.5	82.1	104.1	107.2	105.6
Self decomposition	54.5	69.2	61.8	68.8	100.5	84.7	106.6	105.8	106.2
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	56.5	71.1	63.8	70.6	100.4	85.5	106.1	107.6	106.8
75% N	54.9	67.9	61.4	66.3	96.9	81.6	105.1	104.9	105.0
CD (0.05)	NS	2.6	NS	3.0	NS	3.6	NS	NS	NS
Rice alone	59.7	61.7	60.7	70.9	87.3	79.1	105.9	98.7	102.3
Interaction effects - NS									

Table 4.1.2. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on number of tillers hill^{-1} of dry sown rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Green manure crops									
Horsegram	8.3	22.6	15.5	11.7	27.3	19.5	12.8	16.4	14.6
Cowpea	10.0	23.6	16.8	12.8	26.1	19.4	13.4	17.6	15.5
CD (0.05)	1.1	NS	NS	NS	NS	NS	NS	NS	NS
Methods of incorporation									
Conoweeding	9.6	23.2	16.3	12.4	26.2	19.3	13.0	17.6	15.3
2,4-D spray	8.8	23.0	15.9	11.3	26.3	18.8	12.3	16.3	14.3
Self decomposition	9.2	23.2	16.2	13.0	27.8	20.4	14.0	17.1	15.6
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	9.5	23.5	16.5	12.3	26.8	19.6	13.1	17.3	15.2
75% N	8.9	22.7	15.8	12.2	26.6	19.4	13.1	16.7	14.9
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	9.5	29.3	19.4	13.0	21.3	17.2	13.3	14.3	13.8
Interaction effects - NS									

Table 4.1.3. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on number of tillers m^{-2} of dry sown rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
		2nd year	Mean	1st year	2nd year	Mean	1st year	2nd year	Pooled
Green manure crops									
Horsegram	278.1	753.6	515.9	390.7	911.0	650.7	426.8	546.2	486.5
Cowpea	333.7	787.0	560.3	425.1	870.3	647.7	446.8	587.0	566.6
CD (0.05)	36.1	NS	*	NS	NS	*	NS	NS	NS
Methods of incorporation									
Conoweeding	317.2	772.1	544.7	413.3	872.1	642.7	432.2	586.1	509.1
2,4-D spray	293.9	766.6	530.2	376.6	874.9	625.8	411.1	544.4	477.7
Self decomposition	306.6	772.1	539.4	433.8	924.9	679.4	467.2	569.4	518.3
CD (0.05)	NS	NS	*	NS	NS	*	NS	NS	NS
Levels of nitrogen									
100% N	315.2	783.3	549.2	409.6	894.4	652.0	436.3	577.7	507.0
75% N	296.6	757.3	527.0	406.3	886.9	646.6	437.4	555.5	496.4
CD (0.05)	NS	NS	*	NS	NS	*	NS	NS	NS
Rice alone	317.7	977.7	647.7	433.3	711.0	572.2	442.1	477.7	460.0
Interaction effects - NS									

* Pooling not possible as the errors heterogenous and interaction absent

Table 4.1.4. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on number of leaves $hill^{-1}$ of dry sown rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Green manure crops									
Horsegram	35.3	86.2	60.8	51.6	112.5	82.1	29.5	36.8	33.1
Cowpea	42.0	94.1	68.1	59.2	103.3	81.2	38.5	36.1	37.3
CD (0.05)	3.3	NS	NS	5.8	NS	NS	4.5	NS	NS
Methods of incorporation									
Conoweeding	40.8	96.3	68.5	57.1	114.4	85.8	37.8	38.5	38.1
2,4-D spray	37.2	87.9	62.6	47.8	101.9	74.8	31.0	34.8	32.9
Self decomposition	38.0	86.3	62.2	61.3	107.3	84.3	33.3	35.9	34.6
CD (0.05)	NS	NS	NS	7.1	NS	NS	NS	NS	5.5
Levels of nitrogen									
100% N	39.0	91.4	65.2	53.9	107.5	80.7	35.1	36.7	35.9
75% N	39.0	88.9	63.7	56.9	108.3	82.6	32.9	36.2	34.5
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	45.4	105.0	75.2	60.9	93.0	76.9	29.3	40.0	34.7
Interaction effects - NS									

both the years including active tillering stage of second year (Table 4.1.3). In the initial growth stage the number of tillers m^{-2} was found higher in control plot, but in later stages green manure intercropped treatments recorded more number of tillers m^{-2}. Interaction effects had no significant influence on the number of tillers m^{-2} at different growth stages.

4.1.1.4. Number of leaves $hill^{-1}$

Pooled data showed that different green manure crops, methods of incorporation and levels of nitrogen had no significant influence on the number of leaves $hill^{-1}$ at different growth stages except in the case of method of incorporation at harvest (Table 4.1.4). At active tillering stage, number of leaves $hill^{-1}$ was more in pure crop of rice. In panicle initiation stage the number of leaves was found significantly less in pure crop of rice compared with green manure intercropped rice. At harvest stage, leaf production of green manure intercropped rice was found on par with pure crop. Interaction had no significant influence on the leaf production at different growth stages.

4.1.1.5. Leaf area $hill^{-1}$

In the 1st year, leaf area of rice at all growth stages in cowpea intercropped treatment was found significantly higher compared to horse gram intercropped and pure crop of rice (Table 4.1.5). In the 2nd year, leaf area was significantly higher in cowpea intercropped treatment during active tillering stage only. During both the years, the leaf area of rice intercropped with cowpea was higher than that of horse gram intercropping and pure crop. The leaf area of pure crop of rice was significantly less at panicle initiation and harvest stages. Methods of incorporation of green manure crops influenced the leaf area of rice only at panicle initiation stage. Conoweeded treatment recorded the highest leaf area. Levels of nitrogen had no significant influence on the leaf area of rice at different growth stages. Interaction effects did not significantly influence the leaf area of dry sown rice at any of the growth stage.

4.1.1.6. Leaf area index

Concurrent growing of cowpea recorded the highest leaf area index of rice at active tillering stage during both the years. During 1st year, leaf area index at all the growth

Table 4.1.5. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on leaf area hill $^{-1}$ (cm^2) of dry sown rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Mean	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Green manure crops									
Horsegram	576	2553	1564	1509	7624	4566	798	1467	1132
Cowpea	730	3248	1989	1856	7266	4576	1013	1390	1201
CD (0.05)	140	555	*	255	NS	NS	160	NS	NS
Methods of incorporation									
Conoweeding	701	3203	1952	1835	8154	4994	1023	1395	1209
2,4-D spray	628	2833	1731	1420	6644	4032	805	1421	1113
Self decomposition	630	2666	1648	1792	7582	4687	888	1469	1178
CD (0.05)	NS	NS	*	313	NS	527	NS	NS	NS
Levels of nitrogen									
100% N	664	3017	1841	1692	7581	4636	966	1473	1219
75% N	642	2784	1713	1672	7339	4505	845	1384	1114
CD (0.05)	NS	NS	*	NS	NS	NS	NS	NS	NS
Rice alone	793	3060	1926	1936	5109	3523	771	1198	985
Interaction effects - NS									

* Pooling not possible as the errors heterogenous and interaction absent

Table 4.1.6. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on leaf area index of dry sown rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Green manure crops									
Horsegram	1.92	8.51	5.22	5.03	25.42	15.22	2.66	4.89	3.78
Cowpea	2.43	11.05	6.74	6.19	24.32	15.25	3.38	4.63	4.01
CD (0.05)	0.47	1.79	1.45	0.85	NS	NS	0.53	NS	NS
Methods of incorporation									
Conoweeding	2.34	10.68	6.51	6.12	27.18	16.65	3.41	4.65	4.03
2,4-D spray	2.09	9.45	5.77	4.73	22.15	13.44	2.68	4.74	3.71
Self decomposition	2.10	9.22	5.66	5.97	25.27	15.62	2.96	4.90	3.93
CD (0.05)	NS	NS	NS	1.04	NS	2.15	NS	NS	NS
Levels of nitrogen									
100% N	2.21	10.28	6.25	5.64	25:27	15.46	3.22	4.91	4.07
75% N	2.14	9.28	5.71	5.57	24.47	15.02	2.82	4.61	3.72
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	2.64	10.20	6.42	6.45	17.03	11.74	2.57	3.99	3.28
Interaction effects - NS									

stages were significantly higher in cowpea intercropped plots compared to horse gram intercropped and pure crop of rice (Table 4.1.6). But in the 2nd year, at later growth stages, green manures had no significant influence on the leaf area index. At all growth stages the leaf area index of pure crop of rice was less compared with cowpea intercropped rice. Leaf area index of pure crop was significantly less at panicle initiation stage compared with green manure intercropped rice. Methods of incorporation of green manure had no significant influence on the leaf area index except at panicle initiation stage. Interaction effect showed no significant influence on leaf area index.

4.1.1.7. Dry matter production

It can be seen from the data that during both the years, at active tillering and harvest stage different green manure crops, methods of incorporation of green manure crops and levels of nitrogen had no significant influence on the dry matter production of rice (Table 4.1.7). At panicle initiation stage, dry matter production of cowpea intercropped rice was significantly higher compared with horse gram intercropped and pure crop of rice. The dry matter production of pure crop of rice was higher at active tillering stage but at later growth stages, the dry matter production was found less in pure crop. Interaction had not significantly influenced the dry matter production of rice at any of the growth stages.

4.1.2. Growth characters of green manure crops in dry seeded rice

4.1.2.1. Plant height

During the first year cowpea recorded significantly higher plant height than horse gram. But in the second year the height of horse gram was more. Pooled data showed no significant variation (Table 4.1.8). Levels of N had significant influence on the plant height of green manure crops. Plant height was significantly higher with lower dose of nitrogen..

4.1.2.2. Nodule count

Nodules produced by both the green manure crops were very low. It was evident from the data that the number of nodules $plant^{-1}$ was significantly more in cowpea (4.64)

Table 4.1.7. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on dry matter production (kg ha^{-1}) of dry sown rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Green manure crops									
Horsegram	4294	5447	4870	5847	7975	6911	8909	10987	9948
Cowpea	4368	5760	5064	5817	8869	7343	9077	11351	10214
CD (0.05)	NS	NS	NS	NS	429	407	NS	NS	NS
Methods of incorporation									
Conoweeding	4314	5771	5043	5770	8737	7253	9364	10893	10127
2,4-D spray	4335	5302	4819	5974	8258	7116	8369	11308	9838
Self decomposition	4343	5738	5041	5752	8272	7012	9245	11305	10275
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	4346	5622	4984	5884	8518	7201	9250	10930	10090
75% N	4315	5586	4951	5780	8326	7053	8736	11407	10072
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	4045	6136	5090	5555	7098	6327	8422	10392	9407
Interaction effects - NS									

Table 4.1.8. Plant height, nodule count and leaf area of green manure crops grown along with dry sown rice at the time of incorporation

Treatments	Plant height (cm)			Nodule count plant^{-1}			Leaf area (cm^2)		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Green manure crops									
Horsegram	61.8	27.3	44.6	1.05	0.96	1.01	1005.0	208.2	606.8
Cowpea	55.5	34.4	44.9	5.11	4.17	4.64	2890.0	845.6	1868.0
CD (0.05)	4.3	2.0	NS	0.56	1.80	0.76	279.1	69.0	137.6
Methods of incorporation									
Conoweeding	61.4	29.7	45.5	2.91	2.18	2.55	1955.0	483.3	1219.0
2,4-D spray	55.6	31.0	43.3	3.16	2.53	2.85	1941.0	546.2	1244.0
Self decomposition	58.9	31.9	45.4	3.16	3.00	3.08	1948.0	551.2	1249.0
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	55.8	31.4	43.6	3.16	2.27	2.72	1974.0	544.1	1259.0
75% N	61.5	30.3	45.9	3.00	2.86	2.93	1921.0	509.8	1216.0
CD (0.05)	4.3	NS	2.4	NS	NS	NS	NS	NS	NS

compared with horse gram (Table 4.1.8). Levels of nitrogen failed to show any significant influence on the nodule count.

4.1.2.3. Leaf area

Leaf area of green manure crops varied significantly. Leaf area of cowpea (1868 cm^2) was significantly higher compared with horse gram (Table 4.1.8). Levels of nitrogen had no significant influence on the leaf area of green manure crops.

4.1.2.4. Leaf Area Index

Regarding the leaf area index, there was significant difference among the green manure crops. Leaf area index of cowpea (6.23) was significantly superior to that of horse gram (Table 4.1.9). Leaf area index of green manure crop was not affected by different levels of nitrogen.

4.1.2.5. Biomass production

The biomass production of cowpea was significantly higher (12352 kg ha^{-1}) and almost three times to that of horse gram (Table 4.1.9). Levels of nitrogen did not significantly influence the biomass production of green manure crops.

4.1.2.6. Dry matter production

The dry matter production of cowpea was significantly higher (1628 kg ha^{-1}) and almost double to that of horse gram (Table 4.1.9). Levels of nitrogen had no significant influence on the dry matter production of green manure crops.

4.1.3. Yield and yield attributes of dry seeded rice

4.1.3.1. Days to 50 per cent flowering

During both the years, different green manure crops, methods of incorporation and levels of nitrogen had no significant influence on the time of 50 per cent flowering of dry sown rice (Tables 4.1.10). Interaction effect had no significant influence on the time of 50 per cent flowering.

Table 4.1.9. Leaf area index, biomass production and dry matter addition of green manure crops grown along with dry sown rice at the time of incorporation

Treatments	Leaf area Index			Biomass (kg ha^{-1})			Dry matter (kg ha^{-1})		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Green manure crops									
Horsegram	3.35	0.70	2.04	5181	2366	3774	849	821	835
Cowpea	9.64	2.82	6.23	15639	9066	12352	1883	1372	1628
CD (0.05)	0.93	0.23	0.46	1091	509	576	134	67	72
Methods of incorporation									
Conoweeding	6.52	1.61	4.06	10191	5672	7931	1336	1102	1219
2,4-D spray	6.47	1.82	4.15	10601	5594	8097	1391	1079	1235
Self decomposition	6.49	1.84	4.16	10439	5883	8161	1371	1109	1240
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	6.58	1.81	4.20	10784	5796	8290	1409	1100	1254
75% N	6.41	1.70	4.05	10036	5636	7836	1324	1093	1208
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

4.1.3.2. Panicles m $^{-2}$

Green manure crops had significant influence on the number of panicles m^{-2}. Rice intercropped with cowpea produced significantly superior number of panicles m^{-2} (373.3) compared with horse gram intercropping (Tables 4.1.10). Method of incorporation significantly influenced the number of panicles m^{-2}. Maximum number of panicles m^{-2} was observed when the green manure crops were incorporated by conoweeding (398.3) followed by self decomposition. The number of panicles produced m^{-2} was significantly superior (375.9) with 100 % nitrogen. The number of panicles m^{-2} was the highest in pure crop of rice. None of the interaction effects had any significant influence on the number of panicles m^{-2}

4.1.3.3. Panicles hill^{-1}

Panicles hill^{-1} was significantly affected by the green manure crops. Rice with cowpea recorded significantly higher number of panicles hill^{-1} compared to rice with horse gram during the 1st and 2nd years (Tables 4.1.10). Pooled data was not significantly different. Method of incorporation and levels of nitrogen did not significantly influence the number of panicles hill^{-1}. Interaction effect showed no significant influence on the number of panicles hill^{-1}

4.1.3.4. Panicle weight

Concurrent growing of green manure crops significantly influenced the weight of panicles. Panicle weight was significantly higher in cowpea intercropped rice (27.3 g) compared with horse gram intercropped rice and pure crop of rice (Tables 4.1.10). Pure crop of rice recorded the lowest panicle weight (22.15 g). The weight of panicle was not affected by different methods of incorporation of green manure crops. Levels of nitrogen behaved similarly. No significant effect was noticed in any of the interaction effects on the weight of panicle.

4.1.3.5. Number of filled grains panicle^{-1}

Number of filled grains panicle^{-1} in rice with concurrent growing of both the green manures was significantly higher than pure crop of rice (Tables 4.1.11). Both the green manure crops behaved similarly in the production of filled grains panicle^{-1}.

Table 4.1.10. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on yield attributes of dry sown rice

Treatments	Days to 50% flowering			Panicle m^{-2}			Panicle $hill^{-1}$			Panicle weight (g)		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Green manure crops												
Horsegram	82	80	81	318.9	344.9	331.9	8.11	12.39	10.25	17.67	32.10	24.88
Cowpea	82	80	81	407.1	339.6	373.3	9.78	13.83	11.81	18.56	36.10	27.30
CD (0.05)	NS	NS	NS	13.4	NS	11.6	1.50	0.93	NS	NS	3.89	2.24
Methods of incorporation												
Conoweeding	82	80	81	415.0	381.9	398.3	9.25	13.33	11.29	18.17	33.70	25.93
2,4-D spray	82	80	81	300.7	301.7	301.2	8.33	12.92	10.63	17.33	33.38	25.35
Self decomposition	82	80	81	373.3	343.3	358.3	9.25	13.08	11.17	18.83	35.15	26.99
CD (0.05)	NS	NS	NS	16.5	12.8	15.2	NS	NS	NS	NS	NS	NS
Levels of nitrogen												
100% N	82	80	81	384.7	367.1	375.9	9.50	13.33	11.42	18.56	33.92	26.24
75% N	82	80	81	341.3	317.3	329.3	8.39	12.89	10.64	17.67	34.23	25.95
CD (0.05)	NS	NS	NS	NS	NS	11.6	NS	NS	NS	NS	NS	NS
Rice alone	81.33	79.33	80.33	429.3	350.7	390.0	9.33	11.33	10.33	16.67	27.64	22.15
Interaction effects - NS												

Methods of green manure incorporation and nitrogen levels did not significantly influence the number of filled grains panicle^{-1}. Interaction effects had no significance on the production of filled grains panicle^{-1}.

4.1.3.6. Percentage of filled grain

Percentage of filled grain was significantly higher in green manure intercropped rice (81% and 82% in horse gram intercropped and cowpea intercropped rice respectively) compared with pure crop of rice (71%). No significant difference in the percentage of filled grain was noticed with different methods of incorporation and levels of nitrogen (Tables 4.1.11). Interaction effects had no significant influence on filled grain percentage.

4.1.3.7. 1000 grain weight

No significant difference was noticed among the main and interaction effects of treatments in respect of 1000 grain weight (Tables 4.1.11). However the green manure intercropped rice recorded more grain weight numerically.

4.1.3.8. Grain yield

Concurrent growing of cowpea produced more grain yield numerically though not significant in the 1st and 2nd year. The pooled data on grain yield showed significant difference in the grain yield of rice (Table 4.1.12). The maximum grain yield (3633 kg ha^{-1}) was recorded by rice intercropped with cowpea followed by rice intercropped with horse gram. The lowest grain yield (3267 kg ha^{-1}) was noticed in pure crop of rice. Method of incorporation and levels of nitrogen had no significant influence on grain production. Interaction effects had no significant influence on the grain yield of dry sown rice.

4.1.3.9. Straw yield

Different green manure crops, methods of incorporation and levels of nitrogen and their interaction effects did not significantly influence the straw yield of rice during both years (Table 4.1.12).

Table 4.1.11. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on yield attributes of dry sown rice

Treatments	Filled grains panicle^{-1}			Filled grain %			1000 grain weight (g)		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Green manure crops									
Horsegram	80.00	64.05	72.02	81.09	81.21	81.15	28.68	30.22	29.45
Cowpea	83.63	64.55	74.09	83.11	81.50	82.30	28.58	30.67	29.62
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Methods of incorporation									
Conoweeding	83.33	62.66	73.00	83.10	81.43	82.27	28.44	30.59	29.52
2,4-D spray	81.25	65.16	73.20	82.48	80.77	81.62	28.93	30.15	29.54
Self decomposition	80.87	65.08	72.97	80.71	81.88	81.29	28.53	30.59	29.56
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	82.97	62.77	72.87	81.83	81.81	81.82	28.71	30.52	29.62
75% N	80.66	65.83	73.25	82.38	80.90	81.64	28.55	30.37	29.46
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	73.00	44.33	58.66	71.05	71.43	71.24	27.93	28.87	28.40
Interaction effects - NS									

Table 4.1.12. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on grain yield, straw yield and harvest index of dry sown rice

Treatments	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Harvest Index		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Green manure crops									
Horsegram	3420	3426	3423	2230	3102	2666	0.607	0.524	0.566
Cowpea	3611	3656	3633	2293	3156	2725	0.611	0.536	0.573
CD (0.05)	NS	NS	210	NS	NS	NS	NS	NS	NS
Methods of incorporation									
Conoweeding	3624	3547	3585	2294	3167	2730	0.612	0.528	0.570
2,4-D spray	3456	3570	3513	2229	3138	2683	0.609	0.530	0.570
Self decomposition	3467	3506	3486	2263	3082	2672	0.605	0.532	0.568
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	3532	3609	3570	2261	3135	2698	0.609	0.535	0.572
75% N	3499	3473	3486	2263	3122	2693	0.608	0.525	0.566
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	3315	3220	3268	2361	3210	2785	0.583	0.503	0.543
Interaction effects - NS									

4.1.3.10. Harvest Index

Neither the main effects nor the interaction effects revealed any significance on the harvest index of rice (Table 4.1.12). Harvest index obtained with pure crop of rice was less compared with green manure intercropped rice.

4.1.3.11. Yield and Yield attributes of cowpea

Data on the number of pods, pod length and pod yield of cowpea showed no significant difference on the yield attributes and pod yield of concurrently grown cowpea (Table 4.1.13).

4.1.4. Weed incidence in dry seeded rice

4.1.4.1. Weed count

Weed count at 30 DAS

The data showed that concurrent growing of green manure crops significantly reduced the count of grasses, broadleaved weeds and sedges at 30 DAS compared to rice grown alone in both years (Table 4.1.14). The count of grasses, broadleaved weeds and sedges at 30 DAS was significantly less in cowpea intercropped treatments compared to horse gram intercropped treatments. The green manure crops were not incorporated at 30DAS hence there is no relevance to the methods of incorporation at 30DAS. Levels of nitrogen had no significant effect on weed count. There was no significant difference on the weed count at 30 DAS due to interactions.

Weed count at 50 DAS

Concurrent growing of green manure crops and their methods of incorporation significantly reduced the weed count in dry seeded rice at 50 DAS (Table 4.1.15). Pure crop of rice recorded the highest weed count of all the three types of weeds such as grasses, broad leaved weeds and sedges. Among the green manure crops, cowpea significantly reduced the population of grasses, broad leaved weeds and sedges compared with horse gram. Methods of incorporation had significant influence on the weed count at 50 DAS. In treatments where the green manure crops were allowed to be incorporated due to flooding recorded the highest weed count of all the three types

Table 4.1.13. Yield and yield attributes of concurrently grown cowpea in dry seeded rice crop

Treatments	Number of pod plant^{-1}			Pod length			Pod yield (kg ha^{-1})		
	1st year	2nd year	Mean	1st year	2nd year	Mean	1st year	2nd year	Mean
T_7 CP+Cono+100%N	13.66	16.66	15.16	15.66	14.66	15.16	488	768	628
T_8 CP+Cono+75%N	15.00	17.66	16.33	17.66	19.00	18.33	408	733	571
T_9 CP+2,4-D+100%N	13.33	16.33	14.83	16.00	15.33	15.67	420	700	560
T_{10} CP+2,4-D+75%N	15.00	19.33	17.17	15.33	16.66	16.00	395	675	535
T_{11} CP+Self+100%N	14.00	16.66	15.33	17.33	16.66	17.00	428	708	568
T_{12} CP+Self+75%N	13.00	14.66	13.83	16.33	17.00	16.67	437	717	577

Table 4.1.14. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on weed count m^{-2} of dry sown rice at 30 DAS (before green manure incorporation)

Treatments	Grass weeds			Broadleaved weeds			Sedges			Total weeds		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Green manure crops												
Horsegram	68.00	53.72	60.86	118.44	85.44	101.94	16.55	17.38	16.97	203.00	156.60	179.80
Cowpea	46.83	38.55	42.69	70.89	48.77	59.83	12.27	9.77	11.02	130.00	97.11	113.60
CD (0.05)	12.44	7.80	7.17	17.07	11.12	14.06	2.31	2.40	2.21	20.99	14.19	17.85
Methods of incorporation												
Conoweeding	56.33	47.83	52.08	106.00	64.00	85.00	14.83	13.66	14.25	177.20	125.50	151.30
2,4-D spray	60.33	44.16	52.25	87.83	69.16	78.50	14.50	13.75	14.12	162.70	127.10	144.90
Self decomposition	55.58	46.41	51.00	90.16	68.16	79.16	13.91	13.33	13.62	159.70	127.90	143.80
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen												
100% N	57.77	44.88	51.33	94.61	68.83	81.72	14.22	13.89	13.08	166.60	127.10	146.90
75% N	57.05	47.38	52.22	94.72	65.38	80.56	14.61	13.77	14.91	166.40	126.60	146.50
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	81.33	111.30	96.33	168.30	169.30	168.80	19.33	21.66	20.50	269.00	302.30	285.70
Interaction effects - NS												

Table 4.1.15. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on weed count m^{-2} of dry sown rice at 50 DAS (after green manure incorporation)

Treatments	Grass weeds			Broadleaved weeds			Sedges count			Total weeds		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Green manure crops												
Horsegram	30.11	43.83	36.97	96.55	63.38	79.97	19.94	14.22	17.08	146.60	121.40	134.00
Cowpea	19.83	36.72	28.27	57.11	39.61	48.36	11.22	8.55	9.88	88.16	84.88	86.52
CD (0.05)	5.11	5.72	8.19	13.48	5.80	24.25	3.04	2.02	1.41	12.76	7.78	6.07
Methods of incorporation												
Conoweeding	15.58	33.33	24.45	87.66	51.33	69.50	13.33	12.00	12.66	116.60	96.66	106.60
2,4-D spray	32.08	43.16	37.62	40.66	41.16	40.91	9.75	9.41	9.58	82.50	93.75	88.12
Self decomposition	27.25	44.33	35.79	102.16	62.00	82.08	23.66	12.75	18.20	153.10	119.10	136.10
CD (0.05)	6.26	7.01	10.03	16.52	7.11	29.70	3.73	2.47	1.73	15.63	9.52	7.44
Levels of nitrogen												
100% N	25.66	38.61	32.13	74.83	51.50	63.16	15.83	10.94	13.38	116.30	101.10	108.70
75% N	24.27	41.94	33.11	78.83	51.50	65.16	15.33	11.83	13.58	118.40	105.30	111.90
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	81.00	118.70	99.83	248.30	185.00	216.70	37.66	22.66	30.16	367.00	326.30	346.70
Interaction of Green manure crop x Method of incorporation significant; Other interactions - NS												

Interaction table should have been given. [illegible] of weeds. Population of grasses was found significantly less in conoweeded treatments. In both the years broad leaved weeds and sedges were significantly less in 2, 4-D applied treatments. The reduction in total weed count, due to the application of 2, 4-D for incorporating the green manure crops, was 47 and 22 per cent compared with self decomposition of green manure crops and the total weed count was 24 and 19 per cent less due to conoweeding during the 1st and 2nd year, respectively. Levels of nitrogen did not show any significant effect on weed count at 50DAS.

Significant interaction was noticed between green manure crops and their methods of incorporation on the population of grasses, broad leaved weeds and total weeds at 50 DAS.

Concurrent growing of green manure crops and its incorporation using conoweeder significantly reduced the grass weed count (Table 4.1.15.1). The lowest grass weed count noticed in rice intercropped with cowpea and incorporated it using conoweeder (22.33). It was on par with the grass weed count in rice intercropped with horse gram and incorporated it using conoweeder. Interaction between green manure crops and other method of incorporations recorded significantly higher number of grasses. Interaction between green manure crops and levels of nitrogen failed to show any significance.

Broad leaved weeds in rice intercropped with green manure crops and incorporated it using 2,4-D spray was significantly less (Table 4.1.15.2). Concurrent growing of cowpea along with 2,4-D spraying resulted in significantly less broad leaved weeds (34.08) compared with other interactions of green manure crop and its incorporation methods. No significant difference was noticed in the count of sedges due to interactions.

Total weed count was significantly less in rice with concurrently grown cowpea incorporated using 2,4-D spray (71.58) compared with other interactions except cowpea with conoweeding (Table 4.1.15.3).

Table 4.1.15.1. Interaction effect of concurrently grown green manure crops and methods of incorporation on grass weed count m^{-2} of dry sown rice at 50DAS

Methods of incorporation / Green Manure crops	1st year			2nd year			Pooled		
	Cono weeding	2,4- D	Self decomp	Cono weeding	2,4- D	Self decomp	Cono weeding	2,4- D	Self decomp
Horsegram	17.83	43.00	29.50	35.33	45.66	50.50	26.58	44.33	40.00
Cowpea	13.33	21.16	25.00	31.33	40.66	38.16	22.33	30.91	31.58
CD (0.05)	6.72			7.09			5.26		

Table 4.1.15.2. Interaction effect of green manure crops and methods of incorporation on broad leaved weed count m^{-2} of dry sown rice at 50DAS

Methods of incorporation / Green Manure crops	1st year			2nd year			Pooled		
	Cono weeding	2,4- D	Self decomp	Cono weeding	2,4- D	Self decomp	Cono weeding	2,4- D	Self decomp
Horsegram	121.30	44.16	124.20	57.83	51.33	81.00	89.58	47.75	102.60
Cowpea	54.00	37.16	80.16	44.83	31.00	43.00	49.41	34.08	61.58
CD (0.05)	11.84			9.82			7.48		

Table 4.1.15. 3. Interaction effect of concurrently grown green manure crops and methods of incorporation on total weed count m^{-2} of dry sown rice at 50DAS

Methods of incorporation / Green Manure crops	1st year			2nd year			Pooled		
	Cono weeding	2,4- D	Self decomp	Cono weeding	2,4- D	Self decomp	Cono weeding	2,4- D	Self decomp
Horsegram	156.00	101.20	182.70	108.30	108.20	147.80	132.20	104.70	165.30
Cowpea	77.16	63.83	123.50	85.00	79.33	90.33	81.08	71.58	106.90
CD (0.05)	16.10			12.57			10.52		

4.1.4.2. Weed dry matter production(DMP)

Weed DMP at 30 DAS

As evident from the data, concurrent growing of cowpea significantly reduced the dry matter production of grasses, broad leaved weeds, sedges and thereby the total weed dry matter at 30DAS compared with concurrent growing of horse gram and pure crop of rice in both the years (Table 4.1.16.). The green manure crops were not incorporated at 30DAS hence there is no relevance to the method of incorporation at 30DAS. Levels of nitrogen had no significant effect on weed dry matter production at 30DAS.

Weed DMP at 50 DAS

The results showed that in both the years, dry matter production of grasses, broad leaved weeds and sedges and thereby the total weed dry matter production was significantly higher in pure crop of rice (Table 4.1.17). Concurrent growing of cowpea along with rice resulted in a significant reduction in dry matter production of grasses, broad leaved weeds, sedges and thereby total weeds dry matter at 50 DAS in both the years compared with concurrent growing of horse gram and pure crop of rice. Methods of incorporation showed significant influence on the weed dry matter production at 50 DAS. Dry weight of grass was significantly less in conoweeded treatment in both years. Dry matter production of broad leaved weeds and sedges were found significantly less in 2, 4- D applied treatments. Among the three methods of incorporation of green manures, total weed dry matter was significantly less in 2, 4-D applied treatments and highest in treatments where the green manure crops were allowed for self decomposition due to flooding. Levels of nitrogen had no significant effect on weed dry matter production at 50DAS.

Interaction between green manure crops and method of interaction showed significant difference on the dry weight of grass, broad leaved weeds and sedges in dry seeded rice at 50DAS.

Table 4.1.16. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on dry weight of weeds ($g\ m^{-2}$) of dry sown rice at 30 DAS (before green manure incorporation)

Treatments	Grass weeds			Broadleaveds			Sedges			Total weeds		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Green manure crops												
Horsegram	6.62	5.08	5.85	6.29	7.21	6.75	3.39	3.55	3.47	16.30	15.85	16.08
Cowpea	5.75	4.28	5.02	5.35	5.73	5.54	1.81	2.32	2.06	12.92	12.34	12.63
CD (0.05)	0.47	0.30	0.50	0.41	0.33	0.37	0.32	0.28	0.30	0.73	0.59	0.67
Methods of incorporation												
Conoweeding	6.05	4.77	5.41	5.66	6.39	6.02	2.66	2.95	2.81	14.38	14.13	14.25
2,4-D spray	6.32	4.57	5.45	5.83	6.52	6.18	2.62	2.97	2.80	14.77	14.08	14.43
Self decomposition	6.19	4.69	5.44	5.96	6.50	6.23	2.51	2.88	2.69	14.68	14.08	14.38
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen												
100% N	6.29	4.59	5.44	5.76	6.44	6.10	2.65	2.93	2.79	14.71	13.97	14.34
75% N	6.08	4.77	5.42	5.87	6.50	6.19	2.54	2.94	2.74	14.51	14.22	14.36
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	9.41	6.66	8.03	7.62	7.69	7.65	4.48	3.89	4.18	21.52	18.24	19.88
Interaction effects - NS												

Table 4.1.17. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on dry weight of weeds ($g\ m^{-2}$) of dry sown rice at 50 DAS (after green manure incorporation)

Treatments	Grass weeds			Broadleaved weeds			Sedges s			Total weeds		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Green manure crops												
Horsegram	6.35	7.17	6.76	10.73	6.92	8.82	5.76	3.43	4.59	22.84	17.53	20.19
Cowpea	4.75	6.28	5.52	7.19	5.88	6.53	4.18	2.83	3.50	16.13	15.00	15.56
CD (0.05)	0.49	0.29	0.99	1.17	0.33	0.59	0.50	0.25	0.28	1.12	0.51	2.20
Method of incorporation												
Conoweeding	4.78	6.39	5.58	8.19	6.71	7.45	4.96	3.10	4.03	17.94	16.21	17.07
2,4-D spray	6.21	6.80	6.51	5.73	6.10	5.92	3.57	3.08	3.32	15.52	15.99	15.76
Self decomposition	5.66	6.99	6.32	12.96	6.39	9.67	6.38	3.20	4.79	25.00	16.59	20.80
CD (0.05)	0.60	0.36	1.21	1.43	0.41	0.73	0.61	NS	0.34	1.37	NS	2.56
Levels of nitrogen												
100% N	5.61	6.70	6.15	8.64	6.44	7.54	4.87	3.13	4.00	19.13	16.27	17.70
75% N	5.49	6.70	6.12	9.28	6.36	7.82	5.07	3.13	4.12	19.84	16.25	18.05
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	11.41	9.54	10.47	29.25	9.66	19.46	9.21	4.29	6.75	49.88	23.50	36.69
Interaction of Green manure crop x Methods of incorporation significant; Other interactions - NS												

Table 4.1.17.1. Interaction effect of concurrently grown green manure crops and methods of incorporation on dry weight of grass weeds (g m^{-2}) in dry sown rice at 50DAS

Methods of incorporation / Green Manure crops	1st year			2nd year			Pooled		
	Cono weeding	2,4- D	Self decomp	Cono weeding	2,4- D	Self decomp	Cono weeding	2,4- D	Self decomp
Horsegram	5.55	7.37	6.13	6.65	7.23	7.64	6.10	7.30	6.88
Cowpea	4.01	5.06	5.19	6.13	6.38	6.34	5.07	5.72	5.76
CD (0.05)	0.77			0.44			0.45		

Table 4.1.17.2. Interaction effect of concurrently grown green manure crops and methods of incorporation on dry weight of broad leaved weeds (g m^{-2}) in dry sown rice at 50DAS

Methods of incorporation / Green Manure crops	1st year			2nd year			Pooled		
	Cono weeding	2,4- D	Self decomp	Cono weeding	2,4- D	Self decomp	Cono weeding	2,4- D	Self decomp
Horsegram	9.97	6.25	15.97	7.19	6.55	7.03	8.58	6.40	11.50
Cowpea	6.41	5.21	9.94	6.23	5.66	5.76	6.32	5.43	7.85
CD (0.05)	2.08			0.58			1.03		

Table 4.1.17. 3. Interaction effect of concurrently grown green manure crops and methods of incorporation on dry weight of sedges (g m^{-2}) in dry sown rice at 50DAS

Methods of incorporation / Green Manure crops	1st year			2nd year			Pooled		
	Cono weeding	2,4- D	Self decomp	Cono weeding	2,4- D	Self decomp	Cono weeding	2,4- D	Self decomp
Horsegram	5.90	4.82	6.57	3.29	3.38	3.62	4.59	4.10	5.09
Cowpea	4.02	2.33	6.19	2.92	2.77	2.79	3.47	2.55	4.49
CD (0.05)	0.88			0.45			0.48		

Interaction of cowpea with conoweeding significantly reduced the dry weight of grasses (5.07) in dry seeded rice compared with other interactions (Table 4.1.17.1). Concurrent growing of cowpea and its incorporation using 2,4-D resulted in significant reduction of broad leaved weeds (Table 4.1.17.2) and sedges (Table 4.1.17.3) compared with other interactions. No significant difference was noticed in the total weed dry weight due to interactions.

4.1.5. Nutrient content and nutrient uptake of plants

4.1.5.1. Nutrient content of rice

4.1.5.1.1. Nitrogen content

Nitrogen contents of rice at active tillering and panicle initiation stages were significantly higher when rice was grown along with green manure crops compared to rice grown alone (Table 4.1.18). Nitrogen content of rice at panicle initiation stage was significantly higher when cowpea was grown concurrently with rice compared with concurrent growing of horse gram and pure crop of rice. Nitrogen content of rice intercropped with green manure crops showed a declining trend towards crop maturity. In pure crop of rice the N content was found maximum at panicle initiation stage. Method of incorporation of green manure crops significantly influenced the N content of rice only at panicle initiation stage. Self decomposition of green manure crops resulted in higher N content compared to other method of incorporation. Levels of nitrogen and interaction did not influence the N content

4.1.5.1.2. Phosphorus content

Different green manure crops, methods of incorporation and levels of nitrogen had no significant influence of the P content of rice at various growth stages (Table 4.1.19). Phosphorus contents at active tillering and panicle initiation stages of rice grown along with green manure crops was significantly higher compared to rice grown alone. Interactions had no significant influence on the P content of rice at various growth stages.

Table 4.1.18. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on nitrogen content (%) of dry sown rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Green manure crops									
Horsegram	0.932	1.092	1.012	0.966	0.773	0.870	1.319	0.480	0.900
Cowpea	1.020	1.003	1.011	0.964	0.901	0.933	1.318	0.500	0.909
CD (0.05)	0.087	0.065	NS	NS	0.075	0.147	NS	NS	NS
Methods of incorporation									
Conoweeding	1.055	1.044	1.050	0.892	0.764	0.828	1.361	0.505	0.933
2,4-D spray	0.942	1.042	0.992	0.945	0.902	0.923	1.298	0.500	0.899
Self decomposition	0.932	1.055	0.993	1.058	0.846	0.952	1.297	0.465	0.881
CD (0.05)	0.106	NS	NS	NS	0.092	0.180	NS	NS	NS
Levels of nitrogen									
100% N	1.027	1.084	1.056	0.960	0.839	0.900	1.332	0.503	0.917
75% N	0.925	1.010	0.967	0.971	0.835	0.903	1.306	0.477	0.891
CD (0.05)	0.087	0.065	NS	NS	NS	NS	NS	NS	NS
Rice alone	0.687	0.430	0.558	0.783	0.763	0.773	1.137	0.293	0.715
Interaction effects - NS									

Table 4.1.19. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on phosphorus content (%) of dry sown rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Green manure crops									
Horsegram	0.134	0.117	0.126	0.187	0.118	0.153	0.107	0.093	0.100
Cowpea	0.127	0.147	0.137	0.141	0.119	0.130	0.098	0.102	0.100
CD (0.05)	NS	0.000	NS	0.040	NS	NS	NS	NS	NS
Methods of incorporation									
Conoweeding	0.132	0.132	0.132	0.147	0.110	0.129	0.098	0.103	0.100
2,4-D spray	0.128	0.135	0.132	0.178	0.128	0.153	0.101	0.088	0.095
Self decomposition	0.132	0.128	0.130	0.166	0.118	0.142	0.109	0.102	0.106
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	0.131	0.122	0.127	0.179	0.112	0.137	0.105	0.098	0.102
75% N	0.131	0.141	0.136	0.148	0.126	0.146	0.100	0.097	0.098
CD (0.05)	NS	0.000	NS	NS	NS	NS	NS	NS	NS
Rice alone	0.110	0.090	0.100	0.160	0.103	0.132	0.107	0.067	0.087
Interaction effects - NS									

4.1.5.1.3. Potassium content

Different treatments had no significant influence of the K content of rice at various growth stages (Table 4.1.20). Potassium contents of rice at all the growth stages were significantly higher when rice was grown along with green manure crops compared to rice grown alone. Potassium content of rice was found maximum at panicle initiation stage irrespective of rice grown along with green manure crops or alone. Interactions showed no significance on the K content at different growth stages

4.1.5.2. Nutrient uptake by rice

4.1.5.2.1. Nitrogen uptake

Green manure crops, methods of incorporation and levels of nitrogen had no significant influence on the nitrogen uptake of rice at various growth stages (Table 4.1.21). Nitrogen uptake showed an increasing trend as the plant matures. Nitrogen uptake of rice grown along with green manure crops was significantly higher than the N uptake of pure crop of rice. Interaction effects had no significant influence on N uptake of dry sown rice.

4.1.5.2.2. Phosphorus uptake

Different green manure crops, methods of incorporation and levels of nitrogen had no significant influence of the P uptake of rice at various growth stages (Table 4.1.22). Phosphorus uptake of rice grown along with green manure crops at active tillering stage was significantly higher than the P uptake of pure crop of rice. Phosphorus uptake of rice increased as the crop matures irrespective of the treatments. Interaction effects failed to show any significant influence on the P uptake of dry sown rice.

4.1.5.2.3. Potassium uptake

Different treatments had no significant influence on the K uptake of rice at various growth stages (Table 4.1.23). Potassium uptake at all the growth stages of rice grown along with green manure crops was significantly higher compared with rice grown as pure crop. Potassium uptake of rice was found maximum at panicle initiation stage

Table 4.1.20. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on potassium content (%) of dry sown rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Green manure crops									
Horsegram	0.658	1.927	1.292	1.691	2.056	1.873	0.869	1.629	1.249
Cowpea	0.656	1.896	1.262	1.669	2.111	1.890	0.742	1.698	1.220
CD (0.05)	NS	NS	NS	NS	NS	NS	0.102	NS	NS
Methods of incorporation									
Conoweeding	0.640	2.037	1.338	1.643	2.113	1.878	0.773	1.680	1.227
2,4-D spray	0.690	1.837	1.263	1.737	2.090	1.913	0.793	1.620	1.207
Self decomposition	0.640	1.820	1.230	1.660	2.047	1.853	0.850	1.690	1.270
CD (0.05)	NS	0.130	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	0.667	1.880	1.273	1.682	2.107	1.894	0.816	1.620	1.218
75% N	0.647	1.916	1.281	1.678	2.060	1.869	0.796	1.707	1.251
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	0.560	1.547	1.053	1.587	1.693	1.640	0.853	1.373	1.113
Interaction effects - NS									

Table 4.1.21. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on nitrogen uptake (kg ha^{-1}) of dry sown rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Green manure crops									
Horsegram	39.96	59.26	49.61	56.63	61.64	59.13	117.52	52.09	84.80
Cowpea	44.61	58.13	51.37	56.09	79.29	67.69	120.07	56.67	88.37
CD (0.05)	4.57	NS	NS	NS	6.75	NS	NS	NS	NS
Methods of incorporation									
Conoweeding	45.57	60.70	53.14	51.42	66.88	59.15	127.68	54.30	90.99
2,4-D spray	40.94	54.90	47.92	56.72	74.47	65.60	108.96	56.74	82.85
Self decomposition	40.34	60.49	50.41	60.92	70.04	65.48	119.74	52.10	85.92
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	44.64	60.94	52.79	56.37	71.39	63.88	123.13	54.87	89.00
75% N	39.93	56.46	48.19	56.34	69.54	62.94	114.45	53.89	84.17
CD (0.05)	4.57	NS	4.50	NS	NS	NS	NS	NS	NS
Rice alone	27.79	26.98	27.38	43.59	54.04	48.81	96.29	30.43	63.36
Interaction effects - NS									

Table 4.1.22. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on phosphorus uptake (kg ha^{-1}) of dry sown rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Green manure crops									
Horsegram	5.772	6.375	6.073	11.06	9.419	10.24	9.496	10.2	9.848
Cowpea	5.552	8.438	6.995	8.231	10.43	9.332	8.964	11.47	10.217
CD (0.05)	NS	0.78	0.467	2.4	NS	NS	NS	NS	NS
Methods of incorporation									
Conoweeding	5.704	7.631	6.667	8.543	9.538	9.041	9.244	10.94	10.092
2,4-D spray	5.527	7.26	6.393	10.78	10.55	10.66	8.384	10.18	9.282
Self decomposition	5.754	7.328	6.541	9.614	9.693	9.654	10.06	11.39	10.725
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	5.688	6.88	6.284	10.68	9.508	10.1	9.728	10.68	10.204
75% N	5.635	7.933	6.784	8.608	10.34	9.476	8.732	10.99	9.861
CD (0.05)	NS	0.78	NS	NS	NS	NS	NS	NS	NS
Rice alone	4.45	5.47	4.96	8.897	7.313	8.105	9.108	6.88	7.994
Interaction effects - NS									

Table 4.1.23. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on potassium uptake (kg ha^{-1}) of dry sown rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Green manure crops									
Horsegram	28.14	104.75	66.45	99.01	163.90	131.50	77.44	178.40	127.90
Cowpea	28.62	107.83	68.23	97.07	187.20	142.10	67.48	193.20	130.30
CD (0.05)	NS	NS	NS	NS	9.86	6.26	NS	NS	*
Methods of incorporation									
Conoweeding	27.56	117.65	72.60	94.82	185.10	139.90	72.61	182.20	127.40
2,4-D spray	29.87	96.89	63.38	104.00	172.50	138.30	66.84	183.60	125.20
Self decomposition	27.72	104.30	66.03	95.28	169.10	132.20	77.93	191.50	134.70
CD (0.05)	NS	9.94	NS	NS	12.08	7.67	NS	NS	*
Levels of nitrogen									
100% N	28.92	105.20	67.07	98.88	179.60	139.20	75.52	177.50	126.50
75% N	27.84	107.40	67.61	97.21	171.50	134.40	69.39	194.10	131.80
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	*
Rice alone	22.63	93.16	57.90	88.27	120.10	104.10	71.68	142.70	107.20
Interaction effects - NS									

*** Pooling not possible as the errors heterogenous and interaction absent**

when rice was grown along with green manure crops. Potassium uptake of pure crop showed an increasing trend as the crop matures.

None of the interaction was found significant on K uptake at various growth stages.

4.1.5.3. Nutrient content of green manure crops

Data on nutrient content of green manure crops grown along with dry sown rice is given in Table 4.1.24.

Nitrogen content of cowpea was significantly higher than that of horse gram. Levels of nitrogen did not influence the nitrogen content of green manure crops

Green manure crops significantly differed in the phosphorus content. Phosphorus content of cowpea was higher, compared to horse gram. Levels of nitrogen had no significant influence on the P content of green manure crops.

There was significant difference in the potassium content between green manure crops. Cowpea recorded significantly higher K content (2.476), compared with horse gram (1.084) as evident from the pooled data. Potassium content of green manure crop was significantly higher with 75 per cent nitrogen compared with 100 per cent nitrogen.

4.1.5.4. Nutrient contribution by green manure crops

Nutrient contribution of green manure crops grown along with dry seeded rice is presented in Table 4.1.25.

Contribution of nitrogen by cowpea (29.72 kg ha^{-1}) was significant and 62 per cent higher compared with horse gram (11.40 kg ha^{-1}). Nitrogen contribution of green manure crops with 100 per cent nitrogen was significantly higher than 75 per cent nitrogen.

Phosphorus contribution of cowpea (4.08 kg ha^{-1}) was significantly superior to that of horse gram. Levels of nitrogen had no significant influence on P addition by green manure crops.

Table 4.1.24. Nutrient content (%) of green manure crops grown along with dry sown rice

Treatments	N content			P content			K content		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Green manure crops									
Horsegram	1.318	1.418	1.368	0.228	0.162	0.195	1.051	1.118	1.084
Cowpea	1.613	2.112	1.862	0.262	0.236	0.249	2.429	2.522	2.476
CD (0.05)	0.061	0.202	0.101	0.014	0.030	0.021	0.115	0.163	0.094
Methods of incorporation									
Conoweeding	1.470	1.783	1.627	0.242	0.188	0.215	1.650	1.810	1.730
2,4-D spray	1.486	1.823	1.654	0.248	0.205	0.226	1.770	1.917	1.843
Self decomposition	1.441	1.689	1.565	0.245	0.203	0.224	1.800	1.733	1.767
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	1.520	1.799	1.660	0.244	0.205	0.225	1.738	1.678	1.708
75% N	1.411	1.731	1.571	0.246	0.192	0.219	1.742	1.962	1.852
CD (0.05)	0.061	NS	NS	NS	NS	NS	NS	0.163	0.094

Table 4.1.25. Nutrient contribution (kg ha^{-1}) of green manure crops grown along with dry sown rice

Treatments	N			P			K		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Green manure crops									
Horsegram	11.17	11.64	11.40	1.94	1.33	1.64	8.92	9.12	9.02
Cowpea	30.55	28.98	29.72	4.93	3.24	4.08	45.89	34.54	40.21
CD (0.05)	2.56	3.02	1.88	0.50	0.44	0.32	4.60	2.32	2.47
Methods of incorporation									
Conoweeding	20.58	20.65	20.61	3.32	2.22	2.77	25.03	21.95	23.49
2,4-D spray	21.41	20.32	20.87	3.52	2.24	2.88	28.97	22.62	25.79
Self decomposition	20.45	19.96	20.20	3.47	2.40	2.94	28.21	20.92	24.57
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	22.16	20.70	21.43	3.54	2.38	2.96	28.57	20.26	24.42
75% N	19.46	19.92	19.69	3.33	2.19	2.76	26.23	23.40	24.81
CD (0.05)	2.56	NS	1.88	NS	NS	NS	NS	2.32	NS

Significant difference was noticed in the potassium contribution of green manure crops. Potassium contribution of cowpea (40.21 kg ha^{-1}) was almost four times to that of horse gram (9.02 kg ha^{-1}). Levels of nitrogen did not influence the K contribution of green manure crops.

4.1.6. Soil Nutrient status

4.1.6.1. Organic Carbon (%)

Organic carbon percentage of soil increased significantly in green manure intercropped rice compared with rice grown alone (Table 4.1.26). Green manure crops behaved similarly in soil organic carbon content. Method of incorporation levels of nitrogen and interactions showed no variation in the soil organic carbon content.

4.1.6.2. Available nitrogen

Soil available nitrogen content showed a significant increase by concurrent growing of green manure crops compared with pure crop of rice (Table 4.1.26). Concurrent growing of cowpea resulted in significantly superior nitrogen content of soil (288.1 kg ha^{-1}) than concurrent growing of horse gram (263.7 kg ha^{-1}). Method of incorporation and levels of nitrogen did not influence the soil available nitrogen content. Interactions had no significant influence on the available nitrogen content of the soil.

4.1.6.3. Available phosphorus

Available soil phosphorus content was not affected by different green manure crops, methods of incorporation and levels of nutrients (Table 4.1.26). Phosphorus content was less in pure crop of rice. There was no significant difference in the available phosphorus content of the soil due to interactions.

4.1.6.3. Available potassium

Potassium content of the soil was significantly higher in green manure intercropped treatments compared with rice grown alone (Table 4.1.26). The highest soil K content was recorded in cowpea intercropped treatments (989.3 kg ha^{-1}) than horse gram intercropped treatment (914.7 kg ha^{-1}). Soil K content was not affected by different

Table 4.1.26. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on soil nutrient status of dry sown rice at harvest

Treatments	Organic carbon (%)			Available nitrogen (kg ha^{-1})			Available phosphorus (kg ha^{-1})			Available potassium (kg ha^{-1})		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Green manure crops												
Horsegram	0.61	0.86	0.74	265.4	262.0	263.7	83.3	52.3	67.8	133.8	914.7	524.2
Cowpea	0.67	0.87	0.77	294.7	281.5	288.1	84.8	52.2	68.5	136.1	989.3	562.7
CD (0.05)	NS	NS	NS	15.5	NS	17.3	NS	NS	NS	NS	57.9	*
Methods of incorporation												
Conoweeding	0.64	0.89	0.77	279.2	269.8	274.5	85.3	54.3	69.8	134.2	952.0	543.1
2,4-D spray	0.63	0.86	0.75	273.1	269.7	271.4	81.6	52.0	66.8	136.5	952.0	544.3
Self decomposition	0.64	0.85	0.75	287.7	275.7	281.8	85.3	50.4	67.9	134.2	952.0	543.1
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*
Levels of nitrogen												
100% N	0.66	0.88	0.77	299.3	280.2	289.7	85.0	53.4	69.2	140.0	970.7	555.3
75% N	0.62	0.86	0.74	260.8	263.4	260.8	83.1	51.1	67.1	129.9	933.3	531.6
CD (0.05)	NS	NS	NS	15.5	NS	NS	NS	NS	NS	NS	NS	*
Rice alone	0.52	0.70	0.61	233.7	221.6	227.7	76.5	43.2	59.8	126.0	858.7	492.3
Interaction effects - NS												

* Pooling not possible as the errors heterogenous and interaction absent

Initial soil test data	0.42	0.69	0.55	235.5	238.3	236.9	52.5	44.6	48.5	112.0	896.0	504.0

method of incorporation and levels of nitrogen. No significant difference was indicated due to various interactions with regard to the available potassium content of the soil.

4.1.7. Nitrogen release pattern

4.1.7.1. Ammoniacal nitrogen release pattern

Ammoniacal nitrogen (NH_4^+-N) release pattern from dry sown rice crop as affected by green manure crop, method of incorporation and levels of nitrogen during the 1st year, 2nd year and pooled data is presented in Table 4.1.27, 4.1.28 and 4.1.29 respectively.

Data on soil NH_4^+-N suggested that decomposition of both the green manure crops was fast and they have rapidly released nitrogen. Concurrent growing of cowpea and horse gram along with rice and its subsequent incorporation resulted in significantly higher NH_4^+-N release than in rice grown alone. Before incorporation of green manure crops, soil ammoniacal nitrogen was significantly higher in pure crop of rice. An increase in soil NH_4^+-N was noticed up to 30 days after incorporation (DAI) followed by a slight decline up to harvest. From 10 DAI onwards the release of NH_4^+-N was significantly higher under cowpea incorporated treatments compared to horse gram incorporated treatments. Soil NH_4^+-N increased from 94.75 kg ha^{-1} to 159.53 kg ha^{-1} up to 30 DAI, there after decreasing to 139.66 kg ha^{-1} up to harvest in cowpea incorporated plots. In horse gram incorporated plots, soil NH_4^+-N increased from 91.47 kg ha^{-1} to 153.25 kg ha^{-1} up to 30 DAI, there after decreased to 132.84 kg ha^{-1} at harvest. Methods of incorporation of green manure crops did not show any difference in the release of NH_4^+-N. Treatments receiving 100 per cent N showed significantly higher release of NH_4^+-N compared to 75 per cent N. There was no significant difference noticed due to interactions with regard to the ammoniacal nitrogen release pattern from dry sown rice crop.

4.1.7.2. Nitrate nitrogen release pattern

Nitrate nitrogen (NO_3^--N) release pattern from dry sown rice crop as affected by green manure crop, method of incorporation and levels of nitrogen during the 1st year, 2nd year and pooled data is presented in Table 4.1.30, 4.1.31 and 4.1.32 respectively.

Table 4.1.27. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on ammoniacal nitrogen release pattern (kg ha^{-1}) in dry sown rice during 1st year

Treatments	BI	5 DAI	10 DAI	15 DAI	20 DAI	25 DAI	30 DAI	45 DAI	Harvest
Green manure crops									
Horsegram	115.44	127.41	130.66	137.75	139.38	144.28	153.00	147.53	142.09
Cowpea	119.78	126.88	134.47	139.94	143.19	146.47	160.06	154.63	146.47
CD (0.05)	2.84	NS	3.81	NS	NS	NS	5.50	3.16	NS
Methods of incorporation									
Conoweeding	119.25	130.66	134.75	139.66	142.91	147.81	156.81	151.91	145.38
2,4-D spray	116.78	127.47	132.31	139.66	142.91	146.19	154.34	149.44	142.91
Self decomposition	116.78	123.31	130.66	137.22	138.03	142.09	158.44	151.91	144.56
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	121.97	128.50	134.47	141.00	143.19	147.53	158.97	153.00	145.38
75% N	113.25	125.78	130.66	136.66	139.38	143.19	154.09	149.19	143.19
CD (0.05)	2.84	NS	3.81	3.72	NS	3.78	NS	NS	NS
Rice alone	127.41	120.88	120.88	130.66	133.94	137.19	143.75	140.47	137.19
Interaction effects - NS									

BI - Before Incorporation DAI - Days After Incorporation

Table 4.1.28. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on ammoniacal nitrogen release pattern (kg ha^{-1}) in dry sown rice during 2nd year

Treatments	BI	5 DAI	10 DAI	15 DAI	20 DAI	25 DAI	30 DAI	45 DAI	Harvest
Green manure crops									
Horsegram	67.50	86.03	97.47	115.44	135.02	144.81	153.53	144.81	123.59
Cowpea	69.69	88.75	103.44	120.31	140.47	148.63	158.97	149.72	132.84
CD (0.05)	NS	NS	4.00	4.30	4.00	NS	4.80	4.00	3.90
Methods of incorporation									
Conoweeding	70.19	88.19	102.09	118.41	137.20	146.19	156.00	146.19	129.03
2,4-D spray	68.59	86.56	98.81	116.78	139.65	148.63	155.16	149.44	128.22
Self decomposition	66.97	87.38	100.44	118.41	136.38	145.38	157.63	146.19	127.41
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	72.97	91.47	105.09	122.50	142.10	150.28	160.63	150.81	133.94
75% N	64.25	83.31	95.81	113.25	133.39	143.19	151.91	143.75	122.50
CD (0.05)	3.69	4.13	4.00	4.30	4.00	4.22	4.80	4.00	3.90
Rice alone	71.88	81.66	91.47	111.06	127.40	137.19	140.47	133.94	114.34
Interaction effects - NS									

BI - Before Incorporation DAI - Days After Incorporation

Table 4.1.29. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on ammoniacal nitrogen release pattern (kg ha^{-1}) in dry sown rice (pooled data)

Treatments	BI	5 DAI	10 DAI	15 DAI	20 DAI	25 DAI	30 DAI	45 DAI	Harvest
Green manure crops									
Horsegram	91.47	106.72	114.06	126.59	137.19	144.56	153.25	146.19	132.84
Cowpea	94.75	107.81	118.97	130.13	141.84	147.53	159.53	152.19	139.66
CD (0.05)	3.04	NS	3.71	3.75	3.84	3.63	4.57	3.38	4.16
Methods of incorporation									
Conoweeding	94.75	109.44	118.41	129.03	140.06	147.00	156.41	149.03	137.19
2,4-D spray	92.69	107.00	115.56	128.22	141.28	147.41	154.75	149.44	135.56
Self decomposition	91.88	105.34	115.56	127.81	137.19	143.75	158.03	149.03	135.97
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	97.47	109.97	119.78	131.75	142.66	148.91	159.78	151.91	139.66
75% N	88.75	104.53	113.25	124.94	136.38	143.19	153.00	146.47	132.84
CD (0.05)	3.04	4.50	3.71	3.75	3.84	3.63	4.57	3.38	4.16
Rice alone	99.38	101.25	106.16	120.84	130.66	137.19	142.09	137.19	125.75
Interaction effects - NS									

BI - Before Incorporation DAI - Days After Incorporation

Table 4.1.30. Effect of concnrrently grown green manure crops, methods of incorporation and levels of nitrogen on nitrate nitrogen release pattern (kg ha^{-1}) in dry sown rice during 1st year

Treatments	BI	5 DAI	10 DAI	15 DAI	20 DAI	25 DAI	30 DAI	45 DAI	Harvest
Green manure crops									
Horsegram	26.31	29.79	33.45	32.58	35.02	38.50	38.85	43.03	42.16
Cowpea	27.35	30.32	33.10	32.93	34.84	38.33	38.50	43.56	42.86
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Methods of incorporation									
Conoweeding	27.18	31.36	33.71	33.19	35.54	38.42	38.94	43.12	43.12
2,4-D spray	27.18	29.53	33.19	32.93	35.02	38.80	38.42	42.86	42.08
Self decomposition	26.13	29.27	32.93	32.14	34.24	38.16	38.68	43.90	42.34
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	27.88	31.19	34.50	33.45	36.24	39.37	39.90	44.25	43.38
75% N	25.79	28.92	32.06	32.06	33.63	37.46	37.46	42.34	41.64
CD (0.05)	NS	1.91	1.70	NS	1.32	1.08	1.19	1.21	1.19
Rice alone	30.32	33.45	35.54	36.59	37.63	35.54	36.59	41.81	41.81
Interaction effects - NS									

BI - Before Incorporation DAI - Days After Incorporation

Table 4.1.31. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on nitrate nitrogen release pattern (kg ha^{-1}) in dry sown rice during 2nd year

Treatments	BI	5 DAI	10 DAI	15 DAI	20 DAI	25 DAI	30 DAI	45 DAI	Harvest
Green manure crops									
Horsegram	16.03	19.69	22.13	24.57	29.44	33.45	35.54	35.72	40.07
Cowpea	17.25	20.38	22.82	25.09	29.97	34.67	35.54	36.41	41.47
CD (0.05)	NS	NS	NS	NS	NS	1.16	NS	NS	1.33
Methods of incorporation									
Conoweeding	16.46	20.12	22.21	25.09	29.73	33.97	35.8	35.8	40.77
2,4-D spray	16.73	20.12	22.48	24.3	30.05	33.97	35.54	36.59	40.51
Self decomposition	16.73	19.86	22.74	25.09	29.27	34.24	35.28	35.8	41.03
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	17.6	21.26	23.52	25.79	30.84	35.37	36.59	37.63	42.51
75% N	15.68	18.82	21.43	23.87	28.57	32.75	34.5	34.5	39.03
CD (0.05)	NS	2.13	1.22	1.16	1.5	1.16	1.29	0.96	1.33
Rice alone	19.86	23	23	24.04	27.18	31.36	32.41	31.36	35.54
Interaction effects - NS									

BI - Before Incorporation DAI - Days After Incorporation

Table 4.1.32. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on nitrate nitrogen release pattern (kg ha^{-1}) in dry sown rice (pooled data)

Treatments	BI	5 DAI	10 DAI	15 DAI	20 DAI	25 DAI	30 DAI	45 DAI	Harvest
Green manure crops									
Horsegram	21.17	24.74	27.79	28.57	32.23	36.00	37.20	39.37	41.12
Cowpea	22.30	25.35	27.96	29.01	32.41	36.50	37.02	39.98	42.16
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	1.30
Methods of incorporation									
Conoweeding	21.82	25.74	27.96	29.14	32.67	36.20	37.37	39.46	41.94
2,4-D spray	21.95	24.83	27.83	28.62	32.54	36.33	36.98	39.72	41.29
Self decomposition	21.43	24.57	27.83	28.62	31.75	36.20	36.98	39.85	41.68
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	22.74	26.22	29.01	29.62	33.54	37.37	38.24	40.94	42.95
75% N	20.73	23.87	26.74	27.96	31.10	35.11	35.98	38.42	40.33
CD (0.05)	1.88	1.79	1.38	1.31	1.38	1.09	1.19	1.09	1.30
Rice alone	25.08	28.22	29.27	30.32	32.41	33.45	34.49	36.59	38.68
Interaction effects - NS									

BI - Before Incorporation DAI - Days After Incorporation

The release of NO_3^--N was less compared to NH_4^+-N. But an increasing trend was noticed in the release of NO_3^--N up to harvest. In the initial period i.e., up to 20 DAI the release of NO_3^--N from green manure incorporated plots were less compared to pure crop of rice. After 20 days of incorporation, an increase in the release of NO_3^--N was observed from green manure incorporated plots compared to pure crop. The NO_3^--N release pattern of horse gram and cowpea showed a similar trend. In cowpea incorporated plots, soil NO_3^--N increased from 22.3 kg ha^{-1} to 42.16 kg ha^{-1} at harvest. In horse gram incorporated plots the increase in soil NO_3^--N was from 21.17 kg ha^{-1} to 41.12 kg ha^{-1} at harvest. The NO_3^--N release pattern from pure crop of rice was from 25.08 kg ha^{-1} to 38.68 kg ha^{-1}. Methods of incorporation of green manure crops did not significantly influence the release of NO_3^--N. Release of NO_3^--N was significantly higher in treatments receiving 100 per cent N compared with 75 per cent N. No significant difference was noticed due to interactions with regard to the nitrate nitrogen (NO_3^--N) release pattern in dry sown rice crop.

4.1.8. Economics

4.1.8.1. Gross Return

Concurrent growing of cowpea with rice recorded the highest gross return (Rs. 37307 ha^{-1}) compared with concurrent growing of horse gram (Table. 4.1.33). Gross return of pure crop of rice (Rs.27533 ha^{-1}) was significantly less compared with green manure intercropped rice. Gross return of rice was not affected by the methods of incorporation and levels of nitrogen. Interactions had no significant influence on the gross return.

4.1.8.2. Net Return

Concurrent growing of green manure crops significantly increased the net return from rice (Table. 4.1.33). Net return was found to be the highest when cowpea was intercropped with rice (Rs.19132 ha^{-1}) compared to concurrent growing of horse gram. Pure crop of rice recorded the least net return (Rs.4737 ha^{-1}). Methods of incorporation of green manure crops, levels of nitrogen and interactions did not affect the net return.

Table 4.1.33. Effect of concurrently grown green manure crops, methods of incorporation and levels of nitrogen on the economics of dry sown rice

Treatments	Gross Return			Net Return			BC ratio		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Green manure crops									
Horsegram	28473	28960	28716	11748	12234	11991	1.70	1.73	1.72
Cowpea	35189	39430	37307	17014	21251	19132	1.94	2.17	2.05
CD (0.05)	2059	201	1980	2059	201	1980	0.12	0.12	0.12
Methods of incorporation									
Conoweeding	32827	34462	33644	15230	16865	16048	1.85	1.95	1.91
2,4-D spray	31206	34254	32730	14249	17297	15773	1.83	2.01	1.93
Self decomposition	31460	33863	32661	13663	16066	14865	1.76	1.89	1.83
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	32057	34792	33424	14484	17219	15851	1.82	1.97	1.90
75% N	31605	33593	32599	14278	16267	15273	1.82	1.93	1.88
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	27700	27365	27533	4905	4570	4737	1.22	1.20	1.21
Interaction effects - NS									

4.1.8.3. Benefit: Cost Ratio

Benefit: cost ratio of rice with concurrent growing of green manure crops was significantly higher than rice grown alone. The highest B: C ratio (2.05) recorded in cowpea intercropped treatments (Table. 4.1.33). Methods of incorporation of green manure crops and levels of nitrogen had no influence on the B: C ratio. Benefit: cost ratio was not affected by any of the interactions.

4.2. RESIDUAL EFFECT OF CONCURRENT GROWING OF GREEN MANURE CROPS IN THE SUCCEEDING TRANSPLANTED RICE

4.2.1. Growth characters of succeeding rice crop

4.2.1.1. Height of plants

Concurrent growing of green manure crops in the preceding dry seeded rice crop had no significant influence on the height of succeeding crop of rice at different growth stages (Table 4.2.1). Application of nitrogen at different levels to the succeeding crop significantly influenced the height at active tillering and panicle initiation stages. Nitrogen at 100 per cent recorded increased height compared with 75 per cent N. Interaction effects failed to show any significance on height of succeeding rice crop.

4.2.1.2. Number of tillers hill^{-1}

Concurrent growing of different green manure crops, their methods of incorporation and levels of nitrogen in the dry seeded crop significantly influenced the number of tillers hill^{-1} of succeeding rice only at active tillering stage (Table 4.2.2). Concurrent growing of cowpea along with dry seeded rice significantly increased the tiller production of succeeding crop compared to pure crop of rice in the previous season. Nitrogen applied to the succeeding crop showed no significant influence on the number of tillers hill^{-1}. Interaction effects had no significant influence on this character at different growth stages.

4.2.1.3. Number of tillers m^{-2}

Tiller production m^{-2} of succeeding crop was found to be significantly influenced only at active tillering stage by the treatments imposed on the previous dry sown crop

Table 4.2.1. Residual effect of concurrent growing of green manure crops in dry seeded rice on height(cm) of succeeding transplanted rice at different growth stages

Treatments		Active Tillering			Panicle Initiation			Harvest		
		1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot										
T_1	HG+Cono+100%N	42.9	40.0	41.5	53.7	46.2	49.9	73.8	52.5	63.1
T_2	HG+Cono+75%N	43.6	42.3	42.9	54.8	46.8	50.8	77.3	57.0	67.1
T_3	HG+2,4-D+100%N	43.8	46.5	45.2	54.3	53.0	53.7	74.6	57.3	66.0
T_4	HG+2,4-D+75%N	44.2	43.3	43.8	53.4	45.3	49.3	75.0	56.7	65.8
T_5	HG+Self+100%N	44.3	42.4	43.3	53.8	47.9	50.9	74.4	55.7	65.0
T_6	HG+Self+75%N	43.6	42.9	43.3	53.7	45.3	49.5	73.6	53.7	63.6
T_7	CP+Cono+100%N	45.6	41.9	43.7	54.3	43.2	48.8	74.1	52.7	63.4
T_8	CP+Cono+75%N	46.8	46.2	46.5	56.0	49.7	52.8	73.7	51.5	62.6
T_9	CP+2,4-D+100%N	45.7	41.1	43.4	56.9	45.4	51.1	75.8	53.0	64.4
T_{10}	CP+2,4-D+75%N	47.1	46.0	46.5	54.9	47.7	51.3	74.2	54.7	64.4
T_{11}	CP+Self+100%N	46.0	39.8	42.9	57.2	44.7	50.9	74.8	54.2	64.5
T_{12}	CP+Self+75%N	44.7	42.8	43.8	55.5	47.3	51.4	76.6	55.8	66.2
T_{13}	Rice alone+ 100%N	41.4	40.8	41.1	52.1	45.3	48.7	69.9	57.2	63.5
	CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub plot										
S_1	100%N	44.9	43.5	44.2	55.1	47.5	51.3	75.2	55.4	65.3
S_2	75% N	44.3	42.0	43.2	54.3	45.9	50.1	73.7	54.2	63.9
	CD (0.05)	NS	1.2	0.8	NS	1.3	1.0	NS	NS	NS
Interaction effects - NS										

Table 4.2.2. Residual effect of concurrent growing of green manure crops in dry seeded rice on number of tillers hill^{-1} of succeeding transplanted rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot									
T_1 HG+Cono+100%N	6.1	7.0	6.5	7.6	4.3	6.0	7.0	6.2	6.6
T_2 HG+Cono+75%N	5.8	5.5	5.6	6.7	4.0	5.3	7.7	6.2	6.9
T_3 HG+2,4-D+100%N	5.3	7.8	6.5	6.6	5.2	5.9	7.2	6.3	6.8
T_4 HG+2,4-D+75%N	5.3	6.8	6.1	6.8	4.0	5.4	7.5	6.5	7.0
T_5 HG+Self+100%N	6.8	7.5	7.2	7.4	5.3	6.3	7.2	5.7	6.4
T_6 HG+Self+75%N	6.3	6.9	6.6	7.2	3.8	5.5	7.0	5.5	6.3
T_7 CP+Cono+100%N	6.8	6.8	6.8	8.7	4.7	6.7	8.0	5.8	6.9
T_8 CP+Cono+75%N	6.3	7.3	6.8	8.4	5.1	6.8	7.2	6.0	6.6
T_9 CP+2,4-D+100%N	6.7	6.5	6.6	9.0	5.1	7.0	7.5	5.3	6.4
T_{10} CP+2,4-D+75%N	8.1	6.8	7.5	9.0	4.8	6.9	7.3	5.7	6.5
T_{11} CP+Self+100%N	6.3	7.4	6.9	8.1	4.8	6.5	7.8	6.2	7.0
T_{12} CP+Self+75%N	6.5	7.3	6.9	8.5	4.1	6.3	7.2	6.3	6.8
T_{13} Rice alone+ 100%N	4.5	6.5	5.5	5.8	3.9	4.8	5.8	7.0	6.4
CD (0.05)	1.1	NS	1.1	0.9	NS	NS	NS	NS	NS
Sub plot									
S_1 100%N	6.4	7.0	6.7	7.9	4.8	6.4	7.4	6.1	6.8
S_2 75% N	6.0	6.9	6.5	7.4	5.8	6.6	7.1	6.0	6.5
CD (0.05)	NS	NS	NS	0.3	NS	NS	NS	NS	NS
Interaction effects - NS									

(Table 4.2.3). Different treatments had no significant influence on the number of tillers m^{-2} at later growth stages. The tiller production of succeeding crop, where pure crop of rice was grown in the previous season, was significantly less. Application of different levels of nitrogen to the succeeding crop had no significant influence on its tiller production m^{-2}. Interaction effects did not significantly influence the number of tillers m^{-2} at different growth stages.

4.2.1.4. Number of leaves hill^{-1}

Pooled data showed that residual effect of different green manure crops, methods of incorporation and levels of nitrogen had significant influence on the number of leaves hill^{-1} at active tillering and panicle initiation stages (Table 4.2.4). At active tillering and panicle initiation stages, number of leaves hill^{-1} of succeeding crop was the least when it was preceded by a pure crop of rice. At harvest stage production of leaves was on par among different treatments. Leaf production of succeeding rice crop at panicle initiation and harvest stage was significantly higher in 100 per cent N compared with 75 per cent N. None of the interaction had significant influence on the leaf production of rice at different growth stages.

4.2.1.5. Leaf area hill^{-1}

Leaf area of succeeding rice crop, at active tillering and panicle initiation stages, was significantly less when preceded by a pure crop of rice compared with green manure intercropped rice in the 1st crop season (Table 4.2.5). The leaf area of succeeding crop of rice at harvest stage was not significantly affected. Levels of nitrogen had significant influence on the leaf area of rice at different growth stages. Leaf area of succeeding crop receiving 100 per cent N was significantly higher than 75 per cent N. Interaction effects did not significantly influence the leaf area at different growth stages.

4.2.1.6. Leaf area index

Concurrent growing of green manure crops along with rice, during the 1st crop season resulted in the highest leaf area index in the succeeding crop of rice at active tillering and panicle initiation stages (Table 4.2.6). Leaf area index at harvest stage was not significantly influenced by the various treatments applied to the preceding crop. At

Table 4.2.3. Residual effect of concurrent growing of green manure crops in dry seeded rice on number of tillers m^{-2} of succeeding transplanted rice at different growth stages

Treatments		Active Tillering			Panicle Initiation			Harvest		
		1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot										
T_1	HG+Cono+100%N	405.5	466.6	436.1	505.5	288.9	397.1	466.6	411.1	438.8
T_2	HG+Cono+75%N	383.3	366.6	375.0	444.4	266.6	355.5	511.1	411.1	461.1
T_3	HG+2,4-D+100%N	350.0	516.6	433.3	438.9	344.4	391.6	477.7	422.2	450.0
T_4	HG+2,4-D+75%N	355.5	455.5	405.5	455.5	266.6	361.1	500.0	433.3	466.6
T_5	HG+Self+100%N	455.5	500.0	477.7	494.4	345.0	422.2	477.7	377.7	427.7
T_6	HG+Self+75%N	422.2	461.1	441.6	477.7	250.0	363.9	466.6	366.6	416.6
T_7	CP+Cono+100%N	455.5	455.5	455.5	577.7	311.1	444.4	533.3	388.9	461.1
T_8	CP+Cono+75%N	422.2	488.8	455.5	561.1	338.9	450.0	477.7	400.0	438.8
T_9	CP+2,4-D+100%N	444.4	433.3	438.9	599.9	338.9	469.4	500.0	355.5	427.7
T_{10}	CP+2,4-D+75%N	538.8	455.5	497.2	599.9	322.2	461.1	488.8	377.7	433.3
T_{11}	CP+Self+100%N	422.1	494.4	458.3	538.8	322.2	430.5	522.2	411.1	466.6
T_{12}	CP+Self+75%N	433.3	488.8	461.1	566.6	272.2	419.4	477.7	422.2	450.0
T_{13}	Rice alone+ 100%N	296.7	433.3	365.0	383.3	261.1	322.2	388.9	466.6	427.7
CD (0.05)		73.5	NS	76.2	60.7	NS	NS	NS	NS	NS
Sub plot										
S_1	100%N	426.5	466.6	446.5	527.3	321.3	424.3	495.7	408.5	452.1
S_2	75% N	402.0	458.9	430.5	494.8	386.3	440.6	471.8	398.3	435.0
CD (0.05)		NS	NS	NS	17.0	NS	NS	NS	NS	NS
Interaction effects - NS										

Table 4.2.4. Residual effect of concurrent growing of green manure crops in dry seeded rice on number of leaves hill^{-1} of succeeding transplanted rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot									
T_1 HG+Cono+100%N	22.7	30.3	26.5	24.5	21.1	22.8	25.0	31.5	28.3
T_2 HG+Cono+75%N	22.9	25.4	24.2	25.6	23.8	24.7	24.5	30.5	27.5
T_3 HG+2,4-D+100%N	23.3	27.5	25.4	24.2	23.2	23.7	25.2	31.2	28.2
T_4 HG+2,4-D+75%N	21.7	27.3	24.5	24.8	20.3	22.5	25.0	32.5	28.8
T_5 HG+Self+100%N	26.0	27.6	26.8	26.1	25.6	25.8	25.3	31.2	28.3
T_6 HG+Self+75%N	24.0	26.6	25.3	24.6	23.3	24.0	24.2	26.7	25.4
T_7 CP+Cono+100%N	24.9	30.3	27.6	28.8	25.6	27.2	26.7	30.5	28.6
T_8 CP+Cono+75%N	24.3	27.8	26.0	28.5	27.1	27.8	26.2	36.0	31.1
T_9 CP+2,4-D+100%N	27.0	26.3	26.6	31.6	25.0	28.3	25.8	28.5	27.2
T_{10} CP+2,4-D+75%N	26.9	27.9	27.4	30.4	25.3	27.9	24.7	28.0	26.3
T_{11} CP+Self+100%N	25.1	29.2	27.1	29.3	24.4	26.8	27.2	34.3	30.8
T_{12} CP+Self+75%N	26.9	30.3	28.6	27.8	21.8	24.8	25.5	29.2	27.3
T_{13} Rice alone+ 100%N	20.5	27.5	24.0	23.6	22.1	22.8	22.8	36.0	29.4
CD (0.05)	3.1	NS	2.8	3.6	NS	3.3	NS	NS	NS
Sub plot									
S_1 100%N	24.6	28.4	26.5	27.3	25.0	26.2	25.4	32.9	29.2
S_2 75% N	24.1	27.6	25.9	26.5	22.4	24.5	25.0	29.5	27.3
CD (0.05)	NS	NS	NS	0.7	0.9	0.6	NS	3.4	1.8
Interaction effects - NS									

Table 4.2.5. Residual effect of concurrent growing of green manure crops in dry seeded rice on leaf area hill^{-1} (cm^2) of succeeding transplanted rice at different growth stages

Treatments		Active Tillering			Panicle Initiation			Harvest		
		1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot										
T_1	HG+Cono+100%N	412.8	625.9	519.3	717.6	299.6	508.6	482.1	264.7	373.4
T_2	HG+Cono+75%N	417.1	538.7	477.9	829.5	355.8	592.6	477.5	288.1	382.8
T_3	HG+2,4-D+100%N	391.1	684.6	537.9	736.9	520.2	628.5	427.6	303.0	365.3
T_4	HG+2,4-D+75%N	415.3	571.4	493.3	703.2	305.7	504.4	418.3	307.3	362.8
T_5	HG+Self+100%N	451.4	581.6	516.5	773.2	425.0	599.1	414.4	282.1	348.2
T_6	HG+Self+75%N	414.9	552.3	483.6	681.1	347.6	514.3	403.2	228.5	315.9
T_7	CP+Cono+100%N	517.1	619.4	568.3	933.4	408.9	671.2	478.8	278.9	378.8
T_8	CP+Cono+75%N	460.1	698.9	579.5	870.9	500.1	685.5	493.3	282.2	387.8
T_9	CP+2,4-D+100%N	482.8	550.9	516.8	1032.2	354.6	693.4	463.7	261.3	362.5
T_{10}	CP+2,4-D+75%N	545.1	745.5	645.3	957.2	424.5	690.7	450.1	280.9	365.5
T_{11}	CP+Self+100%N	500.3	588.8	544.6	903.5	327.5	615.5	584.6	272.0	428.3
T_{12}	CP+Self+75%N	524.2	656.2	590.2	818.0	322.5	570.2	483.6	250.4	367.0
T_{13}	Rice alone+ 100%N	302.5	599.3	450.9	581.3	299.5	440.4	322.3	306.9	314.6
	CD (0.05)	125.9	NS	106.2	181.2	NS	118.1	NS	NS	NS
Sub plot										
S_1	100%N	454.0	644.0	549.0	832.7	363.5	613.1	468.3	297.9	383.1
S_2	75% N	443.6	588.8	516.2	788.5	359.0	573.8	439.3	256.9	348.1
	CD (0.05)	NS	41.1	30.4	46.0	NS	29.0	NS	NS	33.6
Interaction effects - NS										

Table 4.2.6. Residual effect of concurrent growing of green manure crops in dry seeded rice on leaf area index of succeeding transplanted rice at different growth stages

Treatments		Active Tillering			Panicle Initiation			Harvest		
		1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot										
T_1	HG+Cono+100%N	2.75	2.09	2.42	4.79	1.00	2.89	3.22	0.88	2.05
T_2	HG+Cono+75%N	2.78	1.80	2.29	5.53	1.19	3.36	3.19	0.96	2.07
T_3	HG+2,4-D+100%N	2.61	2.28	2.45	4.91	1.73	3.32	2.85	1.01	1.93
T_4	HG+2,4-D+75%N	2.77	1.91	2.34	4.69	1.02	2.85	2.79	1.03	1.91
T_5	HG+Self+100%N	3.01	1.94	2.48	5.16	1.42	3.29	2.76	0.94	1.85
T_6	HG+Self+75%N	2.77	1.84	2.30	4.54	1.16	2.85	2.69	0.76	1.73
T_7	CP+Cono+100%N	3.45	2.07	2.76	6.22	1.36	3.79	3.19	0.93	2.06
T_8	CP+Cono+75%N	3.07	2.33	2.70	5.81	1.67	3.74	3.29	0.94	2.12
T_9	CP+2,4-D+100%N	3.22	1.84	2.53	6.88	1.18	4.03	3.09	0.87	1.98
T_{10}	CP+2,4-D+75%N	3.64	2.49	3.06	6.38	1.42	3.90	3.00	0.94	1.97
T_{11}	CP+Self+100%N	3.34	1.96	2.65	6.02	1.09	3.56	3.90	0.91	2.40
T_{12}	CP+Self+75%N	3.50	2.19	2.84	5.45	1.08	3.26	3.22	0.84	2.03
T_{13}	Rice alone+ 100%N	2.02	2.00	2.01	3.88	1.00	2.44	2.15	1.02	1.58
	CD (0.05)	0.84	NS	0.50	1.21	NS	0.64	NS	NS	NS
Sub plot										
S_1	100%N	3.03	2.15	2.59	5.55	1.31	3.43	3.12	0.99	2.06
S_2	75% N	2.96	1.96	2.46	5.26	1.20	3.23	2.93	0.86	1.89
	CD (0.05)	NS	0.14	NS	0.31	NS	0.16	NS	NS	0.18
Interaction effects - NS										

panicle initiation and harvest stages the leaf area index of succeeding crop of rice was significantly higher with 100 per cent N. Interaction effects showed no significant influence on leaf area index of succeeding crop.

4.2.1.7. Dry matter production

Treatments applied to the previous dry sown crop had significant influence on the dry matter production of succeeding crop of rice at active tillering stage (Table 4.2.7). At active tillering stage, dry matter production of succeeding rice crop was significantly higher in treatments with concurrent growing of green manure crops during the previous season compared with pure crop of rice. But in the later growth stages the dry matter production was not affected by the preceding crop. The dry matter production of succeeding rice crop at all the growth stages were significantly higher in 100 per cent N compared with lower dose of N. Interactions had no significant influence on the dry matter production of succeeding rice crop at different growth stages.

4.2.2. Yield and yield attributes of succeeding rice crop

4.2.2.1. Yield attributes

Various yield attributes of succeeding crop of rice *viz*., panicles m^{-2}, panicles $hill^{-1}$, panicle weight, number of filled grains $panicle^{-1}$, percentage of filled grain and 1000 grain weight were not significantly affected by the previous season's treatments (Tables 4.2.8 and 4.2.9). No significant difference was noticed among the levels of N and interaction effects of treatments in respect of the above yield attributes. However these yield parameters were numerically higher in treatments where green manure crops were intercropped with rice during preceding dry seeded rice.

4.2.2.2. Grain yield

Grain yield of succeeding crop of rice crop was affected by various treatments given to the previous dry sown crop (Table 4.2.10). The highest grain yield (5093 kg ha^{-1}) was recorded by the treatment, succeeding concurrent growing of cowpea with 100 per cent N during the 1st crop compared with rice grown alone during the previous season. Grain yield of succeeding crop receiving 100 per cent N was significantly

Table 4.2.7. Residual effect of concurrent growing of green manure crops in dry seeded rice on dry matter production (kg ha^{-1}) of succeeding transplanted rice at different growth stages

Treatments		Active Tillering			Panicle Initiation			Harvest		
		1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot										
T_1	HG+Cono+100%N	2811	6540	4676	3235	7191	5213	5289	8410	6849
T_2	HG+Cono+75%N	2956	6675	4816	3753	7152	5453	6133	8910	7522
T_3	HG+2,4-D+100%N	2784	6555	4650	3733	7392	5562	5733	8599	7166
T_4	HG+2,4-D+75%N	2904	6554	4729	3331	7207	5269	6400	8843	7622
T_5	HG+Self+100%N	2818	6529	4673	3577	7582	5579	6355	8139	7247
T_6	HG+Self+75%N	2698	6514	4606	3352	7321	5337	5833	8297	7065
T_7	CP+Cono+100%N	2972	6703	4837	3309	6911	5110	4778	8800	6789
T_8	CP+Cono+75%N	3028	6728	4878	3291	6909	5100	5289	8864	7077
T_9	CP+2,4-D+100%N	2825	6586	4705	3123	7497	5310	4978	8313	6645
T_{10}	CP+2,4-D+75%N	3561	6747	5154	3867	7442	5655	5311	8264	6788
T_{11}	CP+Self+100%N	3639	6862	5251	3652	7535	5594	6011	8665	7338
T_{12}	CP+Self+75%N	3153	6551	4852	3439	7275	5357	5544	8814	7179
T_{13}	Rice alone+ 100%N	2709	6371	4540	2818	7968	5393	5489	8200	6844
	CD (0.05)	NS	NS	436	NS	NS	NS	NS	NS	NS
Sub plot										
S_1	100%N	2945	6696	4820	3746	7384	5565	5661	8762	7212
S_2	75% N	3033	6522	4778	3097	7290	5194	5591	8333	6962
	CD (0.05)	NS	114	NS	464	NS	282	NS	435	NS
Interaction effects - NS										

Table 4.2.8. Residual effect of concurrent growing of green manure crops in dry seeded rice on yield attributes of residual crop of succeeding transplanted rice

Treatments	Panicle m^{-2}			Panicle $hill^{-1}$			Panicle weight (g)		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot									
T_1 HG+Cono+100%N	340.0	264.7	302.3	6.50	6.67	6.58	0.01	6.65	3.33
T_2 HG+Cono+75%N	343.3	216.0	279.7	7.00	6.67	6.83	0.01	7.60	3.80
T_3 HG+2,4-D+100%N	354.0	229.3	291.7	7.00	6.67	6.83	0.01	7.45	3.73
T_4 HG+2,4-D+75%N	339.3	207.3	273.3	6.83	6.50	6.67	0.01	7.03	3.52
T_5 HG+Self+100%N	340.0	210.0	275.0	7.00	6.83	6.92	0.01	7.06	3.53
T_6 HG+Self+75%N	338.0	215.3	276.7	6.83	6.00	6.42	0.01	6.44	3.22
T_7 CP+Cono+100%N	381.3	194.7	288.0	7.00	6.17	6.58	0.01	6.39	3.20
T_8 CP+Cono+75%N	343.3	186.0	264.7	6.83	6.33	6.58	0.01	5.51	2.76
T_9 CP+2,4-D+100%N	325.3	207.3	266.3	7.00	6.00	6.50	0.01	7.02	3.51
T_{10} CP+2,4-D+75%N	342.0	208.7	275.3	6.17	5.33	5.75	0.01	6.56	3.29
T_{11} CP+Self+100%N	338.7	213.3	276.0	7.17	6.67	6.92	0.01	7.19	3.60
T_{12} CP+Self+75%N	337.3	219.3	278.3	6.50	6.17	6.33	0.01	7.62	3.81
T_{13} Rice alone+ 100%N	305.3	188.0	246.7	5.83	5.83	5.83	0.01	6.01	3.01
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub plot									
S_1 100%N	346.7	210.1	278.4	6.95	6.51	6.73	0.01	6.98	3.49
S_2 75% N	334.6	214.6	274.6	6.54	6.08	6.31	0.01	6.64	3.33
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction effects - NS									

Table 4.2.9. Residual effect of concurrent growing of green manure crops in dry seeded rice on yield attributes of succeeding transplanted rice

Treatments		Filled grains panicle^{-1}			Filled grain %			1000 grain weight (g)		
		1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot										
T_1	HG+Cono+100%N	52.67	30.00	41.33	77.69	71.31	74.50	23.43	24.63	24.03
T_2	HG+Cono+75%N	54.17	31.42	42.79	79.23	73.74	76.48	24.05	24.53	24.29
T_3	HG+2,4-D+100%N	56.00	32.67	44.33	80.84	72.76	76.80	23.68	25.25	24.47
T_4	HG+2,4-D+75%N	59.50	30.17	44.83	82.29	68.40	75.34	25.13	24.80	24.97
T_5	HG+Self+100%N	52.83	30.67	41.75	78.94	70.96	74.95	24.92	25.75	25.33
T_6	HG+Self+75%N	56.67	30.83	43.75	78.20	70.63	74.41	23.93	26.13	25.03
T_7	CP+Cono+100%N	58.17	29.42	43.79	86.74	70.41	78.58	24.28	23.97	24.13
T_8	CP+Cono+75%N	49.33	30.92	40.13	77.94	73.07	75.51	24.13	24.33	24.23
T_9	CP+2,4-D+100%N	58.00	29.33	43.67	78.17	71.46	74.81	24.85	24.77	24.81
T_{10}	CP+2,4-D+75%N	56.67	28.50	42.58	79.94	69.89	74.92	24.02	24.87	24.44
T_{11}	CP+Self+100%N	62.67	31.17	46.92	79.20	70.78	74.99	25.25	25.40	25.33
T_{12}	CP+Self+75%N	53.83	31.50	42.67	79.85	71.74	75.79	24.37	25.72	25.04
T_{13}	Rice alone+ 100%N	40.83	26.00	33.42	70.65	65.55	68.10	22.15	23.88	23.02
	CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub plot										
S_1	100%N	56.18	30.23	43.21	79.22	70.61	74.92	24.46	25.13	24.79
S_2	75% N	53.26	30.17	41.71	79.19	71.04	75.11	23.88	24.72	24.30
	CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction effects - NS										

Table 4.2.10. Residual effect of concurrent growing of green manure crops in dry seeded rice on grain yield, straw yield and harvest index of succeeding transplanted rice

Treatments	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Harvest Index		
	1^{st} year	2^{nd} year	Pooled	1^{st} year	2^{nd} year	Pooled	1^{st} year	2^{nd} year	Pooled
Main plot									
T_1 HG+Cono+100%N	4970	3186	4078	3730	1994	2862	0.58	0.61	0.59
T_2 HG+Cono+75%N	5343	3436	4390	3749	2196	2973	0.59	0.61	0.60
T_3 HG+2,4-D+100%N	5320	3462	4391	3720	2153	2936	0.59	0.62	0.60
T_4 HG+2,4-D+75%N	5273	3411	4342	3532	2164	2848	0.60	0.61	0.60
T_5 HG+Self+100%N	5297	3436	4367	3749	2068	2909	0.59	0.62	0.60
T_6 HG+Self+75%N	5157	3286	4221	3197	2132	2664	0.62	0.61	0.61
T_7 CP+Cono+100%N	5997	4189	5093	3828	2100	2964	0.61	0.66	0.64
T_8 CP+Cono+75%N	5250	3386	4318	3542	2206	2874	0.60	0.61	0.60
T_9 CP+2,4-D+100%N	5390	3487	4438	3621	2100	2861	0.60	0.62	0.61
T_{10} CP+2,4-D+75%N	5413	3512	4463	3739	2090	2915	0.59	0.63	0.61
T_{11} CP+Self+100%N	5623	3788	4705	3937	2015	2976	0.59	0.65	0.62
T_{12} CP+Self+75%N	5273	3411	4342	3730	2270	3000	0.59	0.60	0.59
T_{13} Rice alone+ 100%N	4947	3035	3991	4085	2143	3114	0.55	0.58	0.57
CD (0.05)	NS	NS	443	NS	NS	NS	0.03	NS	0.03
Sub plot									
S_1 100%N	5406	3570	4488	3834	2136	2985	0.59	0.62	0.61
S_2 75% N	5248	3357	4303	3575	2115	2845	0.60	0.61	0.60
CD (0.05)	NS	191	132	229	NS	117	NS	NS	NS
Interaction effects - NS									

higher than that of 75 per cent N. Interaction effects failed to show any significance on the grain yield.

4.2.2.3. Straw yield

Straw yield of succeeding crop of rice was not affected by various treatments given to the previous dry sown crop (Table 4.2.10). Succeeding crop receiving 100 per cent N recorded significantly higher straw yield than that of 75 per cent N. Interaction effects did not show any significance on the straw yield of succeeding rice crop.

4.2.2.3. Harvest Index

Various treatments given to the previous dry sown crop significantly influenced the harvest index of succeeding crop (Table 4.2.10). The value of harvest index was less where the preceding crop was pure crop of rice. All the treatments with concurrent growing of green manure crops recorded significantly higher harvest index. The highest value of harvest index (0.64) was noticed when concurrently grown cowpea was incorporated using conoweeder and receiving 100 per cent nitrogen during the previous season. Levels of N applied to succeeding crop and interaction effects failed to influence the harvest index.

4.2.3. Nutrient content and nutrient uptake

4.2.3.1. Nutrient content

4. 2.3.1.1. Nitrogen content

Nitrogen contents of succeeding crop at active tillering was significantly higher, when the previous rice crop was grown along with green manure crops compared to rice grown alone (Table 4.2.11). The highest nitrogen content (1.427) was noticed when concurrently grown cowpea was incorporated with conoweeder and receiving 100 per cent nitrogen during the previous season. Nitrogen content at panicle initiation and harvest stages was not found significantly different. Nitrogen content showed a declining trend as the plant matures. Nitrogen content at all the growth stages was significantly higher with 100 per cent N was applied to succeeding crop. Interaction effects did not influence the N content of succeeding crop of dry sown rice.

Table 4.2.11. Residual effect of concurrent growing of green manure crops in dry seeded rice on nitrogen content (%) of succeeding transplanted rice at different growth stages

Treatments		Active Tillering			Panicle Initiation			Harvest		
		1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot										
T_1	HG+Cono+100%N	1.272	0.767	1.019	1.205	0.898	1.052	0.430	0.293	0.362
T_2	HG+Cono+75%N	1.225	0.802	1.013	1.293	0.890	1.092	0.390	0.315	0.352
T_3	HG+2,4-D+100%N	1.077	0.873	0.975	1.137	0.980	1.058	0.430	0.285	0.357
T_4	HG+2,4-D+75%N	1.382	0.822	1.102	1.285	0.980	1.132	0.390	0.218	0.304
T_5	HG+Self+100%N	1.107	0.853	0.980	1.175	1.038	1.107	0.360	0.310	0.335
T_6	HG+Self+75%N	1.195	0.873	1.034	1.243	0.950	0.097	0.370	0.333	0.352
T_7	CP+Cono+100%N	1.658	1.197	1.427	1.215	1.000	1.107	0.400	0.315	0.357
T_8	CP+Cono+75%N	1.518	1.008	1.263	1.282	1.010	1.146	0.510	0.333	0.422
T_9	CP+2,4-D+100%N	1.490	0.922	1.206	1.362	1.000	1.181	0.597	0.287	0.442
T_{10}	CP+2,4-D+75%N	1.177	0.803	0.990	1.253	0.913	1.083	0.440	0.293	0.367
T_{11}	CP+Self+100%N	1.763	0.942	1.352	1.313	1.088	1.201	0.567	0.363	0.465
T_{12}	CP+Self+75%N	1.645	0.900	1.272	1.225	0.920	1.072	0.635	0.267	0.451
T_{13}	Rice alone+ 100%N	0.990	0.735	0.862	1.263	1.010	1.137	0.605	0.320	0.462
	CD (0.05)	0.222	0.232	0.156	NS	0.114	NS	0.100	NS	0.063
Sub plot										
S_1	100%N	1.447	0.917	1.182	1.294	1.021	1.157	0.537	0.341	0.439
S_2	75% N	1.245	0.852	1.048	1.206	0.930	1.068	0.405	0.264	0.335
	CD (0.05)	0.138	NS	0.078	0.058	0.044	0.035	0.060	0.038	0.034
Interaction effects - NS										

4. 2.3.1.2. Phosphorus content

Treatments applied to the preceding crop had no significant influence on the P content of succeeding rice crop at various growth stages (Table 4.2.12). The P content increased as the plant attained panicle initiation stage and then decreased. Phosphorus contents at panicle initiation and harvest stages of succeeding crop were significantly higher with 100 per cent N applied to succeeding crop. Interaction effects had no significant influence on the P content of succeeding crop of rice at various growth stages.

4. 2.3.1.3. Potassium content

Different treatments had significant influence on the K content of succeeding rice at various growth stages (Table 4.2.13). Potassium contents of rice at active tillering and panicle initiation stages were significantly higher when the previous dry seeded rice was grown along with green manure crops compared to rice grown alone. Potassium content of succeeding rice crop was found less when the preceding crop was pure crop of rice. Potassium content of succeeding rice crop receiving 100 per cent N was significantly different only at harvest stage. Interactions showed no significance on the K content of succeeding rice crop at different growth stages.

4. 2.3.2. Nutrient uptake by rice

4. 2.3.2.1. Nitrogen uptake

Concurrent growing of green manure crops along with dry seeded crop had significant influence on the nitrogen uptake of succeeding crop of rice only at active tillering stage (Table 4.2.14). Nitrogen uptake of succeeding rice crop at active tillering stage was significantly higher in treatments preceded by concurrent growing of green manure crops during the previous season compared to the N uptake of succeeding rice crop preceded by pure crop of rice. Nitrogen uptake of succeeding rice crop receiving 100 per cent N was significantly different at all the growth stages compared with lower dose of N. Interaction effects had no significant influence on N uptake of succeeding crop of dry sown rice.

Table 4.2.12. Residual effect of concurrent growing of green manure crops in dry seeded rice on phosphorus content (%) of succeeding transplanted rice at different growth stages

Treatments		Active Tillering			Panicle Initiation			Harvest		
		1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot										
T_1	HG+Cono+100%N	0.102	0.128	0.115	0.212	0.242	0.227	0.067	0.120	0.093
T_2	HG+Cono+75%N	0.138	0.120	0.129	0.165	0.227	0.196	0.092	0.115	0.103
T_3	HG+2,4-D+100%N	0.123	0.123	0.123	0.200	0.243	0.222	0.105	0.093	0.099
T_4	HG+2,4-D+75%N	0.107	0.120	0.113	0.215	0.220	0.217	0.065	0.092	0.078
T_5	HG+Self+100%N	0.140	0.105	0.123	0.202	0.208	0.205	0.055	0.103	0.079
T_6	HG+Self+75%N	0.125	0.113	0.119	0.167	0.227	0.197	0.077	0.103	0.090
T_7	CP+Cono+100%N	0.145	0.127	0.136	0.213	0.237	0.225	0.077	0.082	0.079
T_8	CP+Cono+75%N	0.143	0.113	0.128	0.190	0.197	0.193	0.067	0.118	0.092
T_9	CP+2,4-D+100%N	0.148	0.130	0.139	0.170	0.213	0.192	0.063	0.083	0.073
T_{10}	CP+2,4-D+75%N	0.133	0.118	0.126	0.197	0.193	0.195	0.077	0.078	0.078
T_{11}	CP+Self+100%N	0.118	0.120	0.119	0.200	0.230	0.215	0.070	0.120	0.095
T_{12}	CP+Self+75%N	0.143	0.118	0.131	0.168	0.225	0.197	0.072	0.115	0.093
T_{13}	Rice alone+ 100%N	0.110	0.093	0.102	0.165	0.222	0.193	0.060	0.092	0.076
	CD (0.05)	NS	NS	NS	0.035	NS	NS	NS	NS	NS
Sub plot										
S_1	100%N	0.131	0.121	0.126	0.200	0.230	0.215	0.076	0.107	0.092
S_2	75% N	0.127	0.114	0.121	0.179	0.214	0.196	0.069	0.095	0.082
	CD (0.05)	NS	NS	NS	0.010	NS	0.011	NS	0.009	0.007
Interaction effects - NS										

Table 4.2.13. Residual effect of concurrent growing of green manure crops in dry seeded rice on potassium content (%) of succeeding transplanted rice at different growth stages

Treatments		Active Tillering			Panicle Initiation			Harvest		
		1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot										
T_1	HG+Cono+100%N	1.380	1.247	1.313	1.293	1.413	1.353	1.167	1.287	1.227
T_2	HG+Cono+75%N	1.207	1.473	1.340	1.247	1.313	1.280	1.300	1.193	1.247
T_3	HG+2,4-D+100%N	1.407	1.380	1.393	1.347	1.320	1.333	1.140	1.160	1.150
T_4	HG+2,4-D+75%N	1.500	1.467	1.483	1.347	1.213	1.280	1.107	1.280	1.193
T_5	HG+Self+100%N	1.467	1.453	1.460	1.220	1.287	1.253	1.080	1.280	1.180
T_6	HG+Self+75%N	1.453	1.447	1.450	1.213	1.427	1.320	1.173	1.207	1.190
T_7	CP+Cono+100%N	1.553	1.427	1.490	1.353	1.247	1.300	1.153	1.253	1.203
T_8	CP+Cono+75%N	1.473	1.307	1.390	1.240	1.327	1.283	1.073	1.340	1.207
T_9	CP+2,4-D+100%N	1.393	1.433	1.413	1.227	1.220	1.223	1.227	1.240	1.233
T_{10}	CP+2,4-D+75%N	1.433	1.380	1.407	1.233	1.287	1.260	1.133	1.347	1.240
T_{11}	CP+Self+100%N	1.267	1.407	1.337	1.293	1.320	1.307	1.240	1.380	1.310
T_{12}	CP+Self+75%N	1.553	1.440	1.497	1.233	1.240	1.237	1.233	1.280	1.257
T_{13}	Rice alone+ 100%N	1.287	1.240	1.263	1.073	1.213	1.143	0.960	1.187	1.073
	CD (0.05)	0.168	0.122	0.101	0.119	NS	0.090	NS	NS	NS
Sub plot										
S_1	100%N	1.416	1.400	1.408	1.280	1.303	1.291	1.188	1.302	1.245
S_2	75% N	1.410	1.385	1.397	1.231	1.286	1.258	1.118	1.227	1.172
	CD (0.05)	NS	NS	NS	NS	NS	NS	NS	0.040	0.040
Interaction effects - NS										

Table 4.2.14. Residual effect of concurrent growing of green manure crops in dry seeded rice on nitrogen uptake (kg ha^{-1}) of succeeding transplanted rice at different growth stages

Treatments		Active Tillering			Panicle Initiation			Harvest		
		1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot										
T_1	HG+Cono+100%N	35.71	49.87	42.79	38.38	64.85	51.62	23.29	24.78	24.04
T_2	HG+Cono+75%N	36.91	53.55	45.23	47.87	63.50	55.68	23.89	29.08	26.48
T_3	HG+2,4-D+100%N	29.97	57.59	43.78	42.49	72.55	57.52	24.54	24.51	24.52
T_4	HG+2,4-D+75%N	40.35	53.99	47.17	42.79	70.71	56.75	25.95	19.25	22.60
T_5	HG+Self+100%N	32.26	55.97	44.12	42.51	78.26	60.38	22.38	25.21	23.79
T_6	HG+Self+75%N	32.17	56.53	44.35	41.53	69.64	55.59	22.12	27.68	24.90
T_7	CP+Cono+100%N	49.55	80.23	64.89	39.50	69.37	54.43	19.19	27.94	23.57
T_8	CP+Cono+75%N	46.64	67.47	57.05	42.21	69.95	56.08	26.94	29.37	28.15
T_9	CP+2,4-D+100%N	41.91	60.60	51.26	42.70	74.84	58.77	29.93	24.08	27.00
T_{10}	CP+2,4-D+75%N	41.59	54.14	47.86	49.10	68.00	58.55	22.75	24.40	23.58
T_{11}	CP+Self+100%N	64.25	64.88	64.56	48.29	82.32	65.31	33.64	32.07	32.86
T_{12}	CP+Self+75%N	51.69	58.85	55.27	42.33	66.93	54.63	35.37	23.44	29.41
T_{13}	Rice alone+ 100%N	26.88	46.90	36.89	35.59	80.80	58.20	33.05	26.22	29.64
	CD (0.05)	13.85	15.43	10.10	NS	NS	NS	8.70	NS	8.43
Sub plot										
S_1	100%N	43.10	61.44	52.27	48.35	75.42	61.89	30.02	30.03	30.02
S_2	75% N	38.42	55.57	46.99	37.08	67.92	52.50	22.76	21.98	22.37
	CD (0.05)	NS	5.18	3.95	6.07	4.59	3.71	4.51	3.65	2.83
Interaction effects - NS										

4. 2.3.2.2. Phosphorus uptake

Treatments given to the previous dry seeded crop had no significant influence of the P uptake of succeeding crop of rice at various growth stages (Table 4.2.15). Phosphorus uptake of succeeding rice crop was significantly higher when the succeeding rice crop received 100 per cent N compared with 75 per cent nitrogen. Interaction effects failed to show any significant effects on the P uptake of succeeding crop of rice.

4. 2.3.2.3. Potassium uptake

Different treatments had significant influence on the K uptake of succeeding rice only at active tillering stage (Table 4.2.16). Potassium uptake of succeeding crop of rice with concurrent growing of green manure crops during the previous season was significantly higher than the K uptake of succeeding crop of rice with rice grown alone during the previous season. Potassium uptake of succeeding crop showed an increasing trend as the crop matures. Potassium uptake of succeeding rice crop at panicle initiation stage was significantly higher when the succeeding rice crop received 100 per cent N compared with 75 per cent nitrogen. None of the interactions was found significant on K uptake of succeeding rice crop at various growth stages.

4.2.4. Soil Nutrient status

4.2.4.1 Organic Carbon (%)

Organic carbon percentage of soil increased significantly when the previous dry seeded rice was grown along with green manure crops compared to rice grown alone (Table 4.2.17). Soil organic carbon content after the succeeding crop where cowpea was grown along with rice was significantly higher than that of horse gram intercropping and pure crop of rice during the previous season. Soil organic carbon content was the least when rice alone was the preceding crop. Succeeding rice crop receiving 100 per cent nitrogen recorded significantly higher organic carbon percentage compared with the lower doses. Interactions showed no variation in the soil organic carbon content.

Table 4.2.15. Residual effect of concurrent growing of green manure crops in dry seeded rice on phosphorus uptake ($kg\ ha^{-1}$) of succeeding transplanted rice at different growth stages

Treatments		Active Tillering			Panicle Initiation			Harvest		
		1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot										
T_1	HG+Cono+100%N	2.899	8.386	5.642	6.829	17.451	12.140	3.342	10.134	6.738
T_2	HG+Cono+75%N	4.156	8.043	6.099	6.185	16.200	11.193	5.713	10.184	7.949
T_3	HG+2,4-D+100%N	3.428	7.947	5.687	7.657	18.017	12.837	6.094	7.953	7.024
T_4	HG+2,4-D+75%N	3.081	7.907	5.494	7.111	15.834	11.473	4.561	8.229	6.395
T_5	HG+Self+100%N	3.908	6.841	5.374	7.199	15.905	11.552	3.553	8.350	5.951
T_6	HG+Self+75%N	3.416	7.360	5.388	5.671	16.775	11.223	4.542	8.640	6.591
T_7	CP+Cono+100%N	4.417	8.482	6.449	7.256	16.247	11.751	3.647	7.168	5.408
T_8	CP+Cono+75%N	4.338	7.580	5.959	6.335	13.561	9.948	3.353	10.506	6.930
T_9	CP+2,4-D+100%N	4.274	8.567	6.421	5.293	15.989	10.641	3.151	6.899	5.025
T_{10}	CP+2,4-D+75%N	4.725	7.969	6.347	7.842	14.386	11.114	3.990	6.495	5.243
T_{11}	CP+Self+100%N	4.335	8.195	6.265	7.271	17.130	12.201	4.133	10.473	7.303
T_{12}	CP+Self+75%N	4.477	7.730	6.104	5.759	16.412	11.086	3.926	10.110	7.018
T_{13}	Rice alone+ 100%N	2.955	5.957	4.456	4.625	17.553	11.086	3.313	7.523	5.418
	CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub plot										
S_1	100%N	3.893	8.119	6.006	7.473	16.973	12.223	4.337	9.380	6.859
S_2	75% N	3.862	7.414	5.638	5.610	15.559	10.584	3.866	7.953	5.910
	CD (0.05)	NS	0.610	0.415	1.057	NS	0.973	NS	0.819	0.545
Interaction effects - NS										

Table 4.2.16. Residual effect of concurrent growing of green manure crops in dry seeded rice on potassium uptake ($kg\ ha^{-1}$) of succeeding transplanted rice at different growth stages

Treatments		Active Tillering			Panicle Initiation			Harvest		
		1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot										
T_1	HG+Cono+100%N	38.69	81.56	60.13	41.53	101.6	71.56	60.63	108.3	84.487
T_2	HG+Cono+75%N	34.96	98.53	66.74	47.18	93.71	70.44	79.52	106.3	92.898
T_3	HG+2,4-D+100%N	39.31	90.43	64.87	49.28	97.54	73.41	64.83	99.5	82.144
T_4	HG+2,4-D+75%N	43.51	96.03	69.77	45.17	87.47	66.32	70.85	113.6	92.247
T_5	HG+Self+100%N	41.30	94.83	68.06	44.21	97.52	70.86	69.94	104.1	87.017
T_6	HG+Self+75%N	39.22	94.33	66.77	40.44	104.23	72.34	68.69	99.97	84.329
T_7	CP+Cono+100%N	45.68	95.67	70.67	45.48	86.05	65.76	54.33	110.3	82.293
T_8	CP+Cono+75%N	44.94	87.69	66.32	40.56	91.76	66.16	56.24	120.1	88.147
T_9	CP+2,4-D+100%N	39.58	94.51	67.05	38.29	91.45	64.87	60.96	103.1	82.028
T_{10}	CP+2,4-D+75%N	51.17	93.08	72.12	47.87	95.51	71.69	59.56	111.4	85.471
T_{11}	CP+Self+100%N	45.96	96.68	71.32	47.83	99.57	73.70	74.88	119.3	97.069
T_{12}	CP+Self+75%N	49.29	94.41	71.85	42.43	90.25	66.34	68.86	112.9	90.88
T_{13}	Rice alone+ 100%N	34.92	78.93	56.93	30.18	96.56	63.37	52.57	97.23	74.899
CD (0.05)		NS	9.73	7.732	NS	NS	NS	NS	NS	NS
Sub plot										
S_1	100%N	41.79	93.68	67.73	48.01	96.05	72.03	67.26	113.9	90.589
S_2	75% N	42.60	90.43	66.51	38.21	93.67	65.94	62.26	102.4	82.32
CD (0.05)		NS	NS	NS	6.638	NS	4.033	NS	6.71	5.17
Interaction effects - NS										

4.2.4.2. Available nitrogen

Soil available nitrogen content after the succeeding crop showed a significant increase in treatments involving concurrent growing of green manure crops compared with pure crop of rice during the previous season (Table 4.2.17). Concurrent growing of cowpea during the preceding season resulted in significantly higher nitrogen content of soil than concurrent growing of horse gram and pure crop. The least value of soil available nitrogen content was noticed when rice was grown alone in the preceding crop. The soil available nitrogen content was significantly higher when the succeeding rice crop received 100 per cent N compared with 75 per cent nitrogen. Interaction effects had no significant influence on the available nitrogen content of the soil.

4.2.4.3. Available phosphorus

Available soil phosphorus content after the succeeding crop was significantly affected by the concurrent growing of green manure crops during the 1st crop season (Table 4.2.17). Phosphorus content was less when pure crop of rice was the preceding crop. There was no significant difference in the available phosphorus content of the soil due to levels of N given to the succeeding crop and interactions.

4.2.4.3. Available potassium

Potassium content of the soil after the succeeding crop was not significantly affected by the previous season treatments (Table 4.2.17). Soil K content was significantly higher when 100 per cent nitrogen was given to the succeeding crop. No significant difference was indicated due to interactions with regard to the available potassium content of the soil.

4.2.5. Economics of the dry sowing system

4.2.5.1. Gross Return

Data on the economics of dry sowing system showed that treatments with concurrent growing of cowpea with rice during the previous season registered the highest gross return compared with concurrent growing of horse gram and rice grown alone (Table 4.2.18). The gross return (Rs.61017 ha^{-1}) of pure crop of rice was significantly less compared with green manure intercropped rice. Incorporation of concurrently grown

Table 4.2.17. Residual effect of concurrent growing of green manure crops in dry seeded rice on soil nutrient status of succeeding transplanted rice at harvest

Treatments		Organic carbon (%)			Available nitrogen (kg ha^{-1})			Available phosphorus (kg ha^{-1})			Available potassium (kg ha^{-1})		
		1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot													
T_1	HG+Cono+100%N	0.66	0.79	0.73	239.38	257.15	248.27	84.75	59.95	72.35	373.33	784.00	578.67
T_2	HG+Cono+75%N	0.73	0.73	0.73	344.61	248.79	246.70	82.63	55.50	69.07	373.33	765.33	569.33
T_3	HG+2,4-D+100%N	0.71	0.72	0.71	267.61	236.25	251.93	88.74	59.44	74.09	354.67	765.33	560.00
T_4	HG+2,4-D+75%N	0.72	0.74	0.73	247.22	227.88	237.55	83.00	58.80	70.90	373.33	896.00	634.67
T_5	HG+Self+100%N	0.73	0.68	0.71	246.70	217.43	232.06	72.44	53.88	63.16	392.00	821.33	606.67
T_6	HG+Self+75%N	0.70	0.70	0.70	242.00	209.07	225.53	82.42	55.35	68.89	392.00	765.33	578.67
T_7	CP+Cono+100%N	0.82	0.72	0.77	285.38	284.33	284.86	82.28	58.66	70.47	373.33	914.67	644.00
T_8	CP+Cono+75%N	0.76	0.89	0.82	259.77	240.43	250.10	78.08	54.56	66.32	373.33	821.33	597.33
T_9	CP+2,4-D+100%N	0.78	0.75	0.76	260.81	234.16	247.48	82.71	57.19	69.95	373.33	877.33	625.33
T_{10}	CP+2,4-D+75%N	0.77	0.71	0.74	277.01	196.52	236.77	84.72	53.31	69.01	336.00	877.33	606.67
T_{11}	CP+Self+100%N	0.79	0.80	0.79	269.17	229.97	249.57	87.55	56.72	72.13	373.33	784.00	578.67
T_{12}	CP+Self+75%N	0.78	0.75	0.77	284.85	223.70	254.28	80.52	53.85	67.18	354.67	840.00	597.33
T_{13}	Rice alone+ 100%N	0.62	0.63	0.63	223.70	177.71	200.71	74.02	47.35	60.68	336.00	746.67	541.33
CD (0.05)		0.09	NS	0.08	NS	47.89	37.49	NS	NS	7.13	NS	NS	NS
Sub plot													
S_1	100%N	0.75	0.77	0.76	265.68	239.62	252.65	81.26	56.94	69.10	370.46	875.90	623.18
S_2	75% N	0.72	0.71	0.71	249.43	219.36	234.40	82.40	54.53	68.47	364.72	763.90	564.31
CD (0.05)		NS	0.06	0.03	NS	16.71	14.83	NS	NS	NS	NS	49.39	28.94
Interaction effects - NS													
Initial soil test data		0.42	0.69	0.55	235.5	238.3	236.9	52.5	44.6	48.5	112.0	896.0	504.0

cowpea using conoweeder and receiving 100 per cent N recorded the highest gross return (Rs.81774 ha^{-1}) compared with other treatments. Gross return of dry sowing system was affected by levels of nitrogen given to the succeeding crop. Succeeding crop receiving 100 per cent N registered significantly higher gross return compared with 75 per cent N. Interactions had not significantly influence the gross return.

4.2.5.2. Net Return

Results revealed that the net return from dry sowing system was significantly affected by the treatments given to the preceding crop and the succeeding crops (Table 4.2.18). Concurrent growing of both green manure crops increased the net return of the dry sowing system compared with rice grown alone during the previous season. Net return was found to be the highest (Rs.43912 ha^{-1}) in treatments with concurrently grown cowpea incorporated using conoweeder and receiving 100 per cent N during the previous season. Pure crop of rice with out any green manure crops during the previous season resulted in the least net return (Rs.18805 ha^{-1}). Nitrogen at 100 per cent level applied to the succeeding crop registered significantly higher net return compared with 75 per cent N. Interaction effects did not affect the net return.

4.2.5.3. Benefit: Cost Ratio

Benefit: cost ratio of dry sowing system was significantly affected by the treatments applied to the preceding crop (Table 4.2.18). Concurrent growing of green manure crops along with rice during the previous season resulted in higher B: C ratio than rice grown alone. The highest B: C ratio (2.16) recorded in treatments with concurrently grown cowpea incorporated using conoweeder. Benefit: cost ratio of the dry sowing system was not affected by the levels of N given to the succeeding crop and any of the interactions.

Table 4.2.18 Economics of dry sowing system

Treatments		Gross Return			Net Return			BC Ratio		
		1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot										
T_1	HG+Cono+100%N	69383	56263	62823	32971	19852	26411	1.91	1.55	1.73
T_2	HG+Cono+75%N	72772	57645	65208	36607	21480	29044	2.01	1.59	1.80
T_3	HG+2,4-D+100%N	73803	58699	66251	38032	22927	30479	2.06	1.64	1.85
T_4	HG+2,4-D+75%N	72620	57193	64906	37095	21668	29382	2.04	1.61	1.83
T_5	HG+Self+100%N	72647	57100	64873	36035	20489	28262	1.98	1.56	1.77
T_6	HG+Self+75%N	71332	54950	63141	34968	18585	26776	1.96	1.51	1.74
T_7	CP+Cono+100%N	88143	75405	81774	50281	37544	43912	2.33	1.99	2.16
T_8	CP+Cono+75%N	80916	66360	73638	43301	28745	36023	2.15	1.76	1.96
T_9	CP+2,4-D+100%N	78990	68586	73789	41769	31365	36567	2.12	1.84	1.98
T_{10}	CP+2,4-D+75%N	77890	67759	72825	40916	30785	35850	2.11	1.83	1.97
T_{11}	CP+Self+100%N	81442	71287	76365	43381	33225	38303	2.14	1.87	2.01
T_{12}	CP+Self+75%N	78524	67726	73125	40710	29912	35311	2.08	1.79	1.93
T_{13}	Rice alone+ 100%N	69316	52717	61017	27105	10506	18805	1.64	1.25	1.45
	CD (0.05)	6278	7614	4807	6278	7614	4807	0.17	0.21	0.13
Sub plot										
S_1	100%N	76680	63292	69986	39150	25762	32456	2.05	1.69	1.87
S_2	75% N	75286	61583	68435	38261	24558	31410	2.04	1.67	1.85
	CD (0.05)	NS	1530	1027	NS	NS	1027	NS	NS	NS
Interaction effects - NS										

4.3. CONCURRENT GROWING OF DAINCHA IN WET SEEDED RICE

4.3.1. Growth characters of wet seeded rice crop

4.3.1.1. Height of plants

At active tillering stage, height of plants was significantly higher in pure crop of rice compared to daincha intercropped rice (Table 4.3.1). However stages and methods of incorporation and N levels had no significant influence on plant height at active tillering stage. But at panicle initiation stage, highest plant height was recorded by the treatments involving incorporation of daincha at of 30 days followed by pure crop of rice and the lowest by treatments involving incorporation of daincha at 20 days. Plots receiving 100 per cent nitrogen produced the highest plant height at panicle initiation and harvest stages. Methods of incorporation of daincha did not influence the height of rice at various growth stages. At harvest stage, incorporation of concurrently grown daincha both at 20 and 30 days recorded significantly higher plant height compared to pure crop of rice. Interaction effect failed to show any significance on plant height of wet sown rice.

4.3.1.2. Number of tillers hill^{-1}

Tiller production of rice intercropped with daincha was significantly higher than pure crop of rice at all the growth stages (Table 4.3.2). At harvest stage, the highest tiller production was noticed in treatments where daincha was incorporated at the age of 30 days. Methods of incorporation and levels of nitrogen showed no significant influence on number of tillers hill^{-1} at various growth stages. Interaction effects had no significant influence on this character at any of the growth stages.

4.3.1.3. Number of tillers m^{-2}

Tiller production m^{-2} of rice intercropped with daincha and its incorporation at 20 and 30 days was significantly higher than pure crop of rice at active tillering stage (Table 4.3.3). The number of tillers m^{-2} of pure crop of rice at the later growth stages was significantly higher compared with rice intercropped with daincha incorporated at 20 days after sowing but on par with daincha incorporated at 30 days after sowing. Different methods of incorporation and levels of nutrients failed to exert any

Table 4.3.1. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels on height (cm) of wet sown rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Stages of incorporation									
20 DAS	66.6	66.8	66.7	75.5	101.8	88.7	91.4	113.8	102.6
30 DAS	67.5	69.5	68.5	78.7	105.0	91.9	94.4	119.5	106.9
CD (0.05)	NS	NS	NS	2.8	3.2	3.0	NS	5.0	4.1
Methods of incorporation									
Conoweeding	66.5	69.5	68.0	75.4	104.2	89.8	92.9	116.4	104.7
2,4-D spray	67.1	70.4	68.7	77.6	105.1	91.3	92.7	115.8	104.3
Almix/Algrip spray	67.5	64.6	66.0	78.4	100.9	89.7	93.1	117.7	105.4
CD (0.05)	NS	4.1	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	68.2	67.3	67.7	79.4	104.3	91.9	94.4	118.9	106.6
75% N	65.9	69.0	67.5	74.8	102.5	88.7	91.4	114.4	102.9
CD (0.05)	NS	NS	NS	2.8	NS	3.0	NS	NS	4.1
Rice alone	71.6	76.1	73.8	79.5	101.5	90.5	88.4	103.7	96.1
Interaction effects - NS									

Table 4.3.2. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels on number of tillers hill^{-1} of wet sown rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Stages of incorporation									
20 DAS	8.4	8.9	8.6	7.6	11.5	9.5	15.3	11.7	13.5
30 DAS	8.4	9.5	9.0	8.7	11.1	9.9	16.2	12.3	14.3
CD (0.05)	NS	NS	NS	0.6	NS	NS	NS	NS	0.5
Methods of incorporation									
Conoweeding	8.3	9.5	8.9	8.0	11.7	9.8	15.7	12.0	13.8
2,4-D spray	8.2	8.7	8.5	8.2	11.2	9.7	16.2	12.1	14.1
Almix/Algrip spray	8.6	9.4	9.0	8.2	11.1	9.6	15.5	11.9	13.7
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	8.4	9.1	8.7	8.3	11.2	9.8	15.9	12.1	14.0
75% N	8.4	9.3	8.9	8.0	11.4	9.7	15.6	11.9	13.8
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	7.0	6.3	6.7	6.8	9.9	8.3	14.3	9.3	11.8
Interaction effects - NS									

Table 4.3.3. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels on number of tillers m^{-2} of wet sown rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Stages of incorporation									
20 DAS	376.8	399.3	388.0	341.5	517.5	429.5	690.0	525.0	607.5
30 DAS	376.3	429.3	402.8	390.0	501.0	445.5	730.0	555.0	642.5
CD (0.05)	NS	NS	NS	26.1	NS	NS	NS	NS	22.9
Methods of incorporation									
Conoweeding	372.8	427.1	399.9	360.0	524.3	442.1	705.0	540.0	622.5
2,4-D spray	369.0	393.4	381.2	370.5	504.0	437.3	727.5	543.8	635.6
Almix/Algrip spray	387.8	422.3	405.0	366.8	499.5	433.1	697.5	536.3	616.9
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	375.8	408.0	391.9	372.5	505.0	438.8	717.5	542.5	630.0
75% N	377.3	420.5	398.9	359.0	513.5	436.3	702.5	537.5	620.0
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	378.0	340.2	359.1	367.2	532.8	450.0	774.0	540.0	657.0
Interaction effects - NS									

Table 4.3.4. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels on number of leaves $hill^{-1}$ of wet sown rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Stages of incorporation									
20 DAS	35.9	31.2	33.6	45.2	40.6	42.9	47.6	40.9	44.3
30 DAS	36.7	31.8	34.2	45.4	39.7	42.6	44.8	43.1	44.0
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Methods of incorporation									
Conoweeding	35.8	34.0	34.9	44.6	41.0	42.8	48.8	40.7	44.8
2,4-D spray	36.6	29.2	32.9	45.4	38.5	42.0	45.7	43.3	44.5
Almix/Algrip spray	36.5	31.4	33.9	45.9	41.0	43.5	44.1	42.1	43.1
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	37.6	31.3	34.4	45.8	41.1	43.5	45.7	41.8	43.8
75% N	35.0	31.8	33.4	44.8	39.2	42.0	46.7	42.3	44.5
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	34.7	22.6	28.7	42.2	33.9	38.0	40.0	34.0	37.0
Interaction effects - NS									

significant influence on tiller production m^{-2}. Interaction effects did not significantly influence the number of tillers m^{-2} at different growth stages.

4.3.1.4. Number of leaves $hill^{-1}$

Leaf production $hill^{-1}$ of rice with concurrent growing of daincha was higher than pure crop of rice at all the growth stages (Table 4.3.4). Stages and methods of incorporation of daincha, and levels of nitrogen showed no significant influence on the number of leaves $hill^{-1}$.

4.3.1.5. Leaf area $hill^{-1}$

Leaf area $hill^{-1}$ of rice intercropped with daincha was significantly higher than pure crop of rice at all the growth stages (Table 4.3.5). Leaf area of rice with daincha incorporated at 30 DAS was the highest compared with daincha incorporation at 20 DAS and rice grown alone. During 2^{nd} year, at active tillering stage, leaf area of rice with incorporation of daincha at 30 DAS was significantly higher than daincha incorporation at 20 days and pure crop of rice. Conoweeded treatment recorded the highest leaf area compared with other methods of incorporation. Nitrogen levels had no significant influence on leaf area of rice at various growth stages. Interaction effects had not significantly influenced the leaf area of rice at any of the growth stages.

4.3.1.6. Leaf area index

Leaf area index of rice grown concurrently with daincha was significantly higher than that of rice sown alone at all the growth stages (Table 4.3.6). There was no significant difference in the leaf area index of rice grown along with daincha due to the stages and methods of incorporation of daincha and levels of nitrogen at different growth stages. Interaction effect also showed no significant influence on leaf area index.

4.3.1.7. Dry matter production

Dry matter production of pure crop of rice was less at all the growth stages compared with rice grown concurrently with daincha (Table 4.3.7). At active tillering stage, the highest dry matter production was noticed when daincha was incorporated at the age of 30 days. Methods of incorporation and levels of N showed no significant difference

Table 4.3.5. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels on leaf area hill^{-1} (cm^2) of wet sown rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Mean	1st year	2nd year	Mean	1st year	2nd year	Pooled
Stages of incorporation									
20 DAS	760.5	1340.8	1050.7	1521.9	2301.0	1911.5	1288.1	1404.1	1346.1
30 DAS	775.5	1513.5	1144.5	1477.5	2332.4	1904.9	1228.9	1526.6	1377.7
CD (0.05)	NS	169.8	*	NS	NS	*	NS	NS	NS
Methods of incorporation									
Conoweeding	774.2	1655.5	1214.8	1451.7	2326.3	1889.0	1399.4	1375.2	1387.3
2,4-D spray	743.8	1313.5	1028.6	1450.0	2262.1	1856.1	1170.9	1573.2	1372.0
Almix/Algrip spray	786.0	1312.6	1049.3	1597.3	2361.7	1979.5	1205.2	1447.7	1326.4
CD (0.05)	NS	207.9	*	NS	NS	*	NS	NS	NS
Levels of nitrogen									
100% N	809.7	1361.5	1085.6	1566.4	2378.7	1972.6	1342.4	1439.8	1391.1
75% N	726.4	1492.9	1109.6	1433.0	2254.8	1843.9	1174.5	1491.0	1332.7
CD (0.05)	NS	NS	*	127.6	NS	*	NS	NS	NS
Rice alone	683.9	790.3	737.1	1340.0	1613.6	1476.8	888.3	884.7	886.5
Interaction effects - NS									

* Pooling not possible as the errors heterogenous and interaction absent

Table 4.3.6. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels on leaf area index of wet sown rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Stages of incorporation									
20 DAS	6.08	10.73	8.41	12.18	18.41	15.29	10.31	11.23	10.77
30 DAS	6.20	12.11	9.16	11.82	18.66	15.24	9.83	12.21	11.02
CD (0.05)	NS	1.36	NS	NS	NS	NS	NS	NS	NS
Methods of incorporation									
Conoweeding	6.19	13.24	9.72	11.62	18.61	15.11	11.20	11.00	11.10
2,4-D spray	5.95	10.51	8.23	11.60	18.10	14.85	9.37	12.59	10.98
Almix/Algrip spray	6.29	10.50	8.39	12.78	18.89	15.84	9.64	11.58	10.61
CD (0.05)	NS	1.66	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	6.48	10.89	8.68	12.53	19.03	15.78	10.74	11.52	11.13
75% N	5.81	11.94	8.88	11.49	18.04	14.75	9.40	1.93	10.66
CD (0.05)	NS	NS	NS	1.02	NS	NS	NS	NS	NS
Rice alone	5.47	6.32	5.90	10.72	12.91	11.82	7.11	7.08	7.09
Interaction effects - NS									

Table 4.3.7. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels on dry matter production (kg ha^{-1}) of wet sown rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Mean	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Stages of incorporation									
20 DAS	5348	3471	4409	9728	6464	8096	8793	7613	8203
30 DAS	5513	3772	4643	9356	6063	7709	8928	6804	7866
CD (0.05)	NS	140.0	*	NS	NS	509.1	NS	622.3	NS
Methods of incorporation									
Conoweeding	5282	3578	4430	9129	6169	7649	8719	7114	7917
2,4-D spray	5499	3638	4569	10343	6455	8399	8775	7402	8088
Almix/Algrip spray	5511	3648	4579	9153	6166	7660	9087	7110	8099
CD (0.05)	NS	NS	*	693.5	NS	623.5	NS	NS	NS
Levels of nitrogen									
100% N	5406	3664	4535	9598	6212	7905	9041	7027	8034
75% N	5455	3579	4517	9486	6314	7900	8680	7390	8035
CD (0.05)	NS	NS	*	NS	NS	NS	NS	NS	NS
Rice alone	5322	3292	4307	9383	5410	7397	7306	6188	6747
Interaction effects - NS									

*** Pooling not possible as the errors heterogenous and interaction absent**

Table 4.3.8. Plant height, nodule count and leaf area of daincha grown along with wet sown rice

Treatments	Plant height (cm)			Nodule count plant^{-1}			Leaf area (cm^2)		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Stages of incorporation									
20 DAS	18.2	24.5	21.4	9.66	9.14	9.40	30.5	99.6	65.0
30 DAS	35.8	54.2	45.0	11.88	17.94	14.91	104.8	377.4	241.1
CD (0.05)	1.7	2.3	1.4	1.14	1.88	1.12	9.9	45.9	23.2
Methods of incorporation									
Conoweeding	27.2	40.4	33.8	11.42	14.35	12.88	71.0	245.3	158.2
2,4-D spray	27.2	38.1	32.7	10.07	13.13	11.60	66.8	236.1	151.5
Almix/Algrip spray	26.7	39.6	33.1	10.82	13.15	11.98	65.1	234.0	149.5
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	27.9	40.0	33.9	10.69	13.79	12.24	73.4	244.6	159.0
75% N	26.2	38.8	32.5	10.84	13.30	12.07	61.9	232.4	147.2
CD (0.05)	1.7	NS	1.4	NS	NS	NS	9.9	NS	NS

at this stage. Dry matter production of rice at panicle initiation stage was significantly higher, when daincha was incorporated at 20 DAS. Among the different methods of incorporation, 2, 4 –D application resulted in higher dry matter production compared with other incorporation methods at panicle initiation stage. Stages and methods of incorporation and nitrogen levels had no significant influence on the dry matter production of rice at harvest stage. Interaction had not significantly influenced the dry matter production of rice at different growth stages.

4.3.2. Growth characters of daincha

4.3.2.1. Plant height

Height of daincha (Table 4.3.8) was significantly higher when it was incorporated at the age of 30 days (45.0 cm) and more than double compared with incorporation at 20 days (21.4 cm). Plant height was significantly higher in treatments receiving 100 per cent nitrogen.

4.3.2.2. Nodule count

Significantly higher number of nodules plant^{-1} (14.91) was observed when daincha was incorporated at 30 DAS compared with 20 DAS (Table 4.3.8). Levels of nitrogen failed to show any significance on the nodule count in daincha.

4.3.2.3. Leaf area plant^{-1}

The leaf area of daincha at the age of 30 days (241.1cm^2) was significantly higher than that at the age of 20 days (Table 4.3.8). Nitrogen levels had no significant effect on the leaf area of daincha. Interaction effects did not significantly influence the leaf area at different growth stages.

4.3.2.4. Leaf Area Index

Leaf area index of daincha incorporated at 30 DAS (1.93) was significantly higher than that of daincha incorporated at 20 DAS (Table 4.3.9). Levels of nitrogen showed no significant difference on leaf area index of daincha.

Table 4.3.9. Leaf area index, biomass production and dry matter addition of daincha grown along with wet sown rice

Treatments	Leaf area Index			Biomass (kg ha^{-1})			Dry matter (kg ha^{-1})		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Stages of incorporation									
20 DAS	0.24	0.80	0.52	5424	5864	5644	2224	3079	2651
30 DAS	0.84	3.02	1.93	9754	17643	13698	5501	6637	6069
CD (0.05)	0.08	0.37	0.19	938	1537	856	280.4	243	176
Methods of incorporation									
Conoweeding	0.57	1.96	1.26	7661	11689	9675	3932	4879	4406
2,4-D spray	0.54	1.89	1.21	7603	11718	9661	3888	4875	4382
Almix/Algrip spray	0.52	1.87	1.20	7502	11853	9678	3766	4820	4293
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	0.59	1.96	1.27	7920	11730	9825	3939	4808	4374
75% N	0.50	1.86	1.18	7258	11777	9517	3786	4908	4347
CD (0.05)	0.08	NS	NS	NS	NS	NS	NS	NS	NS

4.3.2.5. Biomass production

Biomass production of daincha was significantly higher when it was incorporated at 30 DAS (13698 kg ha^{-1}) compared with daincha incorporated at 20 DAS (Table 4.3.9). There was no significant difference on the biomass production of daincha due to levels of nitrogen.

4.3.2.6. Dry matter addition

Stages of incorporation showed significant influence on the dry matter addition of daincha (Table 4.3.9). The highest dry matter addition was observed when daincha was incorporated at the age of 30 days (6069 kg ha^{-1}) compared with incorporation of daincha at 20 DAS. Dry matter addition of daincha was not significantly affected by nitrogen levels.

4.3.3. Yield and yield attributes of wet seeded rice

4.3.3.1. Days to 50% flowering

It can be seen from the data that in both years, stages and methods of incorporation of concurrently grown daincha and levels of nitrogen had no significant influence on the time of 50 per cent flowering of wet sown rice (Tables 4.3.10.). Interaction effect had no significance on the time of 50 per cent flowering.

4.3.3.2. Panicles m^{-2}

Concurrent growing of daincha caused a reduction in the number of panicle m^{-2} compared with pure crop of rice (Tables 4.3.10). The highest number of panicles m^{-2} was in pure crop of rice (412.7). Stages and methods of incorporation of daincha and levels of nitrogen did not significantly influence the number of panicles m^{-2}. None of the interaction effects exerted any significant effect on the number of panicles m^{-2}.

4.3.3.3. Panicles $hill^{-1}$

More number of panicles $hill^{-1}$ was noticed in rice with concurrent growing of daincha compared with pure crop (Tables 4.3.10). Stages and methods of incorporation of daincha and levels of nitrogen did not significantly influence the number of panicles

Table 4.3.10. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels on yield attributes of wet sown rice

Treatments	Days to 50% flowering			Panicle m^{-2}			Panicle $hill^{-1}$			Panicle weight (g)		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Stages of incorporation												
20 DAS	77	76	76.5	332.4	425.8	379.1	13.72	8.56	11.14	23.72	13.87	18.80
30 DAS	77	76	76.5	336.9	416.2	376.6	14.06	8.72	11.39	23.67	14.55	19.11
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Methods of incorporation												
Conoweeding	77	76	76.5	327.7	423.7	375.7	13.75	8.92	11.33	24.67	12.97	18.82
2,4-D spray	77	76	76.5	328.3	412.7	370.5	13.92	8.33	11.13	23.25	15.14	19.19
Almix/Algrip spray	77	76	76.5	348.0	426.7	387.3	14.00	8.67	11.33	23.17	14.52	18.84
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen												
100% N	77	76	76.5	343.1	416.7	379.9	14.11	8.83	11.47	24.17	13.19	18.68
75% N	77	76	76.5	326.2	425.3	375.8	13.67	8.44	11.06	23.22	15.23	19.23
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	76	75	75.5	326.7	498.7	412.7	13.00	7.00	10.00	14.67	8.42	11.54
Interaction effects - NS												

hill^{-1}. Interaction effects showed no significant influence on the number of panicles hill^{-1}. .

4.3.3.4. Panicle weight

Results showed that concurrent growing of daincha had significant influence on the weight of panicles (Tables 4.3.10). Panicle weight was significantly higher when daincha was incorporated at 30 DAS (19.11 g) compared with daincha incorporated at 20 DAS and pure crop of rice. Pure crop of rice recorded the lowest panicle weight (11.54g). The weight of panicle was not affected by different methods of incorporation of daincha. Levels of nitrogen behaved similarly. No significant effect was noticed by any of the interaction effects on the weight of panicle.

4.3.3.5. Number of filled grains panicle^{-1}

Number of filled grains panicle^{-1} in rice with concurrent growing of daincha was significantly higher than pure crop of rice (Tables 4.3.11). Stages of incorporation of daincha behaved similarly in the production of filled grains panicle^{-1}. Methods of green manure incorporation and nitrogen levels did not significantly influence the number of filled grains panicle^{-1}. Interaction effects had no significance on the production of filled grains panicle^{-1}.

4.3.3.6. Percentage filled grain

Percentage of filled grain was significantly higher in daincha intercropped rice (80.12% when daincha incorporated at 20 DAS and 81.5% in 30 DAS) compared with pure crop of rice (74.85%). No significant difference in the percentage of filled grains was noticed among different methods of incorporation and levels of nitrogen (Tables 4.3.11.). Interaction effects had no significant influence on filled grain percentage.

4.3.3.7. 1000 grain weight

Daincha intercropped rice recorded more grain weight numerically compared with pure crop of rice (Tables 4.3.11). No significant difference was noticed among the stages and methods of incorporation of daincha. Levels of nitrogen and interaction effects of treatments failed to show any significance in respect of 1000 grain weight.

4.3.3.8. Grain yield

Grain yield obtained by concurrent growing of daincha along with wet sown rice was significantly higher compared with rice grown alone (Table 4.3.12). The highest yield was obtained when daincha was incorporated at 30 DAS (5184 kg ha^{-1}) compared with daincha incorporation at 20 DAS (4907 kg ha^{-1}) and pure crop of rice (4501 kg ha^{-1}). Methods of incorporation of daincha behaved similarly in grain yield production. Rice intercropped with daincha receiving both 100 and 75 per cent nitrogen produced significantly higher grain yield (5165 kg ha^{-1} and 4925 kg ha^{-1} respectively) than pure crop of rice receiving 5 t ha^{-1} farm yard manure and 100 per cent nutrients (4501 kg ha^{-1}). Grain yield of rice with concurrent growing of daincha receiving 100 per cent N recorded significantly higher yield compared with 75 per cent nitrogen and pure crop of rice. Interaction effects had no significant influence on the grain yield of wet sown rice.

4.3.3.9. Straw yield

Stages and methods of incorporation of concurrently grown daincha and levels of nitrogen showed no significant influence on the straw yield of rice in both years (Table 4.3.12). Interaction effects did not significantly influence the straw yield of rice.

4.3.3.10. Harvest Index

Neither the main effects nor the interaction effects revealed any significance on the harvest index of rice (Table 4.3.12). Harvest index obtained with pure crop of rice was less compared with daincha intercropped rice.

4.3.4. Weed incidence in wet seeded crops

4.3.4.1. Weed count

It can be seen from the data that concurrent growing of daincha along with wet seeded rice significantly reduced the population of grasses, broad leaved weeds and sedges in wet sown rice during both the years compared with rice grown alone (Table 4.3.13). Stages of incorporation of daincha had no significant influence on the count of grasses, broad leaved weeds and sedges thereby the total weed count. Methods of

Table 4.3.11. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels on yield attributes of wet sown rice

Treatments	Filled grains panicle^{-1}			Filled grain %			1000 grain weight (g)		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Stages of incorporation									
20 DAS	93.50	59.03	76.26	86.86	73.38	80.12	26.17	30.65	28.41
30 DAS	96.89	64.57	80.73	88.35	74.65	81.50	26.22	30.93	28.57
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Methods of incorporation									
Conoweeding	94.17	59.04	76.60	85.99	72.93	79.46	26.23	31.36	28.80
2,4-D spray	97.42	61.44	79.43	87.18	74.69	80.93	26.15	30.89	28.52
Almix/Algrip spray	94.00	64.92	79.46	89.66	74.42	82.04	26.20	30.12	28.16
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	95.78	57.53	76.65	89.15	72.75	80.95	26.28	30.87	28.57
75% N	94.61	66.07	80.34	86.07	75.27	80.67	26.11	30.71	28.41
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	86.33	33.33	59.83	87.46	62.23	74.85	25.75	28.87	27.31
Interaction effects - NS									

Table 4.3.12. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels on grain yield, straw yield and harvest index of wet sown rice

Treatments	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Harvest Index		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Stages of incorporation									
20 DAS	5121	4694	4907	2887	4457	3672	0.64	0.51	0.58
30 DAS	5417	4951	5184	3138	4313	3725	0.63	0.53	0.58
CD (0.05)	203.3	239.1	202.3	239.2	NS	NS	NS	0.02	NS
Methods of incorporation									
Conoweeding	5319	4912	5115	2873	4453	3663	0.65	0.52	0.59
2,4-D spray	5265	4801	5033	3014	4456	3735	0.64	0.52	0.58
Almix/Algrip spray	5222	4754	4988	3150	4245	3697	0.62	0.53	0.58
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	5384	4947	5165	3076	4317	3697	0.64	0.53	0.59
75% N	5153	4698	4925	2949	4452	3700	0.64	0.51	0.58
CD (0.05)	203.3	239.1	202.3	NS	NS	NS	NS	0.02	NS
Rice alone	4895	4107	4501	2932	4368	3650	0.63	0.48	0.56
Interaction effects - NS									

Table 4.3.13. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels on weed count m^{-2} of wet sown rice at 50 DAS

Treatments	Grass weeds			Broadleaved weeds			Sedges			Total weeds		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Stages of incorporation												
20 DAS	4.33	8.61	6.63	7.28	12.72	10.00	15.33	23.11	19.22	26.94	44.44	35.69
30 DAS	3.11	6.50	4.81	8.17	11.67	9.91	16.44	22.39	19.42	27.72	40.67	34.19
CD (0.05)	1.45	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Methods of incorporation												
Conoweeding	2.33	4.25	3.29	11.25	17.33	14.29	22.67	28.42	25.54	36.25	50.00	43.13
2,4-D spray	4.25	11.50	7.88	5.33	11.33	8.33	9.50	13.42	11.46	19.08	36.00	27.54
Almix/Algrip spray	4.58	6.92	5.75	6.58	7.92	7.25	15.50	26.42	20.96	26.67	41.67	34.17
CD (0.05)	1.77	3.23	3.69	3.73	5.80	5.74	5.61	7.94	6.80	8.76	10.42	2.56
Levels of nitrogen												
100% N	3.83	7.33	5.58	7.17	11.94	9.56	16.06	21.67	18.86	27.06	41.44	34.25
75% N	3.61	7.78	5.69	8.28	12.44	10.36	15.72	23.83	19.78	27.61	43.67	35.64
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	25.00	23.33	24.17	18.00	38.33	28.17	80.67	72.33	76.50	123.67	127.67	125.67
Interaction effects - NS												

incorporation of daincha significantly influenced the weed count during both years. The grass weed count was found significantly less in conoweeded treatments (3.29). Application of both weedicides significantly reduced the broad leaved weeds compared to conoweeding. Number of sedges (11.46) was significantly less in 2, 4-D applied treatments. Incorporation of daincha by spraying 2, 4- D resulted in a significant reduction of total weed count. Levels of nitrogen showed no significant influence on the weed count. None of the interaction effects had any significant influence on the count of grasses, broad leaved weeds, sedges and thereby total weed count in wet sown rice.

4.3.4.2. Weed dry matter production

As evident from the data, concurrent growing of daincha along with wet seeded rice significantly reduced the dry weight of grasses, broad leaved weeds and sedges and thereby the total dry matter production of weeds in wet sown rice during both years compared with rice grown alone (Table 4. 3.14). There was no significant influence on the dry matter production of grasses, broad leaved weeds and sedges thereby the total weeds by incorporation of daincha at different stages. Methods of incorporation of daincha significantly influenced the dry weight of weeds during both years. The dry matter production of grass weeds was significantly less in conoweeded treatments (6.46). During the first year, dry weight of broad leaved weeds was significantly less in 2, 4-D applied treatments. But in the 2nd year, dry matter production of broad leaved weeds in algrip applied treatments was significantly less than in 2, 4-D applied and conoweeded treatments. Dry matter production of sedges (8.01) was significantly less in 2, 4-D applied treatments. Incorporation of daincha by spraying 2, 4- D resulted in significant reduction of total weed dry matter production. Dry matter production of weeds was not affected by the levels of nitrogen.

Interaction of stages and methods of incorporation of daincha significantly influenced the total weed dry weight. Incorporation of daincha at 20 and 30 DAS using 2, 4-D significantly reduced the total dry weight of weeds compared with incorporation of daincha at 20 DAS with conoweeder. None of the interaction effects had any significant influence on the dry weight of grasses, broad leaved weeds and sedges in wet sown rice.

Table 4.3.14. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels on dry weight of weeds ($g\ m^{-2}$) of wet sown rice at 50 DAS

Treatments	Grass weeds			Broadleaved weeds			Sedges			Total weeds		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Stages of incorporation												
20 DAS	6.15	10.33	8.24	6.07	8.52	7.30	7.67	10.90	9.28	19.89	29.75	24.82
30 DAS	5.32	9.37	7.35	7.09	9.05	8.07	7.73	12.01	9.87	20.13	30.43	25.28
CD (0.05)	0.70	NS	NS	0.77	NS	NS	NS	NS	NS	NS	NS	NS
Methods of incorporation												
Conoweeding	4.24	8.67	6.46	7.37	10.94	9.15	8.68	11.92	10.30	20.29	31.53	25.91
2,4-D spray	6.47	10.62	8.55	5.89	8.65	7.27	6.33	9.68	8.01	18.69	28.94	23.82
Almix/Algrip spray	6.50	10.27	8.38	6.48	6.78	6.63	8.08	12.76	10.42	21.56	29.81	25.43
CD (0.05)	0.86	1.55	1.98	0.95	1.23	2.09	1.78	2.82	1.49	2.06	NS	NS
Levels of nitrogen												
100% N	5.71	9.36	7.54	6.33	8.75	7.54	6.99	11.07	9.03	19.03	29.18	24.10
75% N	5.76	10.34	8.05	6.83	8.83	7.83	8.40	11.84	10.12	21.00	31.01	26.00
CD (0.05)	NS	NS	NS	NS	NS	NS	1.46	NS	NS	1.68	NS	NS
Rice alone	9.94	19.24	14.59	19.00	17.97	18.48	21.70	27.76	24.73	50.63	64.97	57.80

Table 4.3.14.1. Interaction effect of stages and methods of incorporation of concurrently grown daincha on dry weight of total weeds ($g\ m^{-2}$) in wet sown rice at 50DAS

Stages of incorporation \ Methods of incorporation	1st year			2nd year			Pooled		
	Cono weeding	2,4- D	Almix	Cono weeding	2,4- D	Algrip	Cono weeding	2,4- D	Almix / Algrip
20DAS	21.69	18.16	19.82	32.67	27.96	28.62	27.18	23.05	24.22
30DAS	18.89	19.22	22.29	30.38	29.92	30.98	24.63	24.57	26.63
CD (0.05)	2.58			3.86			2.25		

4.3.5. Nutrient content and nutrient uptake of plants

4.3.5.1. Nutrient content of rice

4.3.5.1.1. Nitrogen content

Nitrogen contents of rice, with concurrent growing of daincha, at all the growth stages were significantly higher compared with pure crop of rice (Table 4.3.15). Nitrogen contents of rice at active tillering and panicle initiation stage were not significantly affected by stage of incorporation of daincha, method of incorporation and levels of nitrogen. The N contents of rice in concurrently grown daincha treatment was highest at active tillering stage followed a decline at panicle initiation stage and then increases at harvest stage. Nitrogen contents of pure crop of rice showed a declining trend as the plant matures. At harvest stage, N content of rice with concurrent growing of daincha was significantly influenced by the stages of incorporation. Daincha incorporation at 30 DAS recorded significantly higher N content (0.864%) compared with daincha incorporation at 20 DAS (0.701%). Methods of incorporation, levels of nitrogen and interaction did not influence the N content of rice.

4.3.5.1.2. Phosphorus content

Concurrent growing of daincha at different stages, methods of incorporation and levels of nitrogen had no significant influence of the P content of rice at active tillering and panicle initiation stages (Table 4.3.16). At harvest stage, P content of rice with concurrent growing of daincha was significantly influenced by the stages of incorporation. Daincha incorporation at 30 DAS recorded significantly higher P content (0.135%) compared with daincha incorporation at 20 DAS (0.116%) and pure crop of rice (0.073%). Phosphorus contents at active tillering and panicle initiation stages of rice grown along with green manure crops were comparable to rice grown alone. The plant P content increased as the plant matures and then decreased at harvest. Interactions had no significant influence on the P content of rice at various growth stages.

Table 4.3.15. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels on nitrogen content (%) of wet sown rice at different growth stages

	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Stages of incorporation									
20 DAS	0.888	1.369	1.128	0.888	0.671	0.780	0.793	0.609	0.701
30 DAS	0.882	1.431	1.156	0.937	0.726	0.831	0.937	0.791	0.864
CD (0.05)	0.123	NS	NS	NS	NS	NS	0.084	0.119	0.095
Methods of incorporation									
Conoweeding	0.921	1.367	1.144	0.901	0.648	0.775	0.902	0.702	0.802
2,4-D spray	0.857	1.495	1.176	0.917	0.764	0.840	0.882	0.721	0.801
Almix/Algrip spray	0.876	1.338	1.107	0.920	0.682	0.801	0.812	0.677	0.744
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	0.898	1.415	1.157	0.897	0.703	0.800	0.904	0.720	0.812
75% N	0.871	1.385	1.128	0.928	0.693	0.811	0.826	0.679	0.752
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	0.690	1.157	0.923	0.787	0.590	0.688	0.627	0.430	0.528
Interaction effects - NS									

Table 4.3.16. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels on phosphorus content (%) of wet sown rice at different growth stages

	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Stages of incorporation									
20 DAS	0.261	0.128	0.195	0.254	0.232	0.243	0.173	0.059	0.116
30 DAS	0.263	0.126	0.194	0.260	0.247	0.253	0.168	0.102	0.135
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	0.022	0.021
Methods of incorporation									
Conoweeding	0.260	0.122	0.161	0.257	0.234	0.245	0.180	0.084	0.132
2,4-D spray	0.260	0.121	0.190	0.256	0.256	0.256	0.175	0.076	0.125
Almix/Algrip spray	0.267	0.138	0.203	0.258	0.227	0.243	0.157	0.081	0.119
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	0.257	0.132	0.194	0.258	0.235	0.247	0.172	0.085	0.129
75% N	0.268	0.122	0.195	0.256	0.243	0.249	0.169	0.076	0.122
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	0.210	0.127	0.168	0.277	0.177	0.227	0.103	0.043	0.073
Interaction effects - NS									

4.3.5.1.3. Potassium content

Different treatments had no significant influence on the K content of rice at various growth stages (Table 4.3.17). Potassium contents of rice at all the growth stages were significantly higher when rice was grown along with daincha compared with rice grown alone. Potassium content of rice was found maximum at panicle initiation stage irrespective of rice grown along with daincha or alone. Interactions showed no significance on the K content at different growth stages

4.3.5.2. Nutrient uptake

4.3.5.2.1. Nitrogen uptake

Nitrogen uptake of rice grown along with daincha was significantly higher than the N uptake of pure crop of rice at various growth stages (Table 4.3.18). Stages and methods of incorporation of concurrently grown daincha and levels of nitrogen had no significant influence on the nitrogen uptake of rice at active tillering stage. At panicle initiation stage, daincha incorporation using 2, 4-D recorded the highest N uptake. Stages of incorporation of daincha and levels of nitrogen failed to show any significant effect at this stage. The uptake of N with daincha incorporation at 30 DAS was found significantly superior than the N uptake at 20 DAS and pure crop of rice at harvest stage. Methods of incorporation of daincha and levels of nitrogen showed no significant effect at this stage. Nitrogen uptake of rice showed an increasing trend as the plant matured. Interaction effects had no significance on N uptake of dry sown rice.

4.3.5.2.2. Phosphorus uptake

Different stages and methods of incorporation of daincha and levels of nitrogen had no significant influence on the P uptake of rice at various growth stages (Table 4.3.19). Phosphorus uptake of rice grown along with daincha at all stages was significantly higher than the P uptake of pure crop of rice. Maximum uptake of phosphorus was noticed at panicle initiation stage irrespective of the treatments. Interaction effects failed to show any significance on the P uptake of dry sown rice.

Table 4.3.17. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels on potassium content (%) of wet sown rice at different growth stages

	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Stages of incorporation									
20 DAS	1.162	2.231	1.697	1.204	2.171	1.688	1.217	2.122	1.624
30 DAS	1.109	2.180	1.644	1.236	2.391	1.813	1.162	2.100	1.631
CD (0.05)	NS	NS	NS	NS	0.183	NS	NS	NS	NS
Methods of incorporation									
Conoweeding	1.140	2.160	1.650	1.193	2.187	1.690	1.183	2.103	1.643
2,4-D spray	1.117	2.243	1.680	1.240	2.440	1.840	1.097	2.133	1.615
Almix/Algrip spray	1.150	2.213	1.682	1.227	2.217	1.722	1.153	2.097	1.625
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	1.102	2.262	1.682	1.200	2.278	1.739	1.124	2.133	1.629
75% N	1.169	2.149	1.659	1.240	2.284	1.762	1.164	2.089	1.627
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	0.867	1.960	1.413	1.133	1.933	1.533	0.973	1.760	1.367
Interaction effects - NS									

Table 4.3.18. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels uptake (kg ha^{-1}) of wet sown rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Stages of incorporation									
20 DAS	47.35	47.36	47.36	86.34	43.57	64.96	69.72	46.08	57.90
30 DAS	48.92	53.86	51.39	87.58	43.90	65.74	83.67	53.45	68.56
CD (0.05)	NS	6.52	NS	NS	NS	NS	8.19	NS	7.75
Methods of incorporation									
Conoweeding	48.74	48.56	48.65	82.19	39.95	61.07	78.39	49.37	63.88
2,4-D spray	47.47	54.42	50.95	94.66	49.00	71.83	77.86	52.63	65.24
Almix/Algrip spray	48.20	48.85	48.53	84.04	42.27	63.15	73.83	47.30	60.56
CD (0.05)	NS	NS	NS	NS	NS	9.81	NS	NS	NS
Levels of nitrogen									
100% N	48.76	51.61	50.18	85.96	43.56	64.76	81.67	50.46	66.06
75% N	47.51	49.61	48.56	87.97	43.92	65.94	71.72	49.07	60.39
CD (0.05)	NS	NS	NS	NS	NS	NS	8.19	NS	NS
Rice alone	36.73	38.23	37.48	73.98	31.94	52.96	45.65	26.24	35.95
Interaction effects - NS									

4.3.5.2.3. Potassium uptake

Different treatments had no significant influence on the K uptake of rice at various growth stages (Table 4.3.20). Potassium uptake at all the growth stages of rice grown along with daincha was significantly higher compared with rice grown as pure crop. Potassium uptake of rice showed an increasing trend up to panicle initiation stage and then decreased as the crop matured. None of the interaction was found significant on K uptake at various growth stages.

4.3.5.3. Nutrient content of daincha

Data on nutrient content of daincha grown along with wet sown rice is given in Table 4.3.21.

Nitrogen content of daincha was not affected by the stages and methods of incorporation of daincha. Levels of nitrogen did not influence the nitrogen content of the green manure crops

Stages of incorporation of daincha significantly influence the phosphorus content. Phosphorus content of daincha was higher at the stage of 20 DAS. Levels of nitrogen had no significant influence on the P content of green manure crops.

There was no significant difference in the potassium content of daincha due to stage of incorporation, method of incorporation and nitrogen levels.

4.3.5.4 . Nutrient contribution by daincha

Nutrient contribution of daincha grown along with wet seeded rice is presented in Table 4.3.22.

Contribution of nitrogen by daincha incorporated at the age of 30 days (126.41kg ha^{-1}) was significant and more than three times as that of incorporation of daincha at 20 DAS (40.14 kg ha^{-1}). Nitrogen contribution of daincha was not significantly affected by the methods of incorporation and levels of nitrogen.

Phosphorus contribution of daincha incorporated at the age of 30 days (8.86 kg ha^{-1}) was significantly superior to that of incorporation of daincha at 20 DAS(5.57 kg ha^{-1}).

Table 4.3.19. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels on phosphorus uptake (kg ha^{-1}) of wet sown rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Stages of incorporation									
20 DAS	13.97	4.46	9.21	24.67	15.09	19.88	15.20	4.47	9.83
30 DAS	14.55	4.73	9.64	24.36	15.07	19.72	15.05	6.97	11.01
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	1.41	NS
Methods of incorporation									
Conoweeding	13.80	4.36	9.08	23.45	14.57	19.01	15.67	5.84	10.75
2,4-D spray	14.28	4.41	9.34	26.44	16.52	21.48	15.41	5.51	10.46
Almix/Algrip spray	14.70	5.02	9.86	23.66	14.16	18.91	14.29	5.80	10.05
CD (0.05)	NS	NS	NS	NS	NS	2.96	NS	NS	NS
Levels of nitrogen									
100% N	13.91	4.81	9.36	24.79	14.76	19.77	15.62	5.93	10.77
75% N	14.61	4.38	9.49	24.25	15.40	19.83	14.63	5.50	10.07
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	11.16	4.17	7.67	25.95	9.37	17.66	7.54	2.62	5.08
Interaction effects - NS									

Table 4.3.20. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels on potassium uptake (kg ha^{-1}) of wet sown rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Stages of incorporation									
20 DAS	62.25	77.55	69.90	117.48	140.75	129.11	98.82	161.84	130.33
30 DAS	60.97	82.11	71.54	115.42	145.10	130.26	104.26	143.35	123.80
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	16.84	NS
Methods of incorporation									
Conoweeding	59.78	77.41	68.59	108.73	135.12	121.93	103.66	150.33	126.99
2,4-D spray	61.78	81.58	71.68	127.98	156.85	142.42	96.37	158.12	127.25
Almix/Algrip spray	63.27	80.51	71.89	112.63	136.81	124.72	104.58	149.34	126.96
CD (0.05)	NS	NS	NS	11.68	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	59.55	82.89	71.22	114.93	142.16	128.55	102.06	150.20	126.18
75% N	63.67	76.77	70.22	117.97	143.69	130.83	101.02	154.89	127.95
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rice alone	46.12	64.72	55.42	106.15	104.70	105.43	71.06	108.72	89.89
Interaction effects - NS									

Table 4.3.21. Nutrient content (%) of daincha grown along with wet sown rice

Treatments	N content			P content			K content		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Stages of incorporation									
20 DAS	1.543	1.493	1.518	0.229	0.196	0.213	1.549	3.002	2.276
30 DAS	2.454	1.774	2.114	0.165	0.130	0.147	1.711	2.780	2.246
CD (0.05)	NS	0.093	NS	0.022	0.014	0.015	0.109	NS	NS
Methods of incorporation									
Conoweeding	2.796	1.663	2.229	0.194	0.178	0.186	1.643	2.820	2.232
2,4-D spray	1.599	1.630	1.615	0.199	0.152	0.176	1.657	2.943	2.300
Almix/Algrip spray	1.600	1.608	1.604	0.198	0.158	0.178	1.590	2.910	2.250
CD (0.05)	NS	NS	NS	NS	0.017	NS	NS	NS	NS
Levels of nitrogen									
100% N	1.596	1.630	1.613	0.199	0.166	0.182	1.640	2.951	2.296
75% N	2.401	1.637	2.019	0.196	0.161	0.178	1.620	2.831	2.226
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4.3.22. Nutrient contribution (kg ha^{-1}) of daincha grown along with wet sown rice

Treatments	N			P			K		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Stages of incorporation									
20 DAS	34.30	45.99	40.14	5.11	6.02	5.57	34.43	92.50	63.47
30 DAS	135.21	117.61	126.41	9.12	8.60	8.86	93.92	184.52	139.22
CD (0.05)	90.36	5.43	43.84	1.27	0.66	0.73	NS	15.33	7.81
Methods of incorporation									
Conoweeding	130.02	82.93	106.48	6.96	7.97	7.47	65.51	136.34	100.92
2,4-D spray	62.95	82.97	72.96	7.33	6.77	7.05	66.07	140.75	103.41
Almix/Algrip spray	61.30	79.49	70.40	7.05	7.20	7.13	60.94	138.45	99.70
CD (0.05)	NS	NS	NS	NS	0.80	NS	NS	NS	NS
Levels of nitrogen									
100% N	63.93	80.92	72.43	7.38	7.54	7.46	66.08	140.33	103.20
75% N	105.58	82.67	94.13	6.85	7.09	6.97	62.27	136.69	99.48
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Methods of incorporation and levels of nitrogen had no significant influence on P addition by daincha.

Significant difference was noticed in the potassium contribution of daincha due to stages of incorporation. Potassium contribution of daincha incorporated at the age of 30 days (139.22 kg ha^{-1}) was almost double to that of incorporation of daincha at 20 DAS (63.47 kg ha^{-1}). Methods of incorporation and levels of nitrogen behaved similarly in K contribution of daincha.

4.3.6. Soil Nutrient status

4.3.6.1. Organic Carbon (%)

Organic carbon percentage of soil increased significantly by concurrent growing of daincha along with rice compared to pure crop of rice (Table 4.3.23.). Stages and methods of incorporation of daincha, levels of nitrogen and interactions showed no appreciable variation in the soil organic carbon content.

4.3.6.2. Available nitrogen

Available nitrogen content in soil showed significant increase by concurrent growing of daincha compared to pure crop of rice (Table 4.3.23). Incorporation of daincha at 30 DAS resulted in significantly superior nitrogen content of soil (360.48 kg ha^{-1}) than incorporation of daincha at 20 DAS (323.97 kg ha^{-1}). Methods of incorporation did not influence the soil available nitrogen content. Interactions also had no significant influence on the available nitrogen content of the soil. Available nitrogen content of soil was significantly higher with 100 per cent nitrogen compared with 75 per cent nitrogen.

4.3.6.3. Available phosphorus

Available soil phosphorus content was less in pure crop of rice compared to rice intercropped with daincha (Table 4.3.23). Phosphorus content of soil was not affected by the stages and methods of incorporation of daincha and levels of nitrogen. There was no significant difference in the available phosphorus content of the soil due to interactions.

Table 4.3.23. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels on soil nutrient status of wet sown rice at harvest

Treatments	Organic carbon (%)			Available nitrogen (kg ha^{-1})			Available phosphorus (kg ha^{-1})			Available potassium (kg ha^{-1})		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Mean
Stages of incorporation												
20 DAS	0.673	1.023	0.848	257.68	390.26	323.97	74.51	66.66	70.58	127.56	1437.33	782.44
30 DAS	0.698	1.075	0.886	285.41	435.56	360.48	77.45	80.87	79.16	139.22	1524.44	831.83
CD (0.05)	NS	NS	NS	21.05	32.00	27.21	10.84	5.57	6.31	10.84	NS	*
Methods of incorporation												
Conoweeding	0.664	1.083	0.873	273.67	388.87	331.27	74.27	71.38	72.83	131.83	1484.00	807.92
2,4-D spray	0.688	1.025	0.857	271.09	425.45	348.27	78.26	71.79	75.03	130.67	1493.33	812.00
Almix/Algrip spray	0.703	1.040	0.872	269.87	424.40	347.14	75.37	78.13	76.76	137.67	1465.33	801.50
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*
Levels of nitrogen												
100% N	0.716	1.072	0.894	278.82	425.80	352.31	75.17	76.33	75.75	137.67	1561.78	849.72
75% N	0.655	1.027	0.841	264.27	400.02	332.14	76.78	71.21	73.99	129.11	1400.00	764.56
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	5.57	NS	NS	140.10	*
Rice alone	0.623	0.620	0.622	235.20	267.60	251.40	65.28	58.01	61.64	116.67	1344.00	730.33
Interaction effects - NS												

*** Pooling not possible as the errors heterogenous and interaction absent**

Initial soil test data	0.480	0.570	0.525	232.06	263.42	247.74	59.86	72.37	66.12	112.00	1120.00	616.00

4.3.6.3. Available potassium

Potassium content of the soil was significantly higher in daincha intercropped treatments compared to rice grown alone (Table 4.3.23). The highest soil K content was recorded in treatments involving incorporation of daincha at 30 DAS (831.83 kg ha^{-1}) compared to incorporation of daincha at 20 DAS (782.44 kg ha^{-1}). Soil K content was not affected by different methods of incorporation and levels of nitrogen. No significant difference was noticed due to interactions.

4.3.7. Nitrogen release pattern

4.3.7.1. Ammoniacal nitrogen release pattern

Ammoniacal nitrogen (NH_4^+-N) release pattern from wet sown rice crop as affected by stages and methods of incorporation of daincha and levels of nitrogen during the 1st year, 2nd year and pooled data is presented in Tables 4.3.24, 4.3.25 and 4.3.26 respectively.

Data on soil NH_4^+-N suggested that release of nitrogen from daincha was fast. Stages of incorporation of daincha had significant influence on the ammoniacal nitrogen release from daincha. Up to 35 DAS (15 DAI of 20 days old daincha and 5 DAI of 30 days old daincha), the ammoniacal nitrogen release from pure crop of rice receiving 5t ha^{-1} of farm yard manure at the time of planting was significantly higher followed by incorporation of 20 days old daincha. From 40 DAS (20 DAI of 20 days old daincha and 10DAI of 30 days old daincha), onwards the ammoniacal nitrogen release was significantly higher in 30 days old daincha incorporated treatments followed by incorporation of 20 days old daincha. There was increased release of NH_4^+-N up to 30 DAI of daincha and subsequently release of NH_4^+-N declined up to harvest. The maximum release of NH_4^+-N from 20 days old daincha (157.02 kg ha^{-1}) was noticed at 50DAS *i.e.,* 30 DAI. Similarly the maximum release of NH_4^+-N from 30 days old daincha (176.53 kg ha^{-1}) was noticed at 60DAS *i.e.,* 30 DAI. In pure crop of rice, the maximum value of NH_4^+-N was noticed at 50DAS and afterwards the value was found decreasing. Methods of incorporation of daincha did not significantly influence the pattern of ammoniacal nitrogen release. Levels of nitrogen showed significant influence on the ammoniacal nitrogen release. The NH_4^+-N release from treatments receiving 100 per cent N was significantly superior to that of 75 per cent nitrogen. Up

Table 4.3.24. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels on ammoniacal nitrogen release pattern (kg ha^{-1}) from wet sown rice during 1st year

Treatments	20DAS	25DAS	30DAS	35DAS	40DAS	45DAS	50DAS	55DAS	60DAS	80DAS	Harvest
Stages of incorporation											
20 DAS	81.10	94.51	103.66	116.47	126.22	136.59	156.10	151.22	141.47	151.22	139.64
30 DAS	78.66	81.71	79.27	112.20	128.66	136.59	163.42	166.47	171.35	167.69	151.83
CD (0.05)	NS	3.51	4.82	3.84	NS	NS	4.95	4.99	4.51	4.71	5.40
Methods of incorporation											
Conoweeding	78.66	86.89	91.47	115.25	128.97	137.20	160.98	159.15	156.41	157.32	143.60
2,4-D spray	82.32	87.81	91.47	112.50	126.22	136.29	159.15	159.15	156.41	161.90	148.18
Almix/Algrip spray	78.66	89.64	91.47	115.25	127.14	136.29	159.15	158.24	156.41	159.15	145.43
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen											
100% N	82.94	89.64	94.51	115.25	131.10	140.25	165.25	163.42	160.98	163.42	149.39
75% N	76.83	86.59	88.42	113.42	123.78	132.93	154.27	154.27	151.83	155.49	142.08
CD (0.05)	4.36	NS	4.82	NS	4.61	5.02	4.95	4.99	4.51	4.71	5.40
Rice alone	109.76	113.42	124.39	131.71	128.05	135.37	160.98	142.69	139.03	153.66	139.03
Interaction effects - NS											

Table 4.3.25. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels on ammoniacal nitrogen release pattern (kg ha^{-1}) from wet sown rice during 2nd year

Treatments	20DAS	25DAS	30DAS	35DAS	40DAS	45DAS	50DAS	55DAS	60DAS	80DAS	Harvest
Stages of incorporation											
20 DAS	83.538	92.687	102.44	115.86	119.52	133.54	157.93	154.88	148.18	149.39	140.86
30 DAS	84.76	82.929	82.929	112.2	128.66	135.37	168.91	170.13	181.71	178.06	156.71
CD (0.05)	NS	3.54	4.86	NS	4.18	NS	4.10	4.88	4.46	6.26	5.48
Methods of incorporation											
Conoweeding	83.234	86.895	90.552	116.16	126.22	133.54	164.64	162.81	164.64	160.98	147.26
2,4-D spray	85.978	87.808	93.296	112.5	123.48	135.37	160.98	161.9	163.73	162.81	150.01
Almix/Algrip spray	83.234	88.722	94.21	113.42	122.57	134.46	164.64	162.81	166.47	167.38	149.09
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen											
100% N	89.64	92.69	98.18	117.69	129.88	140.25	170.74	169.52	172.57	170.74	154.88
75% N	78.66	82.93	87.20	110.37	118.30	128.66	156.10	155.49	157.32	156.71	142.69
CD (0.05)	3.02	3.54	4.86	3.98	4.18	3.40	4.10	4.88	4.46	6.26	5.48
Rice alone	98.78	106.10	109.76	113.42	117.08	120.74	142.69	139.03	135.37	142.69	131.71
Interaction effects - NS											

Table 4.3.26. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels on ammoniacal nitrogen release pattern (kg ha^{-1}) from wet sown rice (pooled data)

Treatments	20DAS	25DAS	30DAS	35DAS	40DAS	45DAS	50DAS	55DAS	60DAS	80DAS	Harvest
Stages of incorporation											
20 DAS	82.32	93.60	103.05	116.16	122.87	135.07	157.02	153.06	144.82	150.31	140.25
30 DAS	81.71	82.32	81.10	112.20	128.66	135.98	166.17	168.30	176.53	172.87	154.27
CD (0.05)	NS	3.60	4.80	4.06	4.23	NS	4.73	4.48	4.34	8.28	5.08
Methods of incorporation											
Conoweeding	80.95	86.89	91.01	115.71	127.60	135.37	162.81	160.98	160.52	159.15	145.43
2,4-D spray	84.15	87.81	92.38	112.50	124.85	135.83	160.07	160.52	160.07	162.35	149.09
Almix/Algrip spray	80.95	89.18	92.84	114.33	124.85	135.37	161.90	160.52	161.44	163.27	147.26
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen											
100% N	86.28	91.16	96.34	116.47	130.49	140.25	167.99	166.47	166.78	167.08	152.14
75% N	77.75	84.76	87.81	111.90	121.04	130.80	155.19	154.88	154.58	156.10	142.38
CD (0.05)	3.78	3.60	4.80	4.06	4.23	4.03	4.73	4.48	4.34	8.28	5.08
Rice alone	104.27	109.76	117.08	122.57	122.57	128.05	151.83	140.86	137.20	148.18	135.37

Table 4.3.27. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels on nitrate nitrogen release pattern (kg ha^{-1}) from wet sown rice during 1st year

Treatments	20DAS	25DAS	30DAS	35DAS	40DAS	45DAS	50DAS	55DAS	60DAS	80DAS	Harvest
Stages of incorporation											
20 DAS	12.72	15.68	14.81	13.94	12.89	12.72	21.43	24.91	24.74	25.44	28.05
30 DAS	13.59	14.29	12.02	15.33	17.25	17.77	23.69	25.44	25.79	27.00	30.84
CD (0.05)	NS	1.25	1.48	1.35	1.19	1.23	1.26	NS	NS	1.34	1.53
Methods of incorporation											
Conoweeding	13.33	15.16	14.37	15.42	15.42	15.68	23.00	24.83	25.87	26.13	30.05
2,4-D spray	13.33	15.16	12.81	14.11	15.16	15.42	22.21	25.61	24.83	26.40	30.05
Almix/Algrip spray	12.81	14.64	13.07	14.37	14.64	14.64	22.48	25.09	25.09	26.13	28.22
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen											
100% N	14.11	16.38	14.81	16.20	16.20	16.55	23.69	26.48	26.66	27.53	30.84
75% N	12.20	13.59	12.02	13.07	13.94	13.94	21.43	23.87	23.87	24.91	28.05
CD (0.05)	1.39	1.25	1.48	1.35	1.19	1.23	1.26	1.67	1.22	NS	1.53
Rice alone	15.68	18.82	16.73	15.68	14.64	13.59	20.91	23.00	20.91	23.00	24.04
Interaction effects - NS											

Table 4.3.26.1. Interaction effect of stage of incorporation of daincha and levels of N on NH_4^+-N release (kg ha-1)) from wet sown rice at 60DAS

Stages of incorporation \ Levels of N	1st year		2nd year		Pooled	
	100%	75%	100%	75%	100%	75%
20DAS	145.11	137.8	153.65	142.66	149.38	140.25
30DAS	176.83	165.83	191.49	171.96	184.14	168.91
CD (0.05)	6.4		6.44		4.49	

Table 4.3.26.2. Interaction effect of stage of incorporation of daincha and levels of N on NH_4^+-N (kg ha^{-1}) release from wet sown rice at harvest

Stages of incorporation \ Levels of N	1st year		2nd year		Pooled	
	100%	75%	100%	75%	100%	75%
20DAS	141.47	137.8	143.89	137.8	142.7	137.8
30DAS	157.29	146.34	165.83	147.56	161.6	146.97
CD (0.05)	7.85		8.12		5.36	

to 35DAS the ammoniacal nitrogen release from pure crop of rice receiving 5 t ha^{-1} of farm yard manure and 100 per cent N was significantly higher than rice with concurrent growing of daincha receiving 100 and 75 per cent N. From 40 DAS onwards the ammoniacal nitrogen release was significantly higher in 100 per cent N compared with 75 per cent N and pure crop of rice.

Interaction effect of stages of incorporation of daincha and levels of nitrogen significantly influenced the release of NH_4^+-N at 60 DAS and harvest. Incorporation of 30 days old daincha along with 100 per cent of nitrogen resulted in the highest release of NH_4^+-N at 60 DAS and harvest. Other interactions showed no significant difference on the ammoniacal nitrogen release.

4.3.7.2. Nitrate nitrogen release pattern

Nitrate nitrogen (NO_3^--N) release pattern from wet sown rice crop, as affected by stages and methods of incorporation of daincha and levels of nitrogen during the 1st year, 2nd year and pooled data is presented in Table 4.3.27, 4.3.28 and 4.3.29 respectively.

Release of nitrate nitrogen showed an increasing trend up to harvest irrespective of the treatments. Up to 30 DAS, NO_3^--N release was significantly higher in pure crop of rice. From 40 DAS onwards the NO_3^--N release was significantly higher in 30 days old daincha incorporated treatments compared to incorporation of daincha at 20 DAS and pure crop of rice. The maximum release of NO_3^- -N was noticed at harvest, irrespective of the treatments. Methods of incorporation of daincha did not significantly influence the NO_3^- -N release. Levels of nitrogen showed significant influence on the nitrate nitrogen release from daincha incorporated treatments. Significantly higher release of NO_3^- -N was observed with 100 per cent N compared to 75 per cent nitrogen. None of the interaction effects showed any significant influence on the NO_3^--N release

Table 4.3.28. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels on nitrate nitrogen release pattern (kg ha^{-1}) from wet sown rice during 2nd year

Treatments	20DAS	25DAS	30DAS	35DAS	40DAS	45DAS	50DAS	55DAS	60DAS	80DAS	Harvest
Stages of incorporation											
20 DAS	14.11	15.85	16.20	16.03	15.68	16.90	20.91	22.65	24.74	26.13	27.88
30 DAS	14.29	14.29	14.11	16.20	17.95	18.29	24.04	25.44	27.35	27.88	30.32
CD (0.05)	NS	0.96	1.44	NS	1.23	1.23	1.15	1.80	1.36	1.33	1.32
Methods of incorporation											
Conoweeding	14.64	14.90	15.42	16.99	16.99	17.77	22.21	23.78	26.40	26.92	29.53
2,4-D spray	14.11	14.90	14.90	15.42	16.73	17.25	22.74	24.30	25.87	27.18	29.27
Almix/Algrip spray	13.85	15.42	15.16	15.94	16.73	17.77	22.48	24.04	25.87	26.92	28.49
CD (0.05)	NS	NS	NS	1.33	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen											
100% N	15.16	16.55	16.38	17.42	18.12	19.16	23.87	25.26	27.53	28.75	30.66
75% N	13.24	13.59	13.94	14.81	15.51	16.03	21.08	22.82	24.57	25.26	27.53
CD (0.05)	0.91	0.96	1.44	1.08	1.23	1.23	1.15	1.80	1.36	NS	1.32
Rice alone	15.68	16.73	15.68	13.59	12.54	11.50	18.82	17.77	16.73	18.82	20.91
Interaction effects - NS											

Table 4.3.29. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels on nitrate nitrogen release pattern (kg ha^{-1}) from wet sown rice (pooled data)

Treatments	20DAS	25DAS	30DAS	35DAS	40DAS	45DAS	50DAS	55DAS	60DAS	80DAS	Harvest
Stages of incorporation											
20 DAS	13.42	15.77	15.51	14.98	14.29	14.81	21.17	23.78	24.74	25.79	27.96
30 DAS	13.94	14.29	13.07	15.77	17.60	18.03	23.87	25.44	26.57	27.44	30.58
CD (0.05)	NS	1.02	1.33	NS	1.19	2.10	1.11	1.61	1.26	1.29	1.31
Methods of incorporation											
Conoweeding	13.98	15.03	14.90	16.20	16.20	16.73	22.61	24.30	26.13	26.53	29.79
2,4-D spray	13.72	15.03	13.85	14.77	15.94	16.33	22.48	24.96	25.35	26.79	29.66
Almix/Algrip spray	13.33	15.03	14.11	15.16	15.68	16.20	22.48	24.57	25.48	26.53	28.36
CD (0.05)	NS	NS	NS	1.44	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen											
100% N	14.64	16.46	15.59	16.81	17.16	17.86	23.78	25.87	27.09	28.14	30.75
75% N	12.72	13.59	12.98	13.94	14.72	14.98	21.26	23.35	24.22	25.09	27.79
CD (0.05)	1.06	1.02	1.33	1.17	1.19	2.10	1.11	1.61	1.26	1.29	1.31
Rice alone	15.68	17.77	16.20	14.64	13.59	12.54	19.86	20.38	18.82	20.91	22.48
Interaction effects - NS											

4.3.8. Economics

4.3.8.1. Gross Return

Concurrent growing of daincha with rice significantly increased the gross return of rice over pure crop of rice (Table 4.3.30). Incorporation of daincha at 30 DAS recorded the highest gross return (Rs.43332 ha^{-1}) compared with incorporation of daincha at 20 DAS. Gross return of rice was not affected by the methods of incorporation. Levels of nitrogen had significant influence on gross return. Gross return of rice was significantly higher with 100 per cent nitrogen (Rs.43172 ha^{-1}). Interactions had not significantly influence the gross return.

4.3.8.2. Net Return

Concurrent growing of daincha significantly increased the net return from rice (Table 4.3.30). Net return was found to be the highest when daincha was incorporated at the age of 30 days (Rs.27473 ha^{-1}) compared daincha incorporation at 20 DAS. Pure crop of rice recorded the least net return (Rs.16135 ha^{-1}). Net return obtained with 100 per cent N (Rs.27190 ha^{-1}) was significantly higher than 75 per cent N (Rs.25519 ha^{-1}). Methods of incorporation of daincha and interactions did not affect the net return.

4.3.8.3. Benefit: Cost Ratio

Benefit: cost ratio of rice with concurrent growing of daincha was significantly higher than rice grown alone (Table 4.3.30). The highest B: C ratio was recorded when daincha was incorporated at 30 DAS (2.73). Methods of incorporation of green manure crops had no influence on the B: C ratio. The B: C ratio was significantly higher at 100 per cent N (2.70). Benefit: cost ratio was not affected by any of the interactions.

Table 4.3.30. Effect of stages and methods of incorporation of concurrently grown daincha and nitrogen levels on the economics of wet sown rice

Treatments	Gross Return			Net Return			BC ratio		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Stages of incorporation									
20 DAS	42408	39780	41094	26550	23921	25236	2.68	2.51	2.59
30 DAS	44902	41761	43332	29044	25903	27473	2.83	2.63	2.73
CD (0.05)	1627	1904	1615	1627	1904	1615	0.10	0.12	0.10
Methods of incorporation									
Conoweeding	43990	41520	42755	27769	25298	26533	2.71	2.56	2.64
2,4-D spray	43627	40635	42131	28045	25053	26549	2.80	2.61	2.70
Almix/Algrip spray	43348	40156	41752	27577	24384	25981	2.75	2.55	2.65
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of nitrogen									
100% N	44611	41732	43172	28630	25750	27190	2.79	2.61	2.70
75% N	42699	39808	41254	26964	24074	25519	2.71	2.53	2.62
CD (0.05)	1627.4	NS	1615	1627	NS	1615	NS	NS	0.10
Rice alone	40622	35037	37830	18927	13342	16135	1.87	1.62	1.74
Interaction effects - NS									

4.4. RESIDUAL EFFECT OF CONCURRENT GROWING OF DAINCHA IN THE SUCCEEDING TRANSPLANTED RICE

4.4.1. Growth characters of succeeding rice crop

4.4.1.1. Height of plants

Concurrent growing of daincha in wet seeded rice during the preceding crop season had no significant influence on the height of succeeding crop of rice at different growth stages (Table 4.4.1). Nitrogen application at different levels to the succeeding crop significantly influenced the height of succeeding crop at panicle initiation stage. Nitrogen at 100 per cent recorded the highest plant height compared with 75 per cent N. Interaction effects failed to show any significant influence on plant height of succeeding rice crop.

4.4.1.2. Number of tillers hill^{-1}

The results showed that concurrent growing of daincha, its stages and methods of incorporation and levels of nitrogen in wet seeded crop did not significantly influence the number of tillers hill^{-1} of succeeding rice (Table 4.4.2). Nitrogen applied to the succeeding crop showed significant influence on the number of tillers hill^{-1} at panicle initiation stage only. Nitrogen at 100 per cent recorded the highest tiller production hill^{-1} compared with 75 per cent N. Interaction effects had no significant influence on this character at different growth stages.

4.4.1.3. Number of tillers m^{-2}

Tiller production m^{-2} of succeeding crop was found significantly influenced only at panicle initiation stage by the treatment effect of previous wet sown crop (Table 4.4.3). Different treatments had no significant influence on the number of tillers m^{-2} at active tillering and harvest stages. The tiller production of succeeding crop, where pure crop of rice was grown in the previous season, was numerically less. Application of different levels of nitrogen to the succeeding crop had significant influence on tiller production m^{-2} of succeeding crop at panicle initiation stage only. Tiller production m^{-2} was higher at panicle initiation stage in 100 per cent N compared with 75 per cent

Table 4.4.1. Residual effect of concurrent growing of daincha in wet seeded rice on height (cm) of succeeding transplanted rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot									
T_1 Daincha 20days+Cono+100%N	36.3	23.8	30.1	45.3	35.5	40.4	66.5	48.3	57.4
T_2 Daincha 20days+Cono+75%N	35.8	22.3	29.0	49.6	35.5	42.5	67.4	49.0	58.2
T_3 Daincha 20days+2,4-D+100%N	35.3	24.7	30.0	49.6	35.4	42.5	65.7	51.8	58.7
T_4 Daincha 20days+2,4-D+75%N	36.5	26.0	31.3	50.6	36.1	43.3	66.6	51.2	58.9
T_5 Daincha 20days+almix/algrip+100%N	36.6	24.8	30.7	48.8	36.1	42.4	68.6	51.8	60.2
T_6 Daincha 20days+almix/algrip+75%N	35.8	24.5	30.1	49.2	34.8	42.0	66.9	48.7	57.8
T_7 Daincha 30days+Cono+100%N	35.4	26.8	31.1	46.3	36.5	41.4	66.6	51.0	58.8
T_8 Daincha 30days+Cono+75%N	34.7	27.3	31.0	45.8	38.0	41.9	67.3	48.2	57.7
T_9 Daincha 30days+2,4-D+100%N	34.5	24.8	29.6	47.4	35.2	41.3	65.5	51.2	58.3
T_{10} Daincha 30days+2,4-D+75%N	35.6	27.3	31.5	45.6	36.7	41.1	65.5	50.8	58.2
T_{11} Daincha 30days+almix/algrip+100%N	35.1	25.0	30.0	50.3	34.7	42.5	68.2	53.0	60.6
T_{12} Daincha 30days+almix/algrip+75%N	35.9	26.2	31.0	48.3	36.7	42.5	67.0	50.7	58.8
T_{13} Rice alone+ 100%N	34.7	27.2	30.9	42.3	33.2	37.7	62.1	44.5	53.3
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub plot									
S_1 100%N	35.9	25.2	30.6	48.2	36.1	42.1	67.1	49.8	58.4
S_2 75% N	35.2	25.7	30.4	47.0	35.3	41.2	65.8	50.3	58.0
CD (0.05)	NS	NS	NS	NS	NS	0.9	NS	NS	NS
Interaction effects - NS									

Table 4.4.2. Residual effect of concurrent growing of daincha in wet seeded rice on number of tillers hill^{-1} of succeeding transplanted rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot									
Daincha 20days+Cono+100%N	8.8	6.6	7.7	8.3	4.2	6.2	9.3	6.3	7.8
T_2 Daincha 20days+Cono+75%N	9.2	6.7	7.9	9.4	4.1	6.8	11.2	6.7	8.9
T_3 Daincha 20days+2,4-D+100%N	6.8	6.5	6.7	7.5	4.8	6.2	9.2	7.0	8.1
T_4 Daincha 20days+2,4-D+75%N	8.0	6.7	7.3	8.9	4.6	6.8	8.3	7.0	7.7
T_5 Daincha 20days+almix/algrip+100%N	8.5	7.0	7.8	8.0	4.0	6.0	8.7	6.3	7.5
T_6 Daincha 20days+almix/algrip+75%N	8.6	7.3	7.9	8.9	5.1	7.0	10.7	6.2	8.4
T_7 Daincha 30days+Cono+100%N	7.5	6.5	7.0	7.7	4.7	6.2	8.8	8.7	8.8
T_8 Daincha 30days+Cono+75%N	8.3	6.3	7.3	8.9	5.0	6.9	10.8	6.7	8.8
T_9 Daincha 30days+2,4-D+100%N	8.6	6.1	7.3	9.0	5.3	7.2	10.3	6.5	8.4
T_{10} Daincha 30days+2,4-D+75%N	8.3	7.1	7.7	7.8	5.0	6.4	8.8	6.3	7.6
T_{11} Daincha 30days+almix/algrip+100%N	8.1	6.5	7.3	8.8	4.2	6.5	9.7	7.7	8.7
T_{12} Daincha 30days+almix/algrip+75%N	8.2	6.0	7.1	7.7	4.4	6.1	9.7	6.3	8.0
T_{13} Rice alone+ 100%N	7.3	5.4	6.3	7.2	4.0	5.6	7.0	5.2	6.1
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub plot									
S_1 100%N	8.4	6.6	7.5	8.7	4.7	6.7	9.5	6.9	8.2
S_2 75% N	7.9	6.4	7.1	7.9	4.4	6.2	9.3	6.5	7.9
CD (0.05)	NS	NS	NS	0.7	NS	0.4	NS	NS	NS
Interaction effects - NS									

Table 4.4.3. Residual effect of concurrent growing of daincha in wet seeded rice on number of tillers m^{-2} of succeeding transplanted rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot									
T_1 Daincha 20days+Cono+100%N	583.3	438.9	511.1	550.0	278.9	414.4	622.2	422.2	522.2
T_2 Daincha 20days+Cono+75%N	611.1	444.4	527.7	627.7	276.2	452.0	744.4	444.4	594.4
T_3 Daincha 20days+2,4-D+100%N	455.5	433.3	444.4	500.0	321.1	410.5	611.1	466.6	538.8
T_4 Daincha 20days+2,4-D+75%N	533.3	444.4	488.8	594.4	308.9	451.6	555.5	466.6	511.1
T_5 Daincha 20days+almix/algrip+100%N	566.6	466.6	516.6	533.3	264.4	398.9	577.7	422.2	500.0
T_6 Daincha 20days+almix/algrip+75%N	572.2	483.3	527.7	594.4	338.9	466.6	711.0	411.1	561.1
T_7 Daincha 30days+Cono+100%N	500.0	433.3	466.6	511.1	313.3	412.2	588.8	577.7	583.3
T_8 Daincha 30days+Cono+75%N	555.5	416.6	486.1	594.4	331.1	462.7	722.2	444.4	583.3
T_9 Daincha 30days+2,4-D+100%N	572.2	405.5	488.8	599.9	354.4	477.2	688.8	433.3	561.1
T_{10} Daincha 30days+2,4-D+75%N	555.5	472.2	513.8	522.2	335.5	428.9	588.8	422.2	505.5
T_{11} Daincha 30days+almix/algrip+100%N	538.8	433.3	486.1	588.8	280.0	434.4	644.4	511.1	577.7
T_{12} Daincha 30days+almix/algrip+75%N	544.4	398.9	471.6	511.1	291.1	401.1	644.4	422.2	533.3
T_{13} Rice alone+ 100%N	483.3	360.0	421.6	482.2	268.9	375.5	466.6	344.4	405.5
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub plot									
S_1 100%N	561.5	441.2	501.3	580.1	315.4	447.7	634.1	458.1	546.1
S_2 75% N	526.4	425.1	475.8	529.0	294.3	411.6	622.2	432.4	527.3
CD (0.05)	NS	NS	NS	47.2	NS	26.2	NS	NS	NS
Interaction effects - NS									

N. Interaction effects did not significantly influence the number of tillers m^{-2} at different growth stages.

4.4.1.4. Number of leaves hill^{-1}

Pooled data showed that concurrent growing of daincha, its stages and methods of incorporation and levels of nitrogen applied to the preceding crop had no significant influence on the number of leaves hill^{-1} at different growth stages (Table 4.4.4). The leaf production of succeeding crop, though not significant was numerically higher, wherein daincha was grown along with rice in the previous season. Leaf production of succeeding rice crop at panicle initiation was significantly higher in 100 per cent N compared with 75 per cent N. Interaction had not significantly influenced the leaf production of rice at different growth stages.

4.4.1.5. Leaf area hill^{-1}

The results showed that leaf area of succeeding crop of rice was not significantly affected by the different treatments imposed on the preceding crop (Table 4.4.5). The leaf area of rice crop, at all the growth stages, succeeding pure crop of rice during the 1st crop season was numerically less compared to the crop succeeding rice with daincha during 1st crop season. Levels of nitrogen had significant influence on the leaf area of rice at panicle initiation stage. At this stage leaf area of succeeding crop receiving 100 per cent N was significantly higher than that of 75 per cent N. Interaction effects did not significantly influence the leaf area at different growth stages.

4.4.1.6. Leaf area index

Leaf area index at different growth stages was not significantly influenced by the residual effect of the various treatments applied to the preceding crop (Table 4.4.6). At panicle initiation stage, the leaf area index of succeeding crop of rice was significantly higher in treatments receiving 100 per cent N. Interaction effects among different factors showed no significant influence on leaf area index of succeeding crop.

Table 4.4.4. Residual effect of concurrent growing of daincha in wet seeded rice on number of leaves hill^{-1} of succeeding transplanted rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot									
T_1 Daincha 20days+Cono+100%N	23.4	29.2	26.3	38.9	26.7	32.8	35.7	35.7	35.7
T_2 Daincha 20days+Cono+75%N	26.8	28.7	27.8	44.6	29.2	36.9	39.3	39.0	39.2
T_3 Daincha 20days+2,4-D+100%N	21.3	27.2	24.3	35.5	30.3	32.8	35.8	38.0	36.9
T_4 Daincha 20days+2,4-D+75%N	25.8	30.9	28.3	41.7	27.9	34.8	36.0	47.7	41.8
T_5 Daincha 20days+almix/algrip+100%N	23.9	27.5	25.7	38.5	26.2	32.3	34.7	39.5	37.1
T_6 Daincha 20days+almix/algrip+75%N	25.2	28.8	27.0	41.4	30.1	35.8	34.8	35.5	35.2
T_7 Daincha 30days+Cono+100%N	21.3	29.7	25.5	39.2	31.1	35.1	34.3	44.2	39.3
T_8 Daincha 30days+Cono+75%N	24.7	30.8	27.8	38.8	31.1	35.0	35.7	42.2	38.9
T_9 Daincha 30days+2,4-D+100%N	28.2	27.1	27.6	40.8	28.1	34.4	36.2	37.8	37.0
T_{10} Daincha 30days+2,4-D+75%N	21.9	32.6	27.3	35.5	31.6	33.6	36.0	37.7	36.8
T_{11} Daincha 30days+almix/algrip+100%N	24.5	31.0	27.8	39.4	27.1	33.3	35.5	39.0	37.3
T_{12} Daincha 30days+almix/algrip+75%N	23.1	27.3	25.2	34.4	28.4	31.4	38.8	36.8	37.8
T_{13} Rice alone+ 100%N	24.7	25.2	24.9	33.2	23.8	28.5	31.2	31.2	31.2
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub plot									
S_1 100%N	24.8	29.8	27.3	40.6	29.1	34.8	35.7	40.6	38.1
S_2 75% N	23.6	28.0	25.8	36.7	28.0	32.3	35.7	37.0	36.3
CD (0.05)	NS	1.8	NS	3.1	NS	1.8	3.4	2.4	NS
Interaction effects - NS									

Table 4.4.5. Residual effect of concurrent growing of daincha in wet seeded rice on leaf area hill^{-1} (cm^2) of succeeding transplanted rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot									
T_1 Daincha 20days+Cono+100%N	470.1	198.2	334.1	645.4	220.6	433.0	504.7	219.8	362.3
T_2 Daincha 20days+Cono+75%N	478.7	171.1	324.9	829.3	234.7	532.0	531.9	250.8	391.4
T_3 Daincha 20days+2,4-D+100%N	415.1	187.4	301.3	671.7	296.1	483.9	575.7	261.4	418.6
T_4 Daincha 20days+2,4-D+75%N	477.3	200.9	339.1	760.1	238.1	499.1	565.5	328.0	446.7
T_5 Daincha 20days+almix/algrip+100%N	433.1	182.8	308.0	683.2	200.8	442.0	543.0	248.3	395.6
T_6 Daincha 20days+almix/algrip+75%N	447.9	210.7	329.3	751.0	265.6	508.3	460.0	229.0	344.5
T_7 Daincha 30days+Cono+100%N	367.3	225.6	296.4	666.5	305.5	486.0	553.6	258.5	406.0
T_8 Daincha 30days+Cono+75%N	417.1	218.0	317.6	723.8	300.5	512.1	451.3	258.7	355.0
T_9 Daincha 30days+2,4-D+100%N	496.6	177.4	337.0	687.0	273.3	480.1	405.0	224.2	314.6
T_{10} Daincha 30days+2,4-D+75%N	356.3	271.2	313.7	578.3	337.1	457.7	524.7	243.7	384.2
T_{11} Daincha 30days+almix/algrip+100%N	437.6	202.9	320.3	657.9	215.1	436.5	604.9	232.5	418.7
T_{12} Daincha 30days+almix/algrip+75%N	421.2	176.6	298.9	594.4	271.2	432.8	655.8	218.6	437.2
T_{13} Rice alone+ 100%N	428.3	138.6	283.5	462.3	156.3	309.3	407.3	172.7	289.9
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub plot									
S_1 100%N	458.6	208.3	333.4	722.5	268.3	495.4	488.7	257.3	373.0
S_2 75% N	410.1	185.8	297.9	617.6	241.7	429.6	554.9	226.7	390.8
CD (0.05)	NS	20.3	NS	78.1	NS	41.7	NS	NS	NS
Interaction effects - NS									

Table 4.4.6. Residual effect of concurrent growing of daincha in wet seeded rice on leaf area index of succeeding transplanted rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot									
T_1 Daincha 20days+Cono+100%N	3.13	0.66	1.90	4.30	0.74	2.52	3.37	0.73	2.05
T_2 Daincha 20days+Cono+75%N	3.19	0.57	1.88	5.53	0.78	3.16	3.55	0.84	2.19
T_3 Daincha 20days+2,4-D+100%N	2.77	0.62	1.70	4.48	0.99	2.73	3.84	0.87	2.35
T_4 Daincha 20days+2,4-D+75%N	3.18	0.67	1.93	5.07	0.80	2.93	3.77	1.09	2.43
T_5 Daincha 20days+almix/algrip+100%N	2.89	0.61	1.75	4.56	0.67	2.61	3.62	0.83	2.22
T_6 Daincha 20days+almix/algrip+75%N	2.99	0.70	1.85	5.01	0.89	2.95	3.07	0.77	1.92
T_7 Daincha 30days+Cono+100%N	2.45	0.76	1.60	4.44	1.02	2.73	3.69	0.86	2.28
T_8 Daincha 30days+Cono+75%N	2.78	0.73	1.75	4.82	1.00	2.91	3.01	0.86	1.94
T_9 Daincha 30days+2,4-D+100%N	3.31	0.60	1.95	4.58	0.91	2.75	2.70	0.75	1.73
T_{10} Daincha 30days+2,4-D+75%N	2.38	0.90	1.64	3.86	1.12	2.49	3.50	0.81	2.16
T_{11} Daincha 30days+almix/algrip+100%N	2.92	0.68	1.80	4.39	0.72	2.55	4.04	0.77	2.40
T_{12} Daincha 30days+almix/algrip+75%N	2.81	0.59	1.70	3.96	0.91	2.43	4.37	0.73	2.55
T_{13} Rice alone+ 100%N	2.86	0.47	1.66	3.08	0.52	1.80	2.72	0.58	1.65
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub plot									
S_1 100%N	3.06	0.70	1.88	4.82	0.90	2.86	3.26	0.86	2.06
S_2 75% N	2.73	0.62	1.68	4.12	0.81	2.46	3.70	0.76	2.23
CD (0.05)	NS	0.07	NS	0.52	NS	0.26	NS	NS	NS

4.4.1.7. Dry matter production

Residual effect of the treatments applied to the previous wet sown crop had no significant influence on the dry matter production of succeeding crop of rice at different growth stages (Table 4.4.7). The dry matter production of succeeding rice crop at panicle initiation stage was significantly higher in treatments receiving 100 per cent N compared with lower dose of N. Interaction effects had not significantly influenced the dry matter production of succeeding rice crop at any of the growth stages.

4.4.2. Yield and yield attributes of succeeding rice crop

4.4.2.1. Yield attributes

The data on yield attributes of succeeding rice crop of wet seeded rice is presented in Tables 4.4.8 and 4.4.9

Weight of panicles and filled grains percentage of succeeding crop was significantly higher in treatments where the preceding wet seeded rice crop grown concurrently with daincha. Succeeding crop receiving 100 per cent N recorded significantly higher panicle weight compared with 75 per cent N. Other yield attributes of succeeding crop of rice *viz.*, panicles m^{-2}, panicles $hill^{-1}$, number of filled grains $panicle^{-1}$ and 1000 grain weight were not significantly affected by the residual effects of treatments imposed during the preceding season. No significant difference was noticed among the levels of N and interaction effects in respect of the above yield attributes. However these yield parameters were marginally higher in treatments where daincha was intercropped with rice during the previous wet seeded rice.

4.4.2.2. Grain yield

Grain yield of succeeding crop of rice was affected by the residual effects of various treatments imposed on previous wet sown crop (Table 4.4.10). The highest grain yield (4136 kg ha^{-1}) was observed in the treatment receiving the incorporation of daincha at 30 DAS using conoweeder and receiving 100 per cent N compared with rice grown alone during the previous season. Grain yield of succeeding crop receiving 100 per

Table 4.4.7. Residual effect of concurrent growing of daincha in wet seeded rice on dry matter production (kg ha^{-1}) of succeeding transplanted rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot									
T_1 Daincha 20days+Cono+100%N	2667	6938	4802	4256	7382	5819	4656	8583	6619
T_2 Daincha 20days+Cono+75%N	1722	6387	4054	4944	6932	5938	5033	9224	7129
T_3 Daincha 20days+2,4-D+100%N	1967	6337	4152	5589	7544	6567	3811	9094	6453
T_4 Daincha 20days+2,4-D+75%N	2611	6434	4523	5200	8017	6608	4156	9878	7017
T_5 Daincha 20days+almix/algrip+100%N	3133	6187	4660	4133	6949	5541	4844	8923	6884
T_6 Daincha 20days+almix/algrip+75%N	2644	6685	4665	4022	6970	5496	4811	8994	6903
T_7 Daincha 30days+Cono+100%N	2800	6700	4750	4567	7519	6043	4256	9689	6972
T_8 Daincha 30days+Cono+75%N	3044	6548	4796	4656	7552	6104	4822	9212	7017
T_9 Daincha 30days+2,4-D+100%N	2800	6700	4750	4544	7231	5888	4478	8953	6715
T_{10} Daincha 30days+2,4-D+75%N	3033	6464	4749	3978	7908	5943	4667	8885	6776
T_{11} Daincha 30days+almix/algrip+100%N	3156	6600	4878	3992	7189	5591	5100	9858	7479
T_{12} Daincha 30days+almix/algrip+75%N	3300	6633	4967	4511	7264	5888	4544	8817	6680
T_{13} Rice alone+ 100%N	3600	6638	5119	5478	7260	6369	5144	8500	6822
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub plot									
S_1 100%N	2981	6589	4785	4814	7489	6151	4549	9383	6966
S_2 75% N	2631	6526	4578	4397	7237	5817	4732	8865	6798
CD (0.05)	NS	NS	NS	NS	NS	335	NS	374	NS
Interaction effects - NS									

Table 4.4.8. Residual effect of concurrent growing of daincha in wet seeded rice on yield attributes of succeeding transplanted rice

Treatments	Panicle m^{-2}			Panicle $hill^{-1}$			Panicle weight (g)		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot									
T_1 Daincha 20days+Cono+100%N	466.7	212.7	339.7	9.00	7.00	8.00	4.73	7.35	6.04
T_2 Daincha 20days+Cono+75%N	462.0	218.7	340.3	9.67	6.83	8.25	7.31	7.07	7.19
T_3 Daincha 20days+2,4-D+100%N	468.7	228.0	348.3	8.17	7.67	7.92	6.04	7.20	6.62
T_4 Daincha 20days+2,4-D+75%N	460.0	257.3	358.7	7.83	9.17	8.50	5.00	6.89	5.94
T_5 Daincha 20days+almix/algrip+100%N	464.0	228.7	346.3	8.50	7.33	7.92	5.00	7.24	6.12
T_6 Daincha 20days+almix/algrip+75%N	457.3	227.3	342.3	9.67	7.00	8.33	6.29	7.16	6.72
T_7 Daincha 30days+Cono+100%N	470.7	288.7	379.7	8.33	10.17	9.25	5.89	7.55	6.72
T_8 Daincha 30days+Cono+75%N	452.0	248.7	350.3	10.17	7.83	9.00	6.91	7.10	7.01
T_9 Daincha 30days+2,4-D+100%N	434.7	244.0	339.3	9.33	7.33	8.33	5.97	7.57	6.77
T_{10} Daincha 30days+2,4-D+75%N	436.7	243.3	340.0	8.17	7.00	7.58	5.80	7.03	6.42
T_{11} Daincha 30days+almix/algrip+100%N	490.0	233.3	361.7	9.00	8.33	8.67	6.56	7.00	6.78
T_{12} Daincha 30days+almix/algrip+75%N	500.0	264.7	382.3	9.67	7.00	8.33	6.93	7.58	7.25
T_{13} Rice alone+ 100%N	430.0	205.3	317.7	7.17	5.83	6.50	4.96	5.57	5.26
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	0.88	0.96
Sub plot									
S_1 100%N	471.1	237.7	354.4	8.85	8.00	8.42	6.12	7.36	6.74
S_2 75% N	450.9	239.3	345.1	8.80	7.15	7.97	5.78	6.85	6.31
CD (0.05)	NS	NS	NS	NS	0.73	NS	NS	0.29	0.31
Interaction effects - NS									

Table 4.4.9. Residual effect of concurrent growing of daincha in wet seeded rice on yield attributes of succeeding transplanted rice

Treatments	Filled grains panicle^{-1}			Filled grain %			1000 grain weight (g)		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot									
T_1 Daincha 20days+Cono+100%N	41.83	24.83	33.33	76.49	72.39	74.44	26.65	22.15	24.40
T_2 Daincha 20days+Cono+75%N	41.33	23.75	32.54	80.09	67.64	73.86	27.87	23.02	25.44
T_3 Daincha 20days+2,4-D+100%N	44.67	24.83	34.75	80.35	66.94	73.64	28.45	21.45	24.95
T_4 Daincha 20days+2,4-D+75%N	41.50	24.33	32.92	80.35	66.27	73.31	27.00	22.45	24.73
T_5 Daincha 20days+almix/algrip+100%N	42.50	23.50	33.00	76.26	63.38	69.82	26.08	21.15	23.62
T_6 Daincha 20days+almix/algrip+75%N	44.67	23.08	33.88	79.86	68.76	74.31	26.90	22.13	24.52
T_7 Daincha 30days+Cono+100%N	51.00	26.07	38.53	79.56	68.03	73.79	25.82	23.30	24.56
T_8 Daincha 30days+Cono+75%N	42.33	25.00	33.67	78.99	70.52	74.75	26.42	23.00	24.71
T_9 Daincha 30days+2,4-D+100%N	46.67	25.58	36.13	80.16	69.94	75.05	26.77	20.77	23.77
T_{10} Daincha 30days+2,4-D+75%N	49.17	25.50	37.33	77.23	65.74	71.48	26.50	23.52	25.01
T_{11} Daincha 30days+almix/algrip+100%N	55.33	25.67	40.50	79.92	68.18	74.05	26.97	23.00	24.98
T_{12} Daincha 30days+almix/algrip+75%N	48.17	26.08	37.13	78.96	65.61	72.29	26.88	20.68	23.78
T_{13} Rice alone+ 100%N	43.83	21.58	32.71	71.83	60.00	65.91	24.47	20.65	22.56
CD (0.05)	NS	NS	NS	NS	NS	4.74	1.89	NS	NS
Sub plot									
S_1 100%N	46.44	24.95	35.69	79.70	67.05	73.37	26.67	22.20	24.43
S_2 75% N	44.80	24.26	34.53	77.23	67.32	72.27	26.68	22.00	24.34
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction effects - NS									

cent N was significantly higher than that of 75 per cent N. Interaction effects failed to exert any significant effect on the grain yield.

4.4.2.3. Straw yield

Straw yield of succeeding crop of rice crop was not affected by the residual effects of various treatments given to the previous wet sown crop (Table 4.4.10). Succeeding crop receiving 100 and 75per cent N and interaction effects did not show any significant effect on the straw yield of succeeding rice crop.

4.4.2.3. Harvest Index

Residual effect of various treatments given to the previous wet sown crop significantly influenced the harvest index of succeeding crop (Table 4.4.10). The value of harvest index (0.53) was less in treatments wherein the preceding crop was pure crop of rice. All the treatments succeeding rice crop with concurrent growing of daincha recorded significantly higher harvest index. Levels of N applied to succeeding crop and interaction effects did not influence the harvest index.

4.4.3. Nutrient content and nutrient uptake

4.4.3.1. Nutrient content

4. 4.3.1.1. Nitrogen content

Nitrogen contents of succeeding crop of wet seeded rice at harvest stage was significantly higher when the previous rice crop was grown along with daincha compared to rice grown alone (Table 4.4.11). Nitrogen contents at active tillering and panicle initiation stage was not found significantly different. Nitrogen contents showed a declining trend as the plant matured. Nitrogen contents at all the growth stages was significantly higher with 100 per cent N applied to succeeding crop. Interaction among different factors did not influence the N content of succeeding crop of dry sown rice.

Table 4.4.10. Residual effect of concurrent growing of daincha in wet seeded rice on grain yield, straw yield and harvest index of succeeding transplanted rice

Treatments	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Harvest Index		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot									
T_1 Daincha 20days+Cono+100%N	4947	2458	3702	3789	1888	2838	0.57	0.56	0.57
T_2 Daincha 20days+Cono+75%N	4947	2383	3665	3799	2026	2912	0.57	0.54	0.55
T_3 Daincha 20days+2,4-D+100%N	4923	2584	3753	3730	2005	2867	0.57	0.56	0.57
T_4 Daincha 20days+2,4-D+75%N	5110	2433	3772	3611	2037	2824	0.57	0.54	0.56
T_5 Daincha 20days+almix/algrip+100%N	4830	2283	3556	3720	1878	2799	0.57	0.55	0.56
T_6 Daincha 20days+almix/algrip+75%N	4923	2258	3590	3443	1909	2676	0.59	0.54	0.57
T_7 Daincha 30days+Cono+100%N	5437	2834	4136	3463	2079	2771	0.61	0.58	0.60
T_8 Daincha 30days+Cono+75%N	5367	2709	4038	3710	2037	2873	0.59	0.57	0.58
T_9 Daincha 30days+2,4-D+100%N	5413	2759	4086	3513	1931	2722	0.61	0.59	0.60
T_{10} Daincha 30days+2,4-D+75%N	5367	2709	4038	3591	2037	2814	0.60	0.57	0.59
T_{11} Daincha 30days+almix/algrip+100%N	5390	2759	4075	3680	1920	2800	0.60	0.59	0.59
T_{12} Daincha 30days+almix/algrip+75%N	5367	2709	4038	3878	1931	2904	0.58	0.58	0.58
T_{13} Rice alone+ 100%N	4503	2182	3343	3937	1909	2923	0.53	0.53	0.53
CD (0.05)	360.8	246.4	212.8	NS	NS	NS	0.04	0.04	0.03
Sub plot									
S_1 100%N	5169	2597	3883	3725	2006	2865	0.58	0.56	0.57
S_2 75% N	5065	2489	3777	3639	1931	2785	0.58	0.56	0.57
CD (0.05)	NS	NS	104.2	NS	72.78	NS	NS	NS	NS
Interaction effects - NS									

Table 4.4.11. Residual effect of concurrent growing of daincha in wet seeded rice on nitrogen content (%) of succeeding transplanted rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot									
T_1 Daincha 20days+Cono+100%N	0.862	1.320	1.090	0.902	0.870	0.886	0.610	0.695	0.652
T_2 Daincha 20days+Cono+75%N	1.010	1.150	1.080	0.835	0.852	0.843	0.560	0.833	0.697
T_3 Daincha 20days+2,4-D+100%N	1.040	1.380	1.210	0.680	0.830	0.755	0.520	0.540	0.530
T_4 Daincha 20days+2,4-D+75%N	0.950	1.110	1.030	0.688	0.862	0.775	0.707	0.620	0.663
T_5 Daincha 20days+almix/algrip+100%N	0.890	1.150	1.020	0.743	0.872	0.807	0.580	0.560	0.570
T_6 Daincha 20days+almix/algrip+75%N	0.940	1.280	1.110	0.745	0.822	0.783	0.588	0.620	0.604
T_7 Daincha 30days+Cono+100%N	0.890	1.430	1.160	0.823	0.793	0.808	0.480	0.540	0.510
T_8 Daincha 30days+Cono+75%N	0.910	1.440	1.180	0.775	0.908	0.842	0.520	0.648	0.584
T_9 Daincha 30days+2,4-D+100%N	1.160	1.290	1.220	0.910	0.912	0.911	0.540	0.647	0.593
T_{10} Daincha 30days+2,4-D+75%N	1.570	1.170	1.370	0.853	0.900	0.877	0.550	0.600	0.575
T_{11} Daincha 30days+almix/algrip+100%N	0.772	1.320	1.050	0.835	0.900	0.867	0.548	0.580	0.564
T_{12} Daincha 30days+almix/algrip+75%N	0.928	1.290	1.110	0.762	0.860	0.811	0.628	0.588	0.608
T_{13} Rice alone+ 100%N	0.747	1.110	0.928	0.707	0.755	0.731	0.440	0.530	0.485
CD (0.05)	NS	0.140	NS	0.150	NS	NS	NS	0.109	0.088
Sub plot									
S_1 100%N	1.060	1.320	1.190	0.826	0.889	0.858	0.583	0.633	0.608
S_2 75% N	0.892	1.210	1.050	0.753	0.824	0.788	0.536	0.598	0.567
CD (0.05)	NS	0.070	0.127	0.070	NS	0.050	NS	NS	0.037
Interaction effects - NS									

4. 4.3.1.2. Phosphorus content

Residual effect of treatment applied to the preceding crop had significant influence on the P content of succeeding crop of rice only at active tillering stages (Table 4.2.12). The P content increased as the plant attained harvest stage irrespective of the treatments given to the preceding crop. Phosphorus content at active tillering stage of was significantly higher with 100 per cent N applied to succeeding crop. Interactions had no significant influence on the P content of succeeding crop of rice at various growth stages.

4. 4.3.1.3. Potassium content

Residual effect of treatments had significant influence on the K content of succeeding rice at various growth stages (Table 4.4.13). Potassium contents of rice at active tillering and panicle initiation stages were significantly higher when the previous wet seeded rice was grown along with daincha compared to rice grown alone. Potassium content of succeeding rice crop receiving 100 per cent N was significantly higher at active tillering and panicle initiation stages. Interaction effects showed no significant influence on the K content of succeeding rice crop at different growth stages.

4.4.3.2. Nutrient uptake by rice

4.4.3.2.1. Nitrogen uptake

Nitrogen uptake at active tillering and panicle initiation stages of succeeding crop of rice with concurrent growing of daincha during the previous season was not significantly different from that of the pure crop of rice grown during the previous season (Table 4.4.14). Nitrogen uptake at harvest stage of succeeding rice crop was significantly higher when the previous rice crop was grown concurrently with daincha. Nitrogen uptake of succeeding rice crop receiving 100 per cent N was significantly different at all the growth stages compared with lower dose of N. Interaction effects had no significant influence on N uptake of succeeding crop.

4. 4.3.2.2. Phosphorus uptake

Treatments given to the previous wet seeded crop had significant influence of the P uptake of succeeding crop of rice at active tillering stage only (Table 4.4.15).

Table 4.4.12. Residual effect of concurrent growing of daincha in wet seeded rice on phosphorus content (%) of succeeding transplanted rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot									
T_1 Daincha 20days+Cono+100%N	0.102	0.218	0.160	0.100	0.188	0.144	0.078	0.063	0.071
T_2 Daincha 20days+Cono+75%N	0.110	0.202	0.156	0.112	0.177	0.144	0.112	0.058	0.085
T_3 Daincha 20days+2,4-D+100%N	0.098	0.175	0.137	0.108	0.213	0.161	0.085	0.065	0.075
T_4 Daincha 20days+2,4-D+75%N	0.122	0.178	0.150	0.100	0.198	0.149	0.093	0.073	0.083
T_5 Daincha 20days+almix/algrip+100%N	0.110	0.165	0.137	0.102	0.193	0.147	0.090	0.063	0.077
T_6 Daincha 20days+almix/algrip+75%N	0.108	0.212	0.160	0.105	0.182	0.143	0.082	0.052	0.067
T_7 Daincha 30days+Cono+100%N	0.093	0.203	0.148	0.102	0.228	0.165	0.072	0.097	0.084
T_8 Daincha 30days+Cono+75%N	0.102	0.185	0.143	0.102	0.187	0.144	0.065	0.082	0.073
T_9 Daincha 30days+2,4-D+100%N	0.118	0.218	0.168	0.123	0.192	0.157	0.060	0.080	0.070
T_{10} Daincha 30days+2,4-D+75%N	0.112	0.230	0.171	0.120	0.177	0.148	0.073	0.087	0.080
T_{11} Daincha 30days+almix/algrip+100%N	0.097	0.222	0.159	0.097	0.170	0.133	0.075	0.075	0.075
T_{12} Daincha 30days+almix/algrip+75%N	0.110	0.195	0.152	0.108	0.202	0.155	0.095	0.073	0.084
T_{13} Rice alone+ 100%N	0.085	0.178	0.132	0.105	0.203	0.154	0.063	0.073	0.068
CD (0.05)	NS	0.040	0.022	NS	NS	NS	0.027	NS	NS
Sub plot									
S_1 100%N	0.112	0.211	0.161	0.110	0.197	0.154	0.079	0.077	0.078
S_2 75% N	0.098	0.186	0.142	0.103	0.189	0.146	0.081	0.068	0.074
CD (0.05)	0.009	0.017	0.0096	NS	NS	NS	NS	NS	NS
Interaction effects - NS									

Table 4.4.13. Residual effect of concurrent growing of daincha in wet seeded rice on potassium content (%) of succeeding transplanted rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot									
T_1 Daincha 20days+Cono+100%N	0.587	1.350	0.967	1.020	1.370	1.197	0.627	0.940	0.783
T_2 Daincha 20days+Cono+75%N	0.600	1.290	0.947	0.953	1.260	1.107	0.587	0.940	0.763
T_3 Daincha 20days+2,4-D+100%N	0.573	1.500	1.037	0.933	1.450	1.190	0.667	0.927	0.797
T_4 Daincha 20days+2,4-D+75%N	0.553	1.370	0.960	0.887	1.360	1.123	0.640	0.967	0.803
T_5 Daincha 20days+almix/algrip+100%N	0.580	1.300	0.940	0.960	1.360	1.160	0.627	0.947	0.787
T_6 Daincha 20days+almix/algrip+75%N	0.587	1.290	0.940	0.953	1.450	1.200	0.520	0.953	0.737
T_7 Daincha 30days+Cono+100%N	0.593	1.440	1.017	0.913	1.350	1.130	0.547	0.987	0.767
T_8 Daincha 30days+Cono+75%N	0.580	1.300	0.940	0.967	1.370	1.167	0.553	0.940	0.747
T_9 Daincha 30days+2,4-D+100%N	0.580	1.420	1.000	0.980	1.400	1.190	0.620	0.947	0.783
T_{10} Daincha 30days+2,4-D+75%N	0.520	1.390	0.957	0.827	1.350	1.087	0.580	0.967	0.773
T_{11} Daincha 30days+almix/algrip+100%N	0.607	1.290	0.947	0.887	1.350	1.117	0.660	0.940	0.800
T_{12} Daincha 30days+almix/algrip+75%N	0.580	1.350	0.963	0.900	1.410	1.157	0.553	0.953	0.753
T_{13} Rice alone+ 100%N	0.527	1.290	0.907	0.833	1.270	1.050	0.493	0.873	0.683
CD (0.05)	0.048	0.135	0.070	NS	NS	0.086	0.103	NS	NS
Sub plot									
S_1 100%N	0.584	1.390	0.985	0.937	1.390	1.164	0.607	0.945	0.776
S_2 75% N	0.565	1.320	0.941	0.911	1.340	1.125	0.573	0.945	0.759
CD (0.05)	NS	0.053	0.028	NS	0.047	0.037	NS	NS	NS
Interaction effects - NS									

Table 4.4.14. Residual effect of concurrent growing of daincha in wet seeded rice on nitrogen uptake (kg ha^{-1}) of succeeding transplanted rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot									
T_1 Daincha 20days+Cono+100%N	23.26	92.04	57.65	37.01	64.05	50.53	28.31	59.88	44.10
T_2 Daincha 20days+Cono+75%N	16.76	73.20	44.98	42.34	58.93	50.63	28.28	77.63	52.95
T_3 Daincha 20days+2,4-D+100%N	19.75	87.45	53.60	37.61	62.91	50.26	19.95	48.90	34.43
T_4 Daincha 20days+2,4-D+75%N	24.84	71.34	48.09	35.69	69.24	52.46	29.27	61.17	45.22
T_5 Daincha 20days+almix/algrip+100%N	27.67	71.13	49.40	30.63	60.75	45.69	27.40	49.77	38.58
T_6 Daincha 20days+almix/algrip+75%N	25.72	85.56	55.64	29.61	57.14	43.38	28.13	56.10	42.11
T_7 Daincha 30days+Cono+100%N	26.25	95.51	60.88	37.47	59.46	48.46	20.55	52.57	36.56
T_8 Daincha 30days+Cono+75%N	28.66	94.21	61.44	35.94	68.73	52.34	24.97	59.45	42.21
T_9 Daincha 30days+2,4-D+100%N	33.15	86.62	59.89	44.14	66.25	55.20	24.27	58.36	41.32
T_{10} Daincha 30days+2,4-D+75%N	46.65	75.70	61.18	34.33	71.23	52.78	25.34	53.18	39.26
T_{11} Daincha 30days+almix/algrip+100%N	24.63	86.81	55.72	33.27	64.76	49.02	27.83	57.44	42.63
T_{12} Daincha 30days+almix/algrip+75%N	31.81	86.10	58.95	34.33	62.63	48.48	28.89	51.34	40.11
T_{13} Rice alone+ 100%N	25.77	73.62	49.70	37.61	54.88	46.25	22.46	45.06	33.76
CD (0.05)	NS	11.20	NS	NS	NS	NS	NS	12.30	7.19
Sub plot									
S_1 100%N	31.51	86.95	59.23	39.69	66.68	53.19	26.33	59.29	42.81
S_2 75% N	23.10	79.10	51.10	32.61	59.62	46.12	25.31	53.15	39.23
CD (0.05)	NS	5.28	3.04	6.22	6.66	1.26	NS	4.88	3.00
Interaction effects - NS									

Phosphorus uptake at active tillering stage of succeeding rice crop was significantly higher when the succeeding rice crop received 100 per cent N compared with 75 per cent nitrogen. Interaction effects failed to show any significant effect on the P uptake of succeeding crop of rice.

4. 4.3.2.3. Potassium uptake

Residual effect of different treatments had no significant influence on the K uptake of succeeding crop of rice (Table 4.4.16). Potassium uptake of succeeding rice crop at active tillering and panicle initiation stages were significantly higher when the succeeding rice crop received 100 per cent N compared with 75 per cent nitrogen. None of the interactions was found significant on K uptake of succeeding rice crop at various growth stages.

4.4.4. Soil Nutrient status

4.4.4.1. Soil Organic Carbon (%)

Organic carbon percentage of soil increased significantly when the previous wet seeded rice was grown along with daincha compared to rice grown alone (Table 4.4.17). Soil organic carbon content was the least when rice alone was the preceding crop. Succeeding rice crop receiving 100 per cent nitrogen recorded significantly higher organic carbon percentage compared with lower doses. Interactions showed no variation in the soil organic carbon content.

4.4.4.2. Available nitrogen content of soil

Soil available nitrogen content after the succeeding crop showed a significant increase in treatments involving concurrent growing of daincha compared with pure crop of rice during the previous season (Table 4.4.17). The lowest value of soil available nitrogen content was noticed when rice alone was the preceding crop. The soil available nitrogen content was significantly higher when the succeeding rice crop received 100 per cent N compared with 75 per cent nitrogen. Interactions had no significant influence on the available nitrogen content of the soil.

Table 4.4.15. Residual effect of concurrent growing of daincha in wet seeded rice on phosphorus uptake (kg ha^{-1}) of succeeding transplanted rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot									
T_1 Daincha 20days+Cono+100%N	2.75	15.09	8.92	4.41	13.86	9.14	3.62	5.45	4.53
T_2 Daincha 20days+Cono+75%N	1.89	12.88	7.38	5.71	12.24	8.97	5.71	5.39	5.55
T_3 Daincha 20days+2,4-D+100%N	2.04	11.10	6.57	5.93	16.03	10.98	3.23	5.87	4.55
T_4 Daincha 20days+2,4-D+75%N	3.13	11.46	7.29	5.33	15.93	10.63	3.88	7.21	5.54
T_5 Daincha 20days+almix/algrip+100%N	3.61	10.22	6.92	4.21	13.28	8.75	4.48	5.69	5.09
T_6 Daincha 20days+almix/algrip+75%N	3.01	14.16	8.58	4.07	12.73	8.40	3.92	4.74	4.33
T_7 Daincha 30days+Cono+100%N	2.65	13.62	8.13	4.80	17.35	11.07	3.08	9.47	6.27
T_8 Daincha 30days+Cono+75%N	3.22	12.14	7.68	4.68	14.01	9.35	3.18	7.36	5.27
T_9 Daincha 30days+2,4-D+100%N	3.36	14.65	9.01	5.80	14.00	9.90	2.56	7.27	4.92
T_{10} Daincha 30days+2,4-D+75%N	3.36	14.92	9.14	4.87	13.92	9.39	3.57	8.00	5.79
T_{11} Daincha 30days+almix/algrip+100%N	2.90	14.54	8.72	3.93	12.20	8.06	3.84	7.52	5.68
T_{12} Daincha 30days+almix/algrip+75%N	3.59	12.81	8.20	5.00	14.65	9.83	4.21	6.57	5.39
T_{13} Rice alone+ 100%N	3.17	11.86	7.52	5.60	15.03	10.32	3.26	6.26	4.76
CD (0.05)	NS	2.71	4.75	NS	NS	NS	NS	NS	NS
Sub plot									
S_1 100%N	3.37	13.89	8.63	5.28	14.80	10.04	3.61	7.33	5.47
S_2 75% N	2.58	12.18	7.38	4.62	13.70	9.16	3.85	6.03	4.94
CD (0.05)	0.64	1.20	0.66	NS	NS	NS	NS	NS	NS
Interaction effects - NS									

Table 4.4.16. Residual effect of concurrent growing of daincha in wet seeded rice on potassium uptake (kg ha^{-1}) of succeeding transplanted rice at different growth stages

Treatments	Active Tillering			Panicle Initiation			Harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot									
T_1 Daincha 20days+Cono+100%N	15.62	93.46	54.54	41.97	101.32	71.65	29.23	81.06	55.14
T_2 Daincha 20days+Cono+75%N	10.34	82.73	46.54	46.64	87.50	67.07	29.72	86.64	58.18
T_3 Daincha 20days+2,4-D+100%N	11.30	95.12	53.21	50.64	109.01	79.83	25.48	84.40	54.94
T_4 Daincha 20days+2,4-D+75%N	14.54	87.92	51.53	46.46	108.84	77.65	26.50	95.61	61.05
T_5 Daincha 20days+almix/algrip+100%N	18.46	80.35	49.41	40.15	94.33	67.24	30.47	84.27	57.37
T_6 Daincha 20days+almix/algrip+75%N	15.09	86.40	50.75	38.36	100.91	69.63	24.11	85.36	54.73
T_7 Daincha 30days+Cono+100%N	17.20	96.32	56.76	41.81	101.22	71.52	23.86	95.05	59.46
T_8 Daincha 30days+Cono+75%N	17.67	85.17	51.42	45.01	103.23	74.12	26.67	86.51	56.59
T_9 Daincha 30days+2,4-D+100%N	16.22	95.19	55.71	45.34	101.41	73.38	28.05	84.82	56.44
T_{10} Daincha 30days+2,4-D+75%N	15.60	90.51	53.05	32.60	106.44	69.52	27.00	86.43	56.72
T_{11} Daincha 30days+almix/algrip+100%N	18.87	85.18	52.02	34.55	96.97	65.76	33.71	92.96	63.34
T_{12} Daincha 30days+almix/algrip+75%N	19.05	89.64	54.35	40.71	102.82	71.76	24.85	84.41	54.63
T_{13} Rice alone+ 100%N	18.96	85.66	52.31	46.12	91.91	69.02	25.60	74.37	49.99
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub plot									
S_1 100%N	17.36	91.39	54.38	45.03	103.96	74.50	27.63	88.97	58.30
S_2 75% N	14.78	86.09	50.44	39.64	96.95	68.29	27.02	83.63	55.32
CD (0.05)	NS	5.04	2.96	5.40	5.52	3.77	NS	NS	NS
Interaction effects - NS									

4.4.4.3. Available phosphorus content of soil

Available soil phosphorus content after the succeeding crop was not significantly affected by concurrent growing of daincha during the 1st crop season (Table 4.4.17). Phosphorus content was seen less when pure crop of rice was the preceding crop. There was significant difference in the available phosphorus content of the soil due to levels of N given to the succeeding crop. Succeeding rice crop receiving 100 per cent N recorded significantly higher soil available P content compared with 75 per cent nitrogen. Interactions showed no significant difference on the available phosphorus content of the soil.

4.4.4.3. Available potassium content of soil

Potassium content of the soil after the succeeding crop was not significantly affected by the previous season treatments as well as the nitrogen levels given to the succeeding crop (Table 4.4.17). No significant difference was indicated due to interactions with regard to the available potassium content of the soil.

4.4.5. Economics of the dry sowing system

4.4.5.1. Gross Return

Data on the economics of wet sowing system showed that treatments with concurrent growing and incorporation of 30 days old daincha with rice during the previous season registered the highest gross return compared with incorporation of 20 days old daincha and rice grown alone (Table 4.4.18). The gross return (Rs.66034 ha^{-1}) of pure crop of rice was significantly less compared with daincha intercropped rice. Incorporation of 30 days old daincha using conoweeder and receiving 100 per cent N recorded the highest gross return (Rs.80954 ha^{-1}) compared with other treatments. Gross return of wet sowing system was affected by levels of nitrogen given to the succeeding crop. Succeeding crop receiving 100 per cent N registered significantly higher gross return compared with 75 per cent N. Interactions had not significantly influence the gross return.

Table 4.4.17. Residual effect of concurrent growing of daincha in wet seeded rice on soil nutrient status of succeeding transplanted rice at harvest

Treatments	Organic carbon (%)			Available nitrogen (kg ha^{-1})			Available phosphorus (kg ha^{-1})			Available potassium (kg ha^{-1})		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot												
T_1 Daincha 20days+Cono+100%N	0.930	0.845	0.887	334.51	183.98	259.24	90.35	111.35	100.85	392.00	802.67	597.33
T_2 Daincha 20days+Cono+75%N	0.920	0.845	0.882	341.30	194.43	267.87	89.06	99.69	94.37	392.00	765.33	578.67
T_3 Daincha 20days+2,4-D+100%N	0.945	0.780	0.862	347.05	215.34	281.19	95.31	103.60	99.45	392.00	896.00	644.00
T_4 Daincha 20days+2,4-D+75%N	0.950	0.795	0.872	347.57	206.98	277.27	92.25	106.04	99.15	354.67	877.33	616.00
T_5 Daincha 20days+almix/algrip+100%N	0.955	0.795	0.875	342.87	200.70	271.79	90.64	113.22	101.93	354.67	784.00	569.33
T_6 Daincha 20days+almix/algrip+75%N	0.925	0.790	0.857	343.39	188.16	265.78	87.34	107.62	97.48	354.67	821.33	588.00
T_7 Daincha 30days+Cono+100%N	1.020	0.825	0.920	362.21	213.25	287.73	91.82	106.33	99.08	429.33	746.67	588.00
T_8 Daincha 30days+Cono+75%N	0.990	0.795	0.892	350.19	190.25	270.22	93.44	106.33	99.88	392.00	765.33	578.67
T_9 Daincha 30days+2,4-D+100%N	0.890	0.815	0.852	353.85	196.52	275.19	95.31	106.83	101.07	392.00	784.00	588.00
T_{10} Daincha 30days+2,4-D+75%N	1.030	0.810	0.920	349.66	169.35	259.50	93.44	107.48	100.46	373.33	858.67	616.00
T_{11} Daincha 30days+almix/algrip+100%N	1.020	0.800	0.907	358.03	215.34	286.68	92.15	106.79	99.47	392.00	877.33	634.67
T_{12} Daincha 30days+almix/algrip+75%N	1.070	0.750	0.957	380.50	206.97	293.74	93.26	104.86	99.06	392.00	840.00	616.00
T_{13} Rice alone+ 100%N	0.790	0.605	0.698	312.03	163.07	237.55	86.59	86.44	86.51	298.67	784.00	541.33
CD (0.05)	0.164	NS	0.102	NS	25.90	26.50	NS	NS	NS	NS	NS	NS
Sub plot												
S_1 100%N	0.991	0.805	0.898	356.14	200.06	278.10	94.50	109.35	101.93	402.05	818.46	610.26
S_2 75% N	0.935	0.772	0.853	339.73	191.38	265.56	88.72	100.89	94.80	353.23	812.72	582.97
CD (0.05)	NS	NS	0.038	NS	NS	11.10	5.43	5.42	3.74	38.26	NS	NS
Interaction effects - NS												
Initial soil test data	0.480	0.570	0.525	232.06	263.42	247.74	59.86	72.37	66.12	112.00	1120.00	616.00

4.4.5.2. Net Return

Results revealed that the net return from wet sowing system was significantly affected by the treatments given to the preceding crop (Table 4.4.18). Concurrent growing of daincha and its incorporation at 20 and 30 days significantly increased the net return of the wet sowing system compared with rice grown alone during the previous season. Net return was found to be the highest (Rs.45193 ha^{-1}) in treatments with concurrently grown 30 days old daincha incorporated using conoweeder and receiving 100 per cent N during the previous season. Pure crop of rice with out daincha during the previous season registered the least net return (Rs.24922 ha^{-1}). Nitrogen levels applied to the succeeding crop and interactions did not affect the net return.

4.4.5.3. Benefit: Cost Ratio

Benefit: cost ratio of wet sowing system was significantly affected by the treatments applied to the preceding crop (Table 4.4.18). Concurrent growing of daincha along with rice during the previous season resulted in higher B: C ratio than rice grown alone. The highest B: C ratio (2.26) recorded in treatments with incorporation of 30 days old daincha using conoweeder. Benefit: cost ratio of the dry sowing system was not affected by the levels of N given to the succeeding crop and any of the interactions.

Table 4.4.18 Economics of wet sowing system

Treatments	Gross Return			Net Return			BC Ratio		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
Main plot									
T_1 Daincha 20days+Cono+100%N	83587	61444	72515	47825	25682	36754	2.34	1.72	2.03
T_2 Daincha 20days+Cono+75%N	83864	58328	71096	48350	22814	35582	2.36	1.64	2.00
T_3 Daincha 20days+2,4-D+100%N	85395	62395	73895	50273	27274	38773	2.43	1.78	2.10
T_4 Daincha 20days+2,4-D+75%N	84127	6028	72212	49252	25423	37338	2.41	1.73	2.07
T_5 Daincha 20days+almix/algrip+100%N	83476	59059	71267	48164	23747	35956	2.36	1.67	2.02
T_6 Daincha 20days+almix/algrip+75%N	82484	58207	70346	47420	23143	35281	2.35	1.66	2.01
T_7 Daincha 30days+Cono+100%N	92277	69631	80954	56516	33870	45193	2.58	1.95	2.26
T_8 Daincha 30days+Cono+75%N	89185	63767	76476	53671	28252	40962	2.51	1.80	2.15
T_9 Daincha 30days+2,4-D+100%N	91441	64561	78001	56319	29439	42879	2.60	1.84	2.22
T_{10} Daincha 30days+2,4-D+75%N	87275	63169	75222	52400	28294	40347	2.50	1.81	2.16
T_{11} Daincha 30days+almix/algrip+100%N	89960	64569	77264	54649	29257	41953	2.55	1.83	2.19
T_{12} Daincha 30days+almix/algrip+75%N	88913	62673	75793	53848	27609	40728	2.54	1.79	2.16
T_{13} Rice alone+ 100%N	78617	53450	66034	37506	12339	24922	1.91	1.30	1.61
CD (0.05)	5076	5291	3572	5076	5291	3572	0.14	0.15	0.10
Sub plot									
S_1 100%N	86638	62109	74373	50662	26133	38397	2.41	1.73	2.07
S_2 75% N	85762	61207	73484	50291	25736	38013	2.42	1.73	2.08
CD (0.05)	NS	NS	830	NS	NS	NS	NS	NS	NS
Interaction effects - NS									

Discussion

DISCUSSION

An investigation entitled "Concurrent growing of green manure crops in dry and wet seeded rice" was conducted to develop a comprehensive management package for increasing the productivity and profitability of direct seeded rice by concurrent growing of green manure crops and its subsequent incorporation at the optimum stage adopting appropriate methods so as to get the maximum benefit and nutrient savings to the current and residual rice crops. Important results of the present study are discussed in this chapter under the following two major sections.

5.1 Concurrent growing of green manure crops in dry seeded rice system

5.2 Concurrent growing of daincha in wet seeded rice system

5.1 CONCURRENT GROWING OF GREEN MANURE CROPS IN DRY SEEDED RICE

The availability of enough green manure is a constraint and allocating an exclusive time slot for raising green manure is a limitation voiced so far. With the objective of evolving a suitable system for raising green manures, without sacrificing any of the economic crops in a rice based system, the strategy of growing green manure crops along with rice as a dual culture has been mooted. Intercropping a green manure in rice and its subsequent incorporation later obviates the need for separate land, labour, inputs and time for raising a green manure crop. In dry seeded rice, the system of concurrent growing can be effectively capitalized by sowing green manure crops such as cowpea or horse gram along with rice crop.

5.1.1 Effect of concurrent growing of green manure crops

Field experiments conducted during 2004 to 2006 revealed that the yield of dry seeded rice was increased by concurrent growing of green manure crops along with it (Table 4.1.12 and Fig. 5). Concurrent growing of green manure crops along with dry seeded rice and its subsequent incorporation has led to a yield increment of 11 per cent compared to pure crop of rice. Similar results were obtained by Mathew *et al.* (1991) and Bridgit *et al.* (1994). Rice, in association with cowpea recorded a yield of 3633 kg ha^{-1}, which was six per cent more than the yield of rice realized in association with horse gram. It was observed that all the growth parameters of rice were superior in concurrent growing of cowpea (Table 4.1.1 to Table 4.1.6). Rice in rice +cowpea system produced more height, tillers, leaves, leaf area and leaf area index than rice in rice+ horse gram system. Jayachandran and Veerabadran (1996) also reported an increase in plant height, leaf area index and total tillers of semi-dry rice as a result of incorporation of intercrops. Though not significant, the better tillering of rice coupled with higher leaf area helped in tapping more solar radiation and have resulted in better dry matter production in rice by concurrent growing of cowpea than the total dry matter production of rice in rice+ horse gram system and pure crop of rice (Table. 4.1.7). Better growth parameters had a positive reflection on yield contributing characters, like number of panicles, panicle weight, filled grains and 1000 grain weight of rice, in the system of concurrent growing of green manures compared with pure crop of rice (Fig. 6). Musthafa (1995) reported a similar increase in grain and straw yield of rice due to the increase in productive attributes viz., productive tillers and 1000 grain weight, brought about by the interacting influences of fertilizer N and cowpea intercropping. It is observed in the present study that the better performances of growth and yield contributing characters resulted in higher yield of rice when intercropped with green manure crops. Pure crop of rice recorded lesser height, tillers and leaf area than green manure intercropped rice resulting in poor development of photosynthetic surface. This has lead to poor expression of yield contributing characters like number of panicles, panicle weight, filled grains and test weight. All these have resulted in 11 per cent reduction in yield of pure crop of rice compared with green manure intercropped rice.

The high yield obtained from concurrent growing of green manure crops along with rice suggested that in a farming situation, where application of green manure is not possible at the time of crop commencement, green manure crops can be grown during the early stage of rice crop with little interference on rice growth but with substantial yield advantage and without sacrificing any of the economic crops in the system. The viability of concurrent raising of green manure crops in closely seeded crops like rice largely depend on the possibility of competition it may offer to the main crop on growth resources. It is observed in the present study that, the better performances of growth and yield contributing characters were noticed when rice was grown along

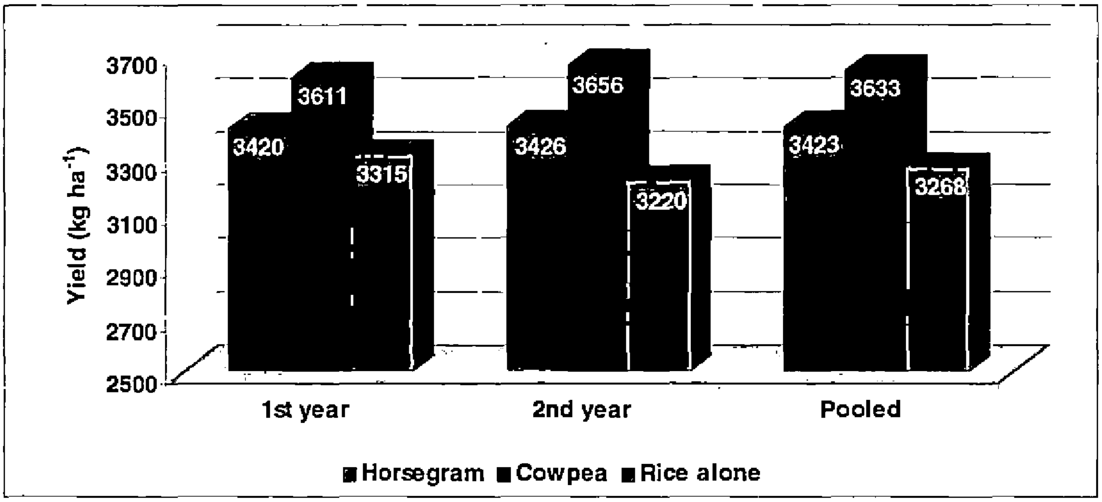


Fig. 5. Effect of green manure crops on the grain yield of dry seeded rice

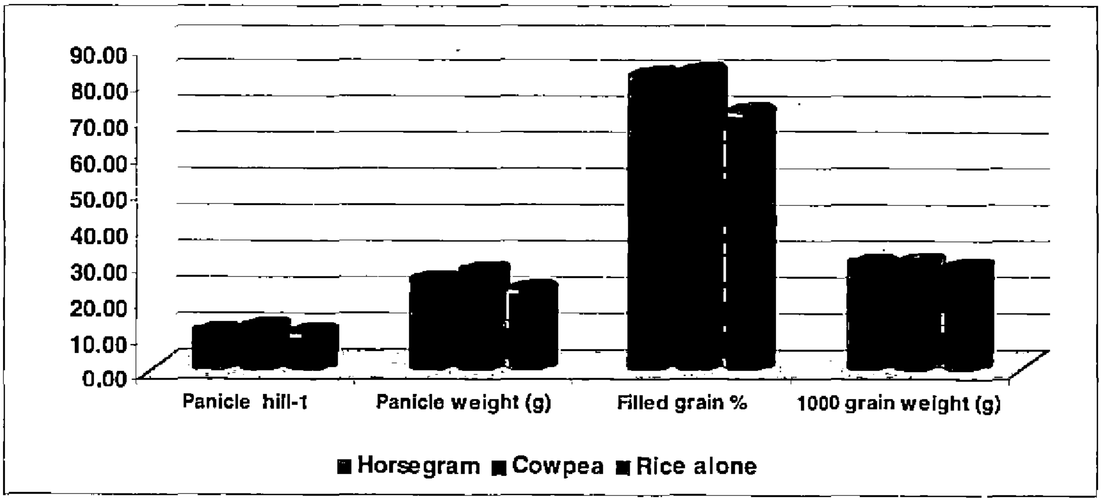


Fig. 6. Effect of green manure crops on the yield attributes of dry seeded rice

with green manure crops than when grown alone. This implied that competition to rice due to concurrent growing of green manure crops was almost absent. In addition green manure crops are leguminous plants that can fix atmospheric N for its need and as such may not compete with rice. The grain yield increase to the tune of 365 kg ha^{-1} obtained due to concurrent growing of green manure crops would imply that easily decomposable green manures can be applied even up to about 45 days of sowing of rice crop. Thus concurrent growing of green manure crops is especially advantageous to dry seeded rice crop as no green manures can be applied at the time of sowing because the soil is dry.

The over whelming influence of concurrent growing of green manure crops on weed suppression is evident from the data on weed population and dry matter production. Green manure intercropping system has brought down the cost and labour requirement of weeding substantially. Green manure crops suppressed the weed growth significantly but the efficiency of weed suppression largely depends on the nature of component crops. Concurrent growing of green manure crops significantly reduced the weed population and weed dry matter than sole cropping of rice in both the years. Major weed flora in the experimental field was *Echinochloa* sp., *Panicum repens* and *Ischaemum rugosum*, among grasses; *Ludwigia parviflora, Alternanthera sp., Cleome viscose* and *Oldenlandia aspera,* among broad leaved weeds; *Cyperus sp.*, and *Fimbristylis miliacea* among sedges. The percentage decline of total weed count in cowpea intercropped treatments were 52 and 68 per cent compared to rice grown alone, during the first and second years respectively. The corresponding figures in horse gram intercropped treatments were 25 and 49 per cent respectively (Table 4.1.15 and Fig. 7). The reduction in total weed dry matter production at 30 DAS due to concurrent growing of cowpea were 40 and 33 per cent and that of horse gram were 25 and 13 per cent respectively compared with control during the 1st and 2nd years (Table 4.1.16). The reduction in total weed count due to concurrent growing of cowpea was 76 and 74 per cent and that of horse gram was 61 and 63 per cent at 50 DAS during the 1st and 2nd year respectively. The reduction in total dry matter production at 50 DAS due to cowpea green manuring was 68 and 37 per cent respectively compared with control during the 1st and 2nd years and that of horse gram was 55 and 25 per cent respectively (Table 4.1.17 and Fig. 8).

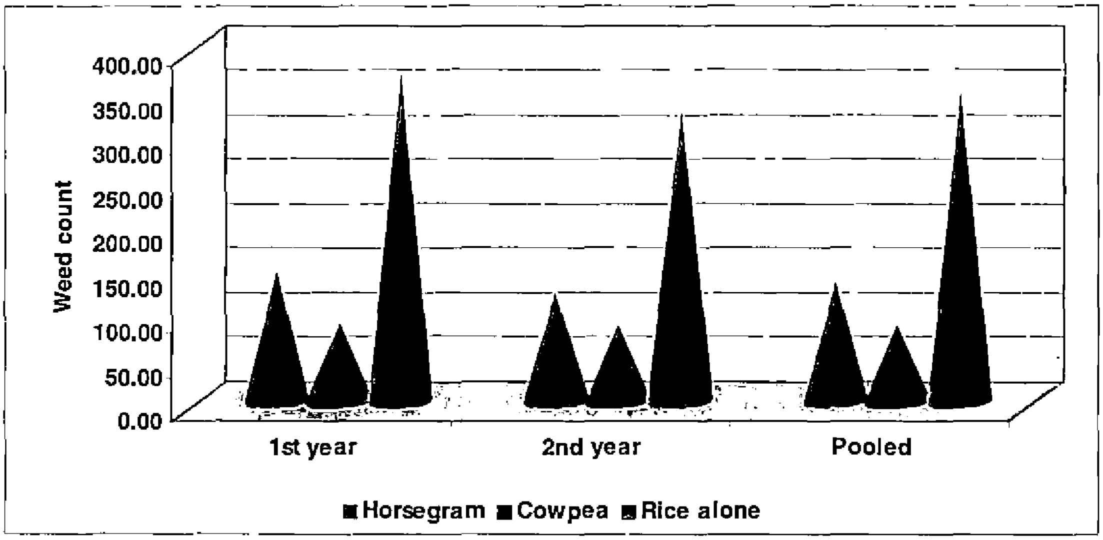


Fig. 7. Effect of green manure crops on the total weed count in dry seeded rice

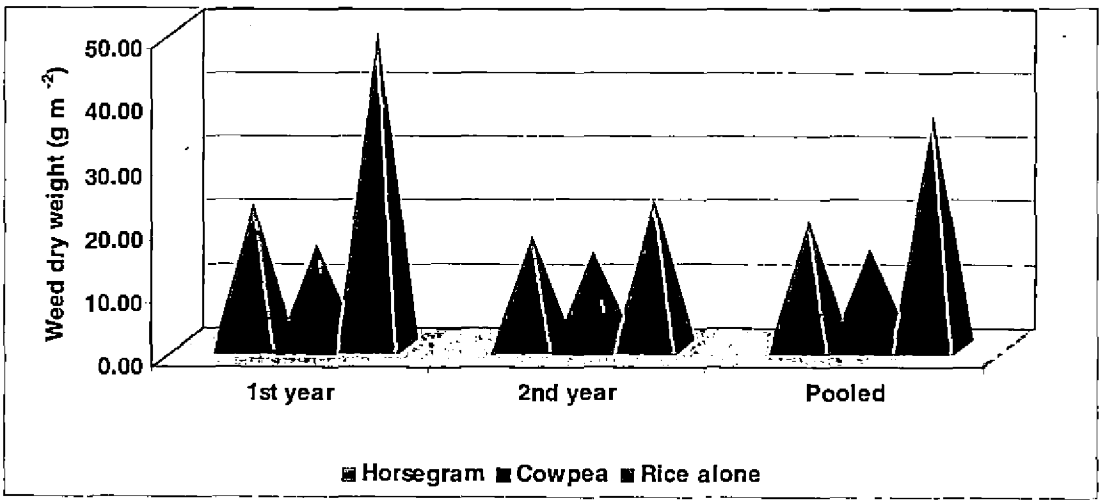


Fig. 8. Effect of green manure crops on the total weed dry weight in dry seeded rice

Between the two green manure crops, cowpea was the most effective in suppressing weeds and recorded the minimum weed population and weed dry matter. The percentage reduction in total weed count due to concurrent growing of cowpea were 36 and 38 per cent at 30 DAS and 40 and 31 per cent at 50 DAS compared with concurrent growing of horse gram during the first and second years respectively. The reduction in weed growth evidently was due to the successful smothering effect of cowpea. Similar results were reported by Musthafa (1995) and Resmy (2003).The reduction in weed population and weed dry matter in the system of concurrent growing of green manure crops may be attributed to shading effect and competition stress created by the canopy of green manure crops in a unit area having suppressive effects on associated weeds, thus preventing the weeds to attain full growth. However the higher weed population and weed dry matter in horse gram intercropped plots compared with cowpea might be due to the slow growth of horse gram, providing more conducive conditions for growth of weeds than cowpea. The system of concurrent growing of green manures resulted in the reduction of weed population and thereby a labour saving of 40 man-days ha^{-1} for weeding alone. This reduced the cost of weed management substantially (Appendix III). The decrease in the population and dry matter production of weeds brought about by concurrent growing of green manure crops pointed out that green manure crops had grown only at the expense of weeds by using the growth resources which weeds would have otherwise utilized and may not have competed with rice for growth resources. Reduced weed population in green manure intercropped treatments appreciably reduced the competition for growth resources for rice and might have resulted in increased nutrient uptake and yield of rice compared with pure crop of rice.

Concurrent growing of green manure crops and its subsequent incorporation in dry seeded rice is very effective in supplying the required quantity of organic manures to rice with minimum investment i.e., the cost of green manure seeds and its sowing and incorporation charges alone. It was observed that incorporation of cowpea resulted in a green matter addition of about 12 t ha^{-1} and was almost three times to that of horse gram (Table 4.1.9 and Fig. 9). It is a clear reflection of increased growth characters viz., plant height and leaf area by cowpea, over horse gram that has contributed to its quick growth rate in the early stages (Table 4.1.8). These results are in agreement with that of Bridigit *et al.* (1994). The green matter addition by cowpea has been more than sufficient to meet the requirement 5 t ha^{-1} of organic manure recommended for rice in the state of Kerala (KAU, 2002). Biomass production of 12 t ha^{-1} utilizing the rainfall received only from the pre-monsoon rains also indicate that the system is viable and is capable of meeting the organic matter requirement of rice with minimum investment on water. The dry matter addition due to cowpea was 1.6 t ha^{-1} and almost double to that of horse gram (Table 4.1.9 and Fig. 9). The corresponding nutrient addition by cowpea was 30 kg N ha^{-1}, 4 kg P ha^{-1} and 40 kg K ha^{-1} (Table 4.1.25 and Fig. 10). These results confirm the finding of Beri *et al.* (1989), John *et al.* (1989) and Maskina *et al.* (1989). The contribution of N, P and K by cowpea was almost double than that of horse gram. Similar was the findings of Resmy (2003). Concurrent growing of cowpea significantly increased the nutrient uptake of rice over pure crop of rice. Nutrient content of plants at any time is a function of availability and is a factor for growth where as nutrient uptake is a function of growth, absorption and accumulation (Musthafa, 1995). The content of N, P and K was found to be higher in rice intercropped with green manure crops compared to pure crop of rice (Fig. 11a to 11f). The increased nutrient content of rice can be attributed to the improvement of soil fertility status and better nutrient availability due to the incorporation of green manure crops over control (Table 4.1.26). Incorporation of green manure crops released nutrients slowly on their decomposition which resulted in better crop growth and higher dry matter production. Higher total N, P and K uptake at harvest due to green manure incorporation might be attributed to higher N, P and K content in plants together with higher dry matter production over the control treatment. Higher nutrient content of rice in the system of concurrent growing of green manure crops resulted in better performance of growth and yield attributes and there by higher yield of rice grown along with green manure crops over pure crop.

Green manure must undergo mineralization before its N becomes available to the crops. During decomposition of green manures, carbon is returned to the atmosphere as CO_2, while organic N is converted into NH_4^+-N and NO_3^- -N through the process of mineralization. The pattern of nitrogen release was studied in terms of ammoniacal nitrogen (NH_4^+-N) and nitrate nitrogen (NO_3^--N) before incorporation of green manure crops and after incorporation up to harvest at periodic intervals. Concurrent

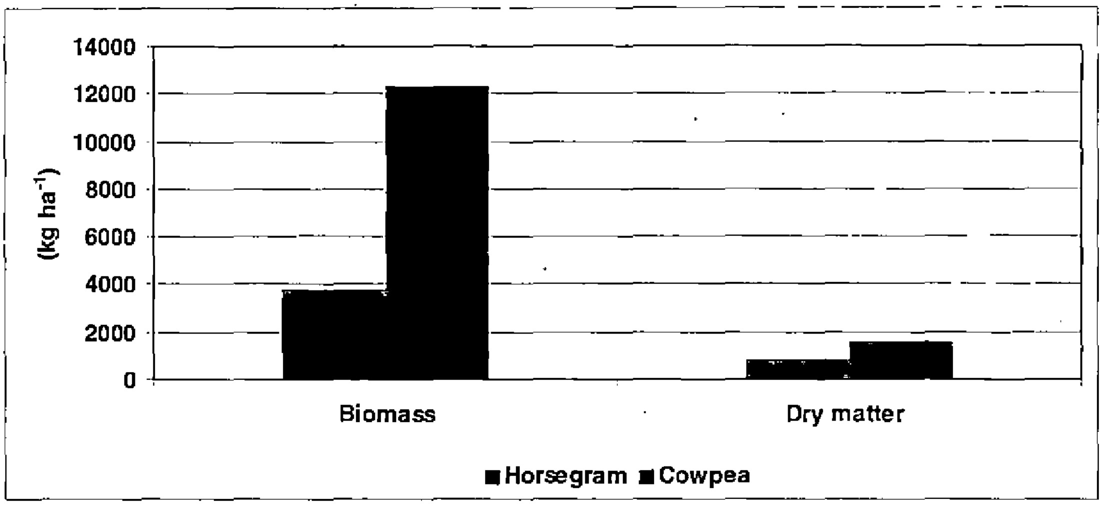


Fig.9. Biomass production and dry matter addition of concurrently grown green manure crops in dry seeded rice

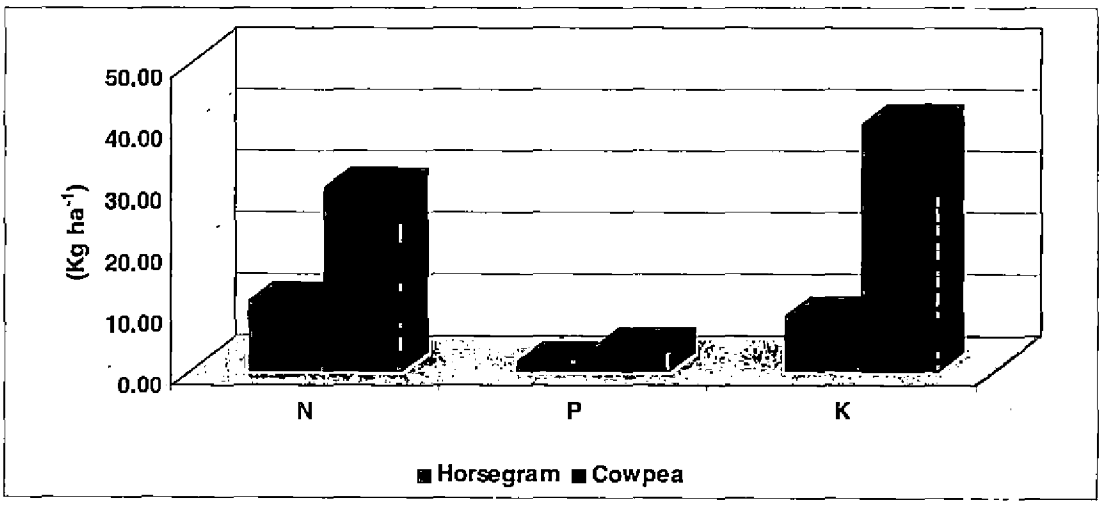


Fig.10. Nutrient contribution of concurrently grown green manure crops in dry seeded rice

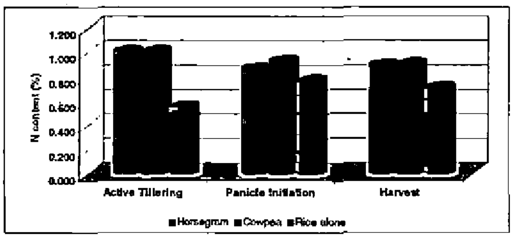


Fig. 11a. Effect of green manure crops on the N content of dry sown rice at different growth stages

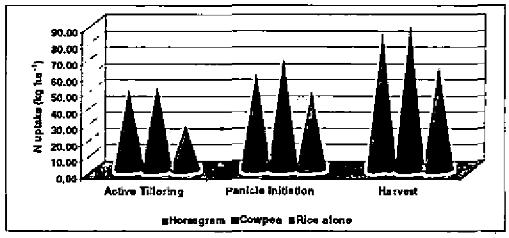


Fig. 11b. Effect of green manure crops on the N uptake of dry sown rice at different growth stages

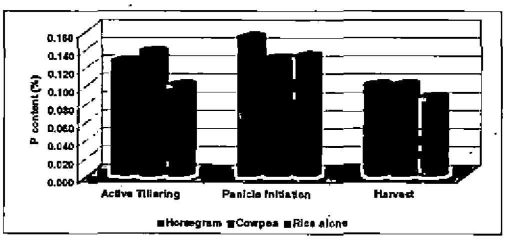


Fig. 11c. Effect of green manure crops on the P content of dry sown rice at different growth stages

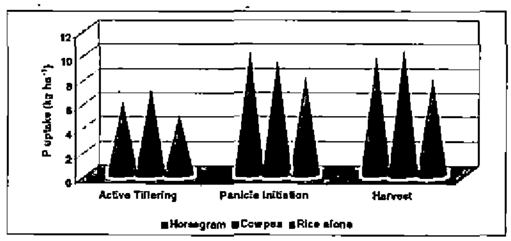


Fig. 11d. Effect of green manure crops on the P uptake of dry sown rice at different growth stages

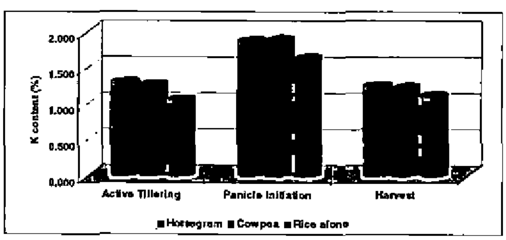


Fig. 11e. Effect of green manure crops on the K content of dry sown rice at different growth stages

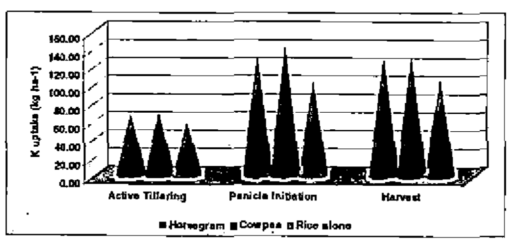


Fig. 11f. Effect of green manure crops on the K uptake of dry sown rice at different growth stages

growing of cowpea and horse gram along with rice and its subsequent incorporation resulted in significantly higher NH_4^+-N release than when rice was grown alone. The low NH_4^+-N content under non-green manure treatments may be probably due to that, soil organic matter was the only source for N mineralization in these plots. In green manure treatments both soil organic matter and the added green manures contributed to the NH_4^+-N release and hence higher N content as suggested by Buresh *et al.*, 1993b. An increase in soil NH_4^+-N was noticed up to 30 days after incorporation (DAI) followed by a slight decline up to harvest (Fig. 12). The gradual increase in soil NH_4^+-N in the initial stages may be probably due to the gradual decline in C: N ratio due to the release of CO_2 and the later decline may be due to the crop uptake (Johnkutty, 1996). From 10 DAI onwards the release of NH_4^+-N was significantly higher under cowpea incorporated treatments compared to horse gram incorporated treatments. This may be due to the higher biomass of cowpea (12 t ha $^{-1}$) compared to horse gram (3.7 t ha $^{-1}$). The N, P and K contribution by cowpea was almost double than that of horse gram. The nutrient addition by cowpea was estimated as 30 kg N ha^{-1}, 4 kg P ha^{-1} and 40 kg K ha^{-1}. Both green manure crops showed a similar trend in the release of NH_4^+-N. The maximum release was noticed on 30 DAI followed by a decline caused by vigorous uptake of N by rice. Soil NH_4^+-N increased from 94.75 kg ha^{-1} to 159.53 kg ha^{-1} up to 30 DAI, there after decreasing to 139.66 kg ha^{-1} up to harvest in cowpea incorporated plots. In horse gram incorporated plots, soil NH_4^+-N increased from 91.47 kg ha^{-1} to 153.25 kg ha^{-1} up to 30 DAI, there after decreased to 132.84 kg ha^{-1} at harvest. (Table 4.1.29). The results suggest that the decomposition of both the green manure crops was fast and they have rapidly released nitrogen. In warm tropical climate, when green manure crops were raised and incorporated before sowing of rice, decomposition of green manure crop is rapid and results in the release of N early in the season i.e., before the rice root system is established. In the system of concurrent growing of green manure crops in dry seeded crop the peak release of $NH4^+$-N coincided with the panicle initiation to flowering stage. The delayed mineralization of green manure crops has the advantage of sustaining N supply at higher level over prolonged period ensuring improved rice growth. The finding of Clement *et al.* (1998) corroborates the present results.

The release of NO_3^--N was less compared to NH_4^+-N. In flooded soil, the nitrate content is expected to be minimum due to denitrification of the nitrate present initially and stopping of the nitrification due to anaerobic condition subsequently. But an increasing trend was noticed in the release of NO_3^--N up to harvest (Fig. 12). The increase of NO_3^--N up to harvest was most probably due to the aerobic condition caused by the draining of the field before harvest. In the initial period i.e., up to 20 DAI, the release of NO_3^--N from green manure incorporated plots were less compared to pure crop of rice. After 20 days of incorporation, an increase in the release of NO_3^--N was observed from green manure incorporated plots compared to pure crop. The NO_3^--N release pattern of horse gram and cowpea showed a similar trend. In cowpea incorporated plots, soil NO_3^--N increased from 22.3 kg ha^{-1} to 42.16 kg ha^{-1} at harvest. In horse gram incorporated plots the increase in soil NO_3^--N was from 21.16 kg ha^{-1} to 41.16 kg ha^{-1} at harvest. The NO_3^--N release pattern from pure crop of rice was from 25.08 kg ha^{-1} to 38.67 kg ha^{-1} (Table 4.1.32).

A substantial build up of soil fertility, with respect to organic carbon, N,P and K status, was noticed after the incorporation of intercropped green manure crops like cowpea and horse gram (Table 4.1.26 and Fig. 13). Bharat and Niranjan (2003) reported higher available N, P and K content of soil in green manure applied plots. Tiwari *et al.* (1980), Swarup (1987) and Sharma and Mittra (1988) have confirmed this. Organic carbon percentage of soil showed an increasing trend in green manure intercropped rice with the highest value in cowpea incorporated treatments compared with horse gram incorporation and pure crop of rice, though the treatment differences did not reach up to level of significance. This was due to the higher dry matter addition of cowpea compared to horse gram. Cowpea incorporation registered the highest available N status of soil (288.1 kg ha^{-1}) compared with horse gram incorporation (263.7 kg ha^{-1}) and pure crop of rice (222.7 kg ha^{-1}). The available nitrogen of soil decreased in pure crop of rice than the initial nitrogen status (236.9 kg ha^{-1}). Under anaerobic conditions, decomposition of turned down crop residue was fairly slowed and resulted in maintenance of soil- available N (Hemalatha *et al.* 2000). Similarly, the treatments receiving cowpea incorporation registered the highest available K in the soil (562.7 kg ha^{-1}) compared with horse gram incorporation (524.2 kg ha^{-1}) and pure crop of rice (492.3kg ha^{-1}). The green manure registered significantly higher K availability in soil due to their easy decomposition of mineral constituents and their effect in dislodging the exchangeable K into the soil solution (Mahapatra and Jee, 1993). The available potassium content of soil decreased in pure crop of rice than the initial K status (504 kg ha^{-1}). The available P status of soil improved over the initial status in all the treatments. The magnitude of increase was higher in green manure incorporated treatments. This increase in available N, P and K status of soil in cowpea incorporated plots might be due to the increased contribution of N, P and K by cowpea. Increase in availability of N, P and K in soil by cowpea is 1.6, 1.5 and 3.5 times more than that of horse gram. The soil test data after the experiment indicated a positive balance of all the nutrients by concurrent growing of green manure crops along with dry sown rice. This showed the sustainable nature of this system. Concurrent growing of cowpea registered the highest N, P and K status of soil. The actual post-harvest nutrient status of the soil, when rice was grown alone, had decreased compared with the initial status of soil nutrients indicating depletion in soil nutrient status of the soil by growing rice alone even with the basal application of 5 t ha^{-1} of farm yard manure and recommended nutrients.

Concurrent growing of cowpea was found more economically viable than concurrent growing of horse gram. The former recorded higher net return (Rs.19133 ha^{-1}), which was 59 per cent more than the net return (Rs.11991 ha^{-1}) realized from concurrent growing of horse gram (Table 4.1.33 and Fig. 14). Higher benefit: cost ratio of 2.05 revealed the superiority of concurrent growing of cowpea with rice. Economic feasibility of intercropping legumes with rice was reported by Ramamoorthy *et al.* (1994), Dutta *et al.* (1994), Quayyam and Maniruzzadin (1995), Ramamoorthy *et al.* (1997) and Mandal *et al.* (2000). The better net return from the system of concurrent growing of cowpea is due to the better gross return realized from this system. This higher gross return is a direct reflection of higher rice yield. There was an added advantage from the concurrent growing of cowpea as it additionally gave an economic produce of green pods at the time of incorporation. If the crop was incorporated at 45 DAS, it gave additional returns from green pod yield (573 kg ha^{-1}). The highest net return is also due to the reduced cost involved in weed management in the cowpea intercropping treatments. Besides, in the system of concurrent growing of green manure crops, the cost for collection, transport and application of organic manures are

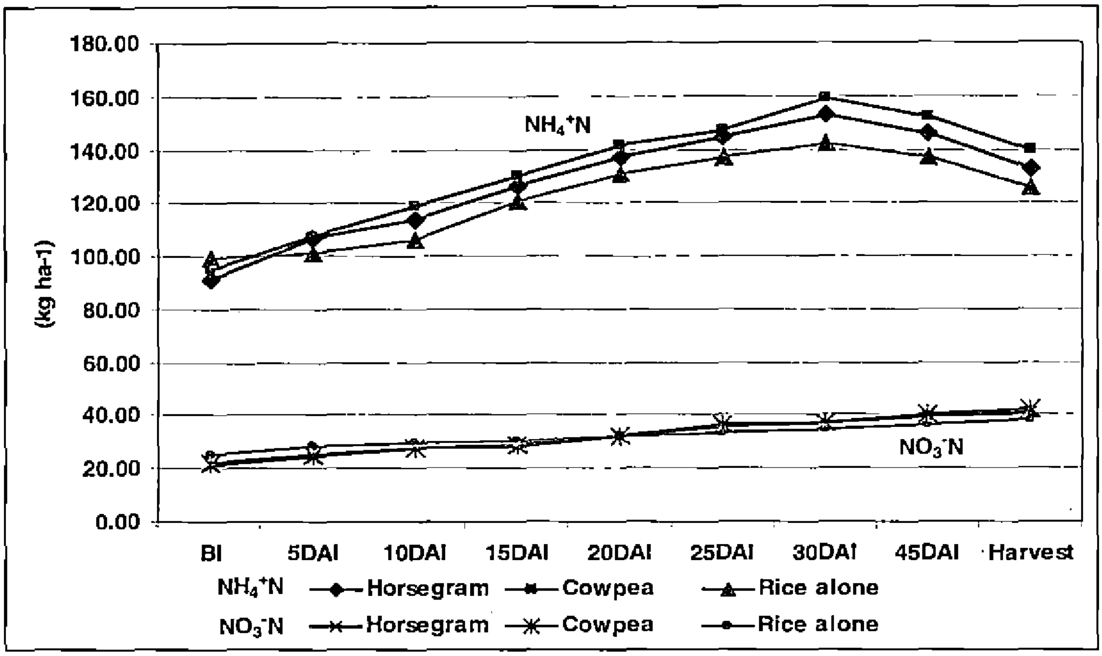


Fig. 12. Effect of green manure crops on the ammoniacal and nitrate nitrogen release pattern in dry sown rice

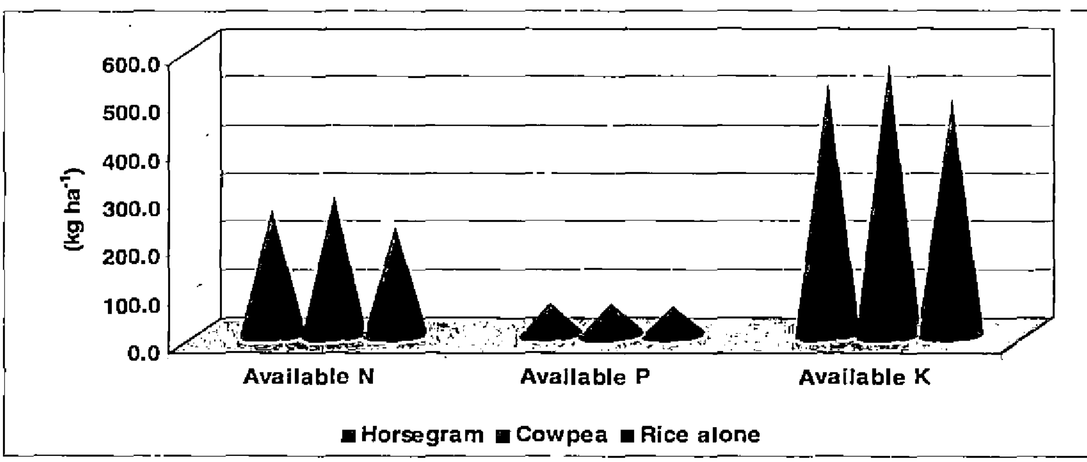


Fig. 13. Effect of green manure crops on the soil available N, P and K status after harvest of dry sown rice

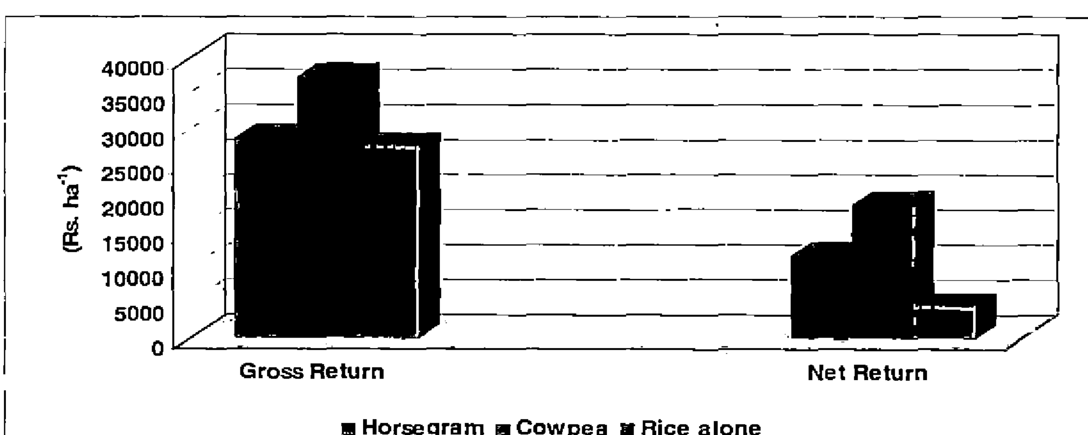


Fig. 14. Effect of green manure crops on the gross return and net return of dry sown rice

all avoided. Here the cost involved is only for the green manure seeds and sowing. The lowest net return and B: C ratio was recorded with pure crop of rice. System of concurrent growing of green manure crops in dry seeded rice is economically profitable with an increase in net return by four times when rice was grown along with cowpea and two times with horse gram compared with pure crop of rice.

5.1.2 Effect of methods of incorporation of green manure crops

As discussed earlier, concurrent growing of green manure crops and its *in situ* incorporation in dry seeded rice has been found to be very efficient in supplying the required quantity of organic manure to rice with minimum investment. Concurrently grown green manure crops in dry seeded rice, is allowed to self decompose and get incorporated, when the fields get flooded with the onset of monsoon. If there is a failure of monsoon and consequent delay in the stagnation of water in the fields, this method of incorporation of green manure crops will not be successful. Thus it is highly essential to identify alternate methods to incorporate the green manure crops particularly in situations of delayed monsoon without any adverse effect to the system. In this investigation three methods were tried for the incorporation of green manure crops viz., using cono weeder, spraying 2,4-D @1.0 kg a.i. / ha, and allowing self decomposition due to flooding at the onset of monsoon. All the three methods were found to be equally effective in incorporating the green manure crops as these methods of incorporation did not significantly vary in their influence on the yield of dry sown rice during both the years (Table 4.1.12 and Fig. 15). This is attributed to the comparable values of growth and yield parameters of rice under different methods of incorporation.

Methods of incorporation of green manure crops significantly influenced the weed count and weed dry matter production at 50 DAS. The treatments, where in the green manure crops were allowed to be incorporated due to flooding, recorded the highest weed count and weed dry matter of all the three types of weeds, leading to higher total weed count and weed dry weight. Incorporation of concurrently grown green manure crop using conoweeder significantly reduced the count and dry matter production of grass weeds. Cono weeder used for uprooting and burying the green manure crops could also bury the weeds in between standing rows of rice. Grass weeds may be more in between the rows than within the rows. That may be the reason for reduced grass weed due to conoweeding. Due to conoweeding the total weed count and dry weight was reduced by 22 and 18 per cent respectively compared to self decomposition (Table 4.1.15 and 4.1.17). Conjoint cropping of rice+daincha and incorporation of daincha on 37 DAS using cono weeder proved better in terms of reducing total weed density over sole rice (Sankar *et al.*, 2003). During both the years, population and dry weight of broad leaved weeds and sedges was significantly less in 2, 4-D applied treatments. This has resulted in reduced total weed count and dry matter production due to the application of 2, 4-D for incorporating the green manure crops, which were to the tune of 35 and 24 per cent compared with self decomposition of green manure crops (Fig. 16a and 16b). Application of 2, 4-D for desiccation of green manure crops has additional advantage of controlling broad leaved weeds and sedges in rice, as 2, 4-D is a selective herbicide against broad leaved weeds and sedges. This has resulted in the lowest count and dry matter of broad leaved weeds and sedges in 2, 4-D applied plots. Gupta *et al.* (2006) reported that co-culture of *Sesbania* in rice and its subsequent knock down by 2, 4-D ester reduced the weed population by nearly half with out any adverse effect on rice yield. Therefore there was a substantial saving in labour requirement and weeding cost when the green manure crops were incorporated using 2, 4 – D.

All the different methods of incorporation significantly reduced the weed count and weed dry matter compared to pure crop of rice. Compared to pure crop of rice, incorporation of green manure crops by self decomposition reduced the weed count and weed dry matter by 60 and 43 per cent (Table 4.1.15 and 4.1.17). Application of 2,4- D for incorporation of green manure crops resulted in a reduction of weed count by 75 per cent and weed dry matter by 57 per cent. Incorporation of green manure crops by conoweeding caused 69 per cent reduction in weed count and 52 per cent reduction in weed dry matter.

Green manure crops incorporated using different methods behaved similarly in the biomass addition and thereby in the nutrient contribution of green manure crops. Nutrient content and nutrient uptake of rice was also similar under different methods of incorporation (Fig. 17a to Fig. 17f). Nitrogen mineralization pattern of green manure crops was not significantly affected by the methods of incorporation of green

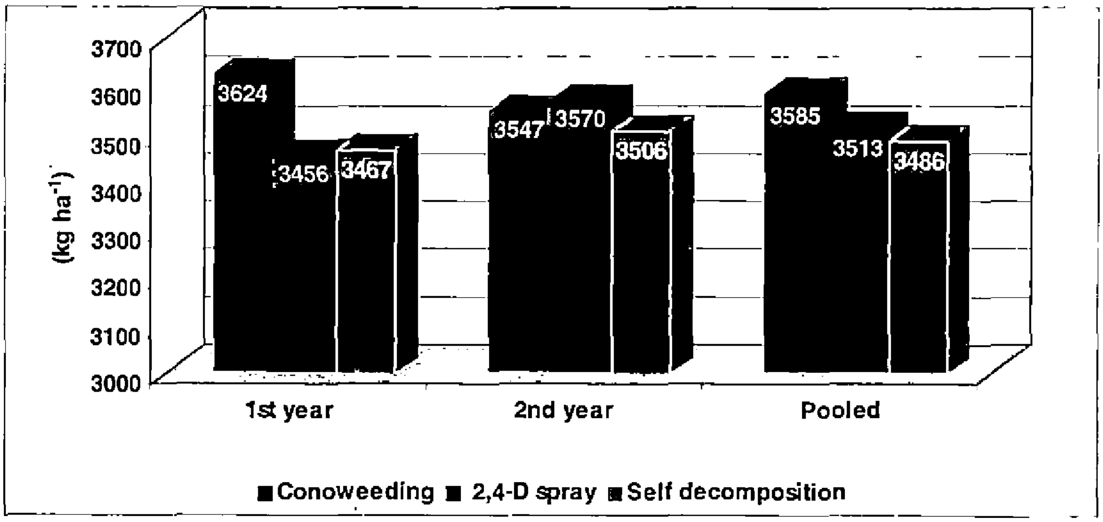


Fig. 15. Effect of methods of incorporation of green manure crops on the yield of dry sown rice

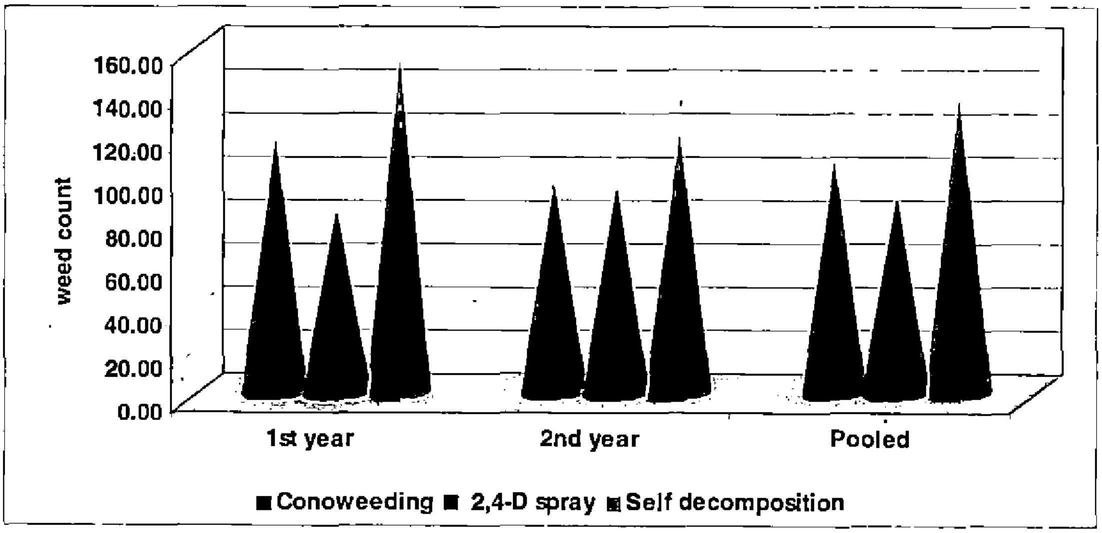


Fig. 16a. Effect of methods of incorporation of green manure crops on the total weed count of dry sown rice

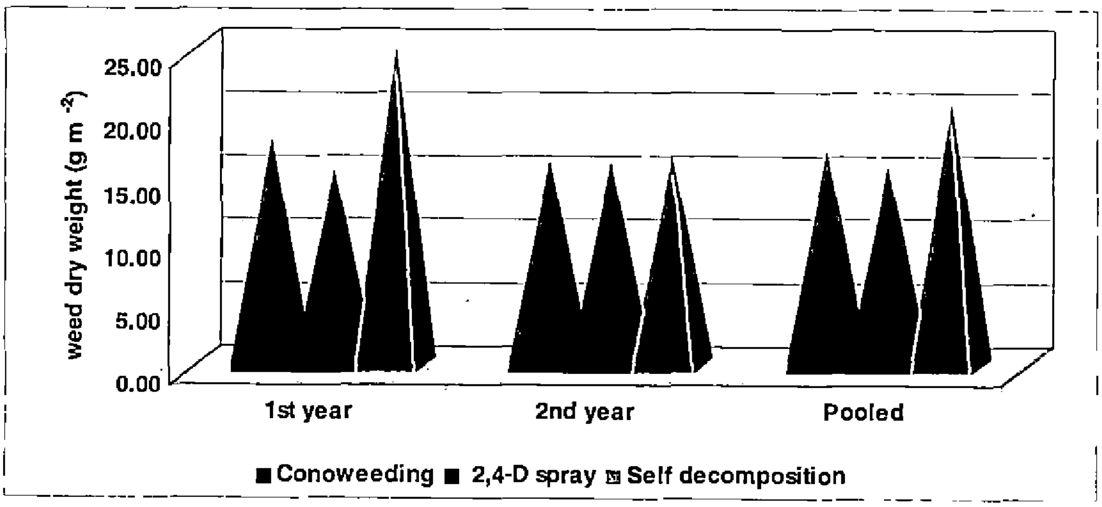


Fig. 16b. Effect of methods of incorporation of green manure crops on the total weed dry weight of dry sown rice

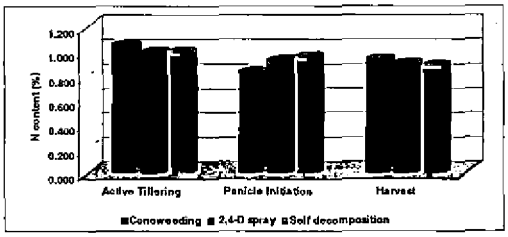


Fig. 17a. Effect of methods of incorporation of green manure crops on the N content of dry sown rice at different growth stages

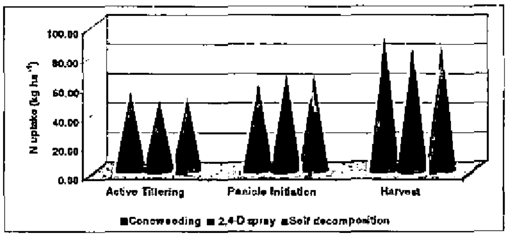


Fig. 17b. Effect of methods of incorporation of green manure crops on the N uptake of dry sown rice at different growth stages

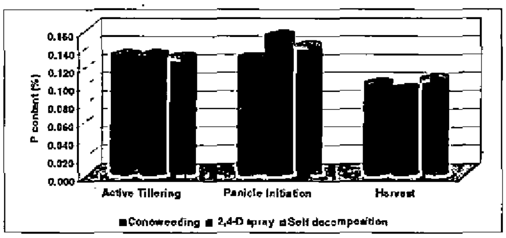


Fig. 17c. Effect of methods of incorporation of green manure crops on the P content of dry sown rice at different growth stages

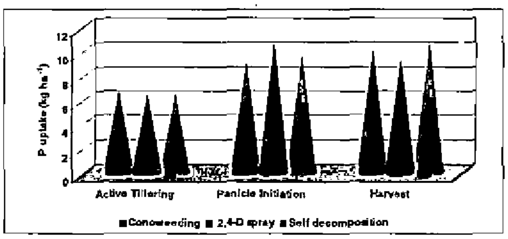


Fig. 17d. Effect of methods of incorporation of green manure crops on the P uptake of dry sown rice at different growth stages

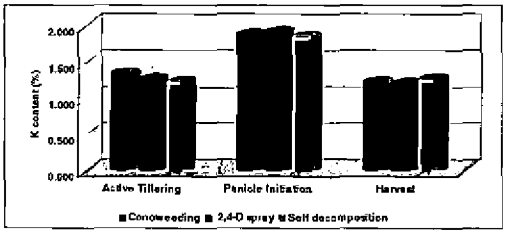


Fig. 17e. Effect of methods of incorporation of green manure crops on the K content of dry sown rice at different growth stages

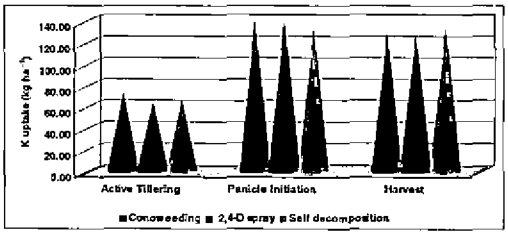


Fig. 17f. Effect of methods of incorporation of green manure crops on the K uptake of dry sown rice at different growth stages

manure crops (Fig. 18). Different methods of incorporation of green manure crops showed no significant variation on the soil organic carbon content and available N, P and K status of the soil (Table 4.1.26 and Fig. 19).

Economic analysis of different treatments showed no significant difference among the methods of incorporation. Cost of cultivation of methods of incorporation such as cono weeding and 2,4-D was less compared to self decomposition of green manures. This is due the reduced weeding cost in cono weeded and 2,4-D applied treatments due to lesser infestation of weeds. Johnkutty and Prasanna (2002) reported that drum seeding of rice and green manure seeds and incorporation of weeds and green manures by cono weeder resulted in a saving of Rs. 2490/ha over broadcasting and hand weeding and Rs.4490/ha over transplanting. But the gross return did not reach the level of significance mainly because the grain and straw yield of rice was not significantly affected by the methods of incorporation. Thus the net return and B: C ratio was not significantly affected by the methods of incorporation (Table 4.1.33 and Fig. 20). Results of the study indicated that all the three methods tested were equally effective in incorporating the green manure crops. The selection of the methods depends on the situations, particularly the receipt of rainfall. If there is an undue delay in the onset of monsoon, green manure crops can be effectively incorporated by employing cono weeding or by the 2,4-D spray.

5.1.3 Effect of nitrogen levels

Understanding the extent of nutrient saving obtained by incorporation of concurrently grown green manure crop is important in formulating an efficient nitrogen management schedule for dry seeded lowland rice. In the present investigation two levels of nitrogen i.e., 100 and 75 per cent of the recommended N were tested to find out the N requirement for the system of concurrent growing of green manure crops. These treatments were compared with control which receives 5 t ha^{-1} of FYM and 100 per cent of the recommended nitrogen. Results revealed that the yield of rice in concurrent growing of green manure crops receiving both 100 and 75 per cent of the recommended N registered higher yield compared to pure crop of rice receiving 5 t ha^{-1} of FYM and 100 per cent of the recommended nitrogen (Fig. 21). The straw yield was higher with rice grown alone receiving 5 t ha^{-1} of FYM and 100 per cent of the

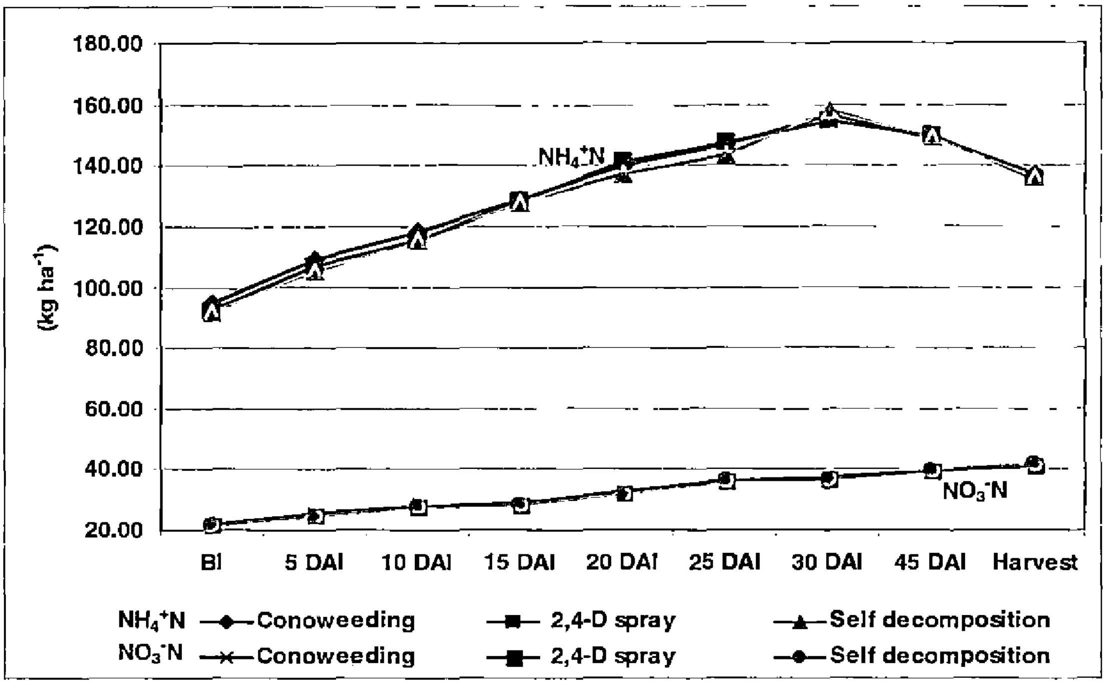


Fig. 18. Effect of methods of incorporation of green manure crops on the ammoniacal and nitrate nitrogen release pattern in dry sown rice

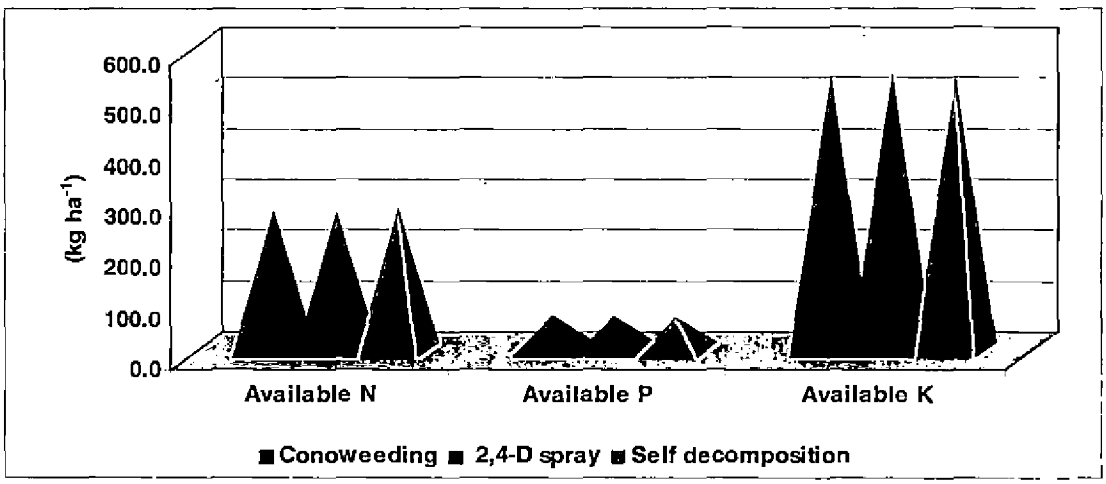


Fig. 19. Effect of method of incorporation of green manure crops on the soil available N, P and K status after harvest of dry sown rice

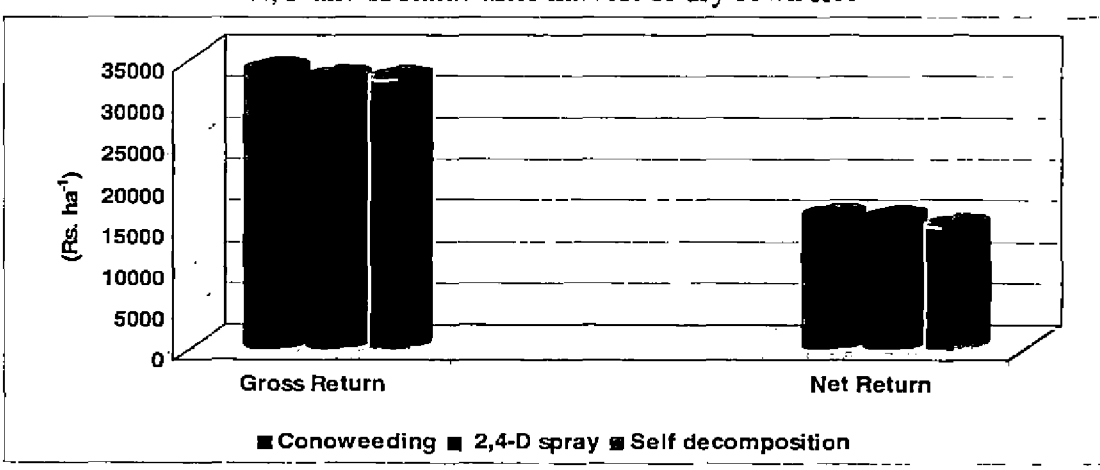


Fig. 20. Effect of methods of incorporation of green manure crops on the gross return and net return of dry sown rice

recommended nitrogen. Significant influence of green manure N could be expected only after 50 days when the green manure crops would have decomposed. Thus it appears that concurrent growing of green manures has helped in improving the use of fertilizer nitrogen by reducing the wasteful use of photosynthates in the productive phase. Nitrogen at 100 per cent of the recommended level produced more yield than 75 per cent N; however the treatment difference did not reach the level of significance. The absence of the yield difference between the application of N levels of 100 and 75 per cent to rice in the system of concurrent growing of green manure crops indicated that 75 per cent N is sufficient along with green manure crops. There is a clear saving of 25 per cent nitrogen to rice by the concurrent growing of green manure crops. The growth and yield attributes of rice grown along with green manure crops receiving 100 and 75 per cent N was higher than the pure crop of rice. But the difference among the nitrogen levels on these growth and yield attributes is non significant. This might be the reason for increased yield of rice in association with green manure crops which received 100 and 75 per cent N and the non – significance of yield between the nitrogen levels.

Nitrogen application at 100 and 75 per cent of the recommended dose had no significant influence on the count and dry matter of weeds like grasses, broad leaved weeds and sedges at 30 DAS and 50 DAS. Concurrent growing of green manure crops receiving both levels of nitrogen registered lower weed population and weed dry matter production compared with rice grown alone receiving 5 t ha^{-1} of FYM and 100 per cent of the recommended nitrogen (Fig. 22a and 22b). With the recommended nitrogen dose, concurrent growing of green manure crops to meet the organic matter requirement of rice was the most effective in suppressing weeds compared to the application of 5 t ha-1 of FYM as this recorded the minimum weed population and weed dry matter. Reduction in weed growth evidently had been due to the successful smothering effect of green manure crops. Broader leaves and early and fast growth of green manure crops might have substantially lowered the quantity of light reaching the ground. Musthafa (1995) indicated similar results. Application of 5 t ha^{-1} of FYM as basal dose to control plots might have benefited the weeds emerged in the early growth period.

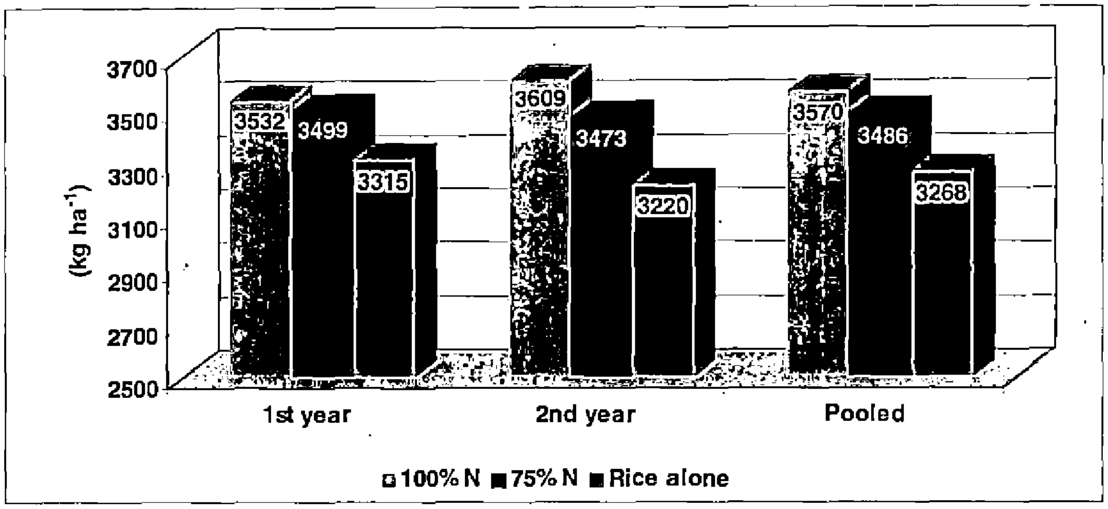


Fig. 21. Effect of levels of nitrogen on the yield of dry sown rice

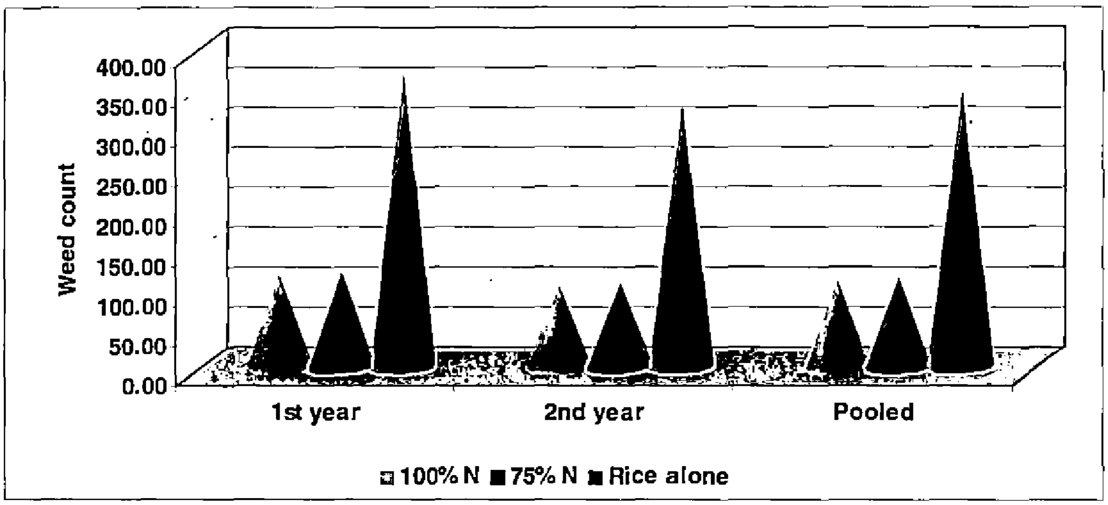


Fig. 22a. Effect of levels of nitrogen on the total weed count of dry sown rice

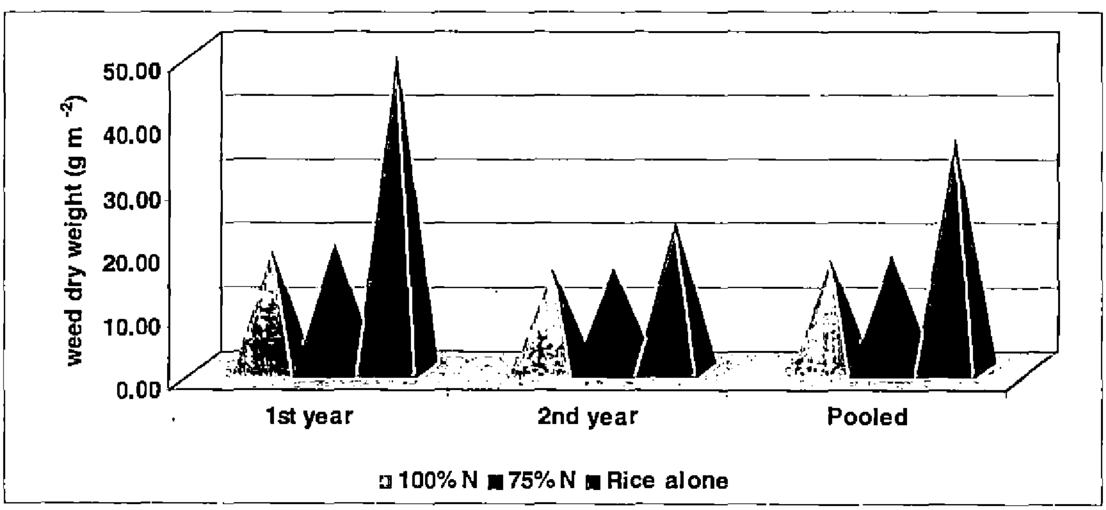


Fig. 22b. Effect of levels of nitrogen on the total weed dry weight of dry sown rice

Application of nitrogen at 100 per cent level though not significant increased the biomass production of green manure crops and resulted in significantly higher contribution of N. Application of both levels of nitrogen to rice grown along with green manure crops has increased the N content and N uptake of the crop through out the growth period of rice (Fig. 23a to 23f). This increase in N content has brought out a corresponding increase in the yield of rice compared with pure crop of rice. The result showed the direct effect of N to increase the yield through an increase in the content and uptake of this element in the crop.

Nitrogen mineralization pattern of green manure crops was significantly affected by the levels of N. The content of NH_4^+-N in soil was significantly higher in treatments receiving 100 per cent N through out the growth period, followed by 75 per cent N (Fig. 24). Release pattern of NO_3^--N also showed a similar trend. The results indicated that release of N was more, when fertilizer N was applied along with green manure crops than with FYM. Selvi (2001) reported that incorporation of intercropped daincha at tender stage coupled with 100 per cent N was found optimum from the point of releasing most of the fast releasing N, showing higher soil available N and P at the crucial stage of rice flowering and there by resulted in better uptake of nutrients, more rice dry matter production, number of panicles m^{-2}, filled grain $panicle^{-1}$, higher grain and straw yield.

The build up of soil fertility, with respect to organic carbon, N, P and K status, was higher in the system of concurrent growing of green manure crops receiving both 100 and 75 per cent of the recommended N compared to pure crop of rice receiving 5t ha^{-1} of FYM and 100 per cent of the recommended nitrogen (Table 4.1.26 and Fig. 25). This is due to increased biomass addition of green manure crops which in turn resulted in higher contribution of N, P and K by green manure crops. But the difference among the nitrogen levels on organic carbon, N, P and K status of soil is non significant.

Economic analysis of the treatments indicated that different levels of N applied to the system of concurrent growing of green manure crops behaved similarly in the net return and B: C ratio. The net return and B: C ratio was significantly higher than the pure crop of rice. All these results suggested that concurrent growing of green manure

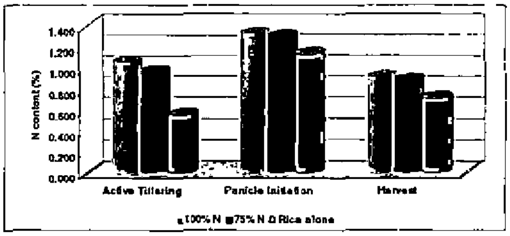


Fig. 23a. Effect of levels of nitrogen on the N content of dry sown rice at different growth stages

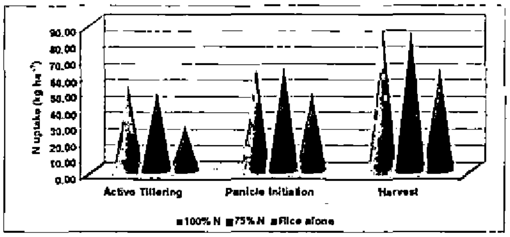


Fig. 23b. Effect of levels of nitrogen on the N uptake of dry sown rice at different growth stages

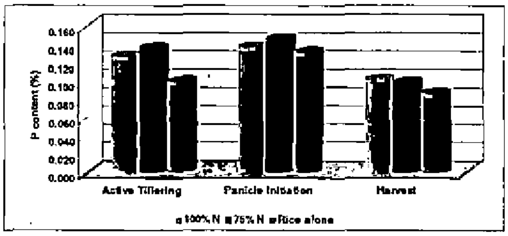


Fig. 23c. Effect of levels of nitrogen on the P content of dry sown rice at different growth stages

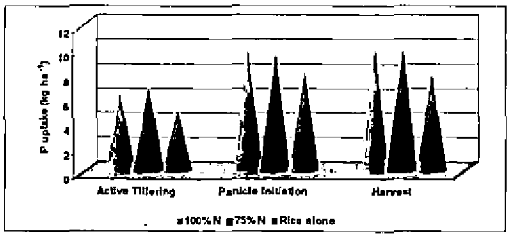


Fig. 23d. Effect of levels of nitrogen on the P uptake of dry sown rice at different growth stages

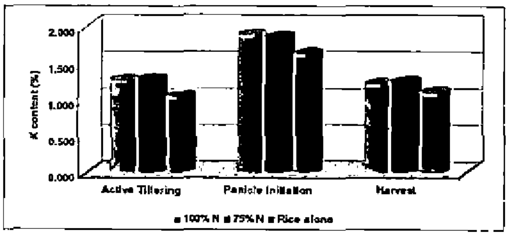


Fig. 23e. Effect of levels of nitrogen on the K content of dry sown rice at different growth stages

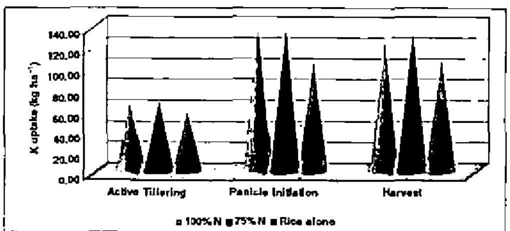


Fig. 23f. Effect of levels of nitrogen on the K uptake of dry sown rice at different growth stages

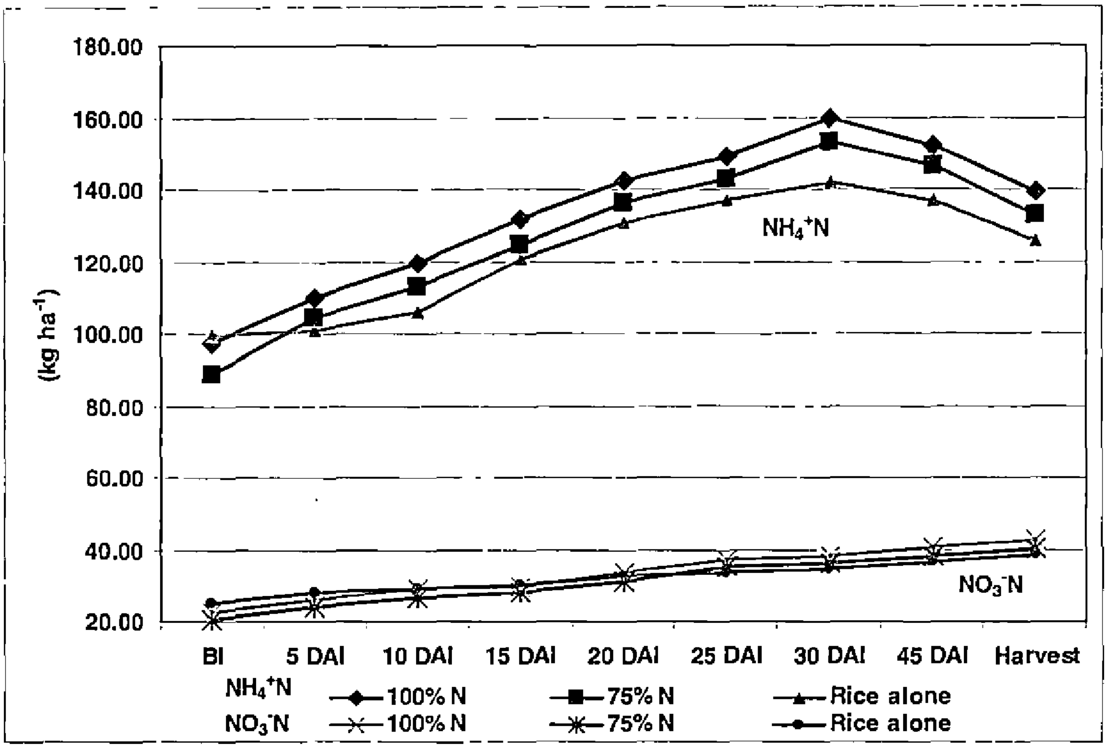


Fig. 24. Effect of levels of N on the ammoniacal and nitrate nitrogen release pattern in dry sown rice

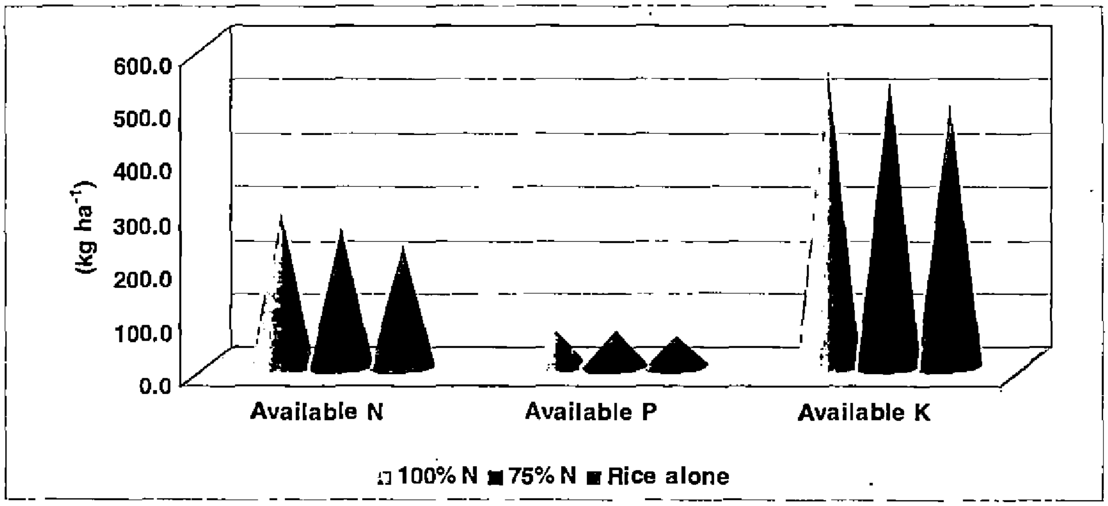


Fig. 25. Effect of levels of N on the soil available N, P and K status after harvest of dry sown rice

crops in dry seeded rice could save 25 per cent N to the current season rice crop with positive effects on the productivity and profitability of the system.

Concurrent growing of cowpea and its subsequent incorporation using cono weeder or by spraying 2,4-D was found to be equally effective to that of self decomposition of cowpea due to flooding in increasing the yield of rice compared with dry sowing of rice alone. This shows that in places where there is an undue delay in the onset of monsoon, green manure crops can be effectively incorporated by employing cono weeding or by 2,4-D spray without affecting the yield or nutrient content of soil with the additional benefit of weed control. Growing of cowpea along with rice and its subsequent incorporation helped to reduce the use of nitrogen fertilizer by 25 per cent with out affecting the yield. Concurrent growing of cowpea guarantees enhancement in yield to the tune of 365 kg ha^{-1}, increase in profitability to the tune of Rs.14562 ha^{-1}, reduction in labour requirement for weeding (40 man-days/ha), weed suppression (69-75%) and assured addition of more than 12 t/ha of organic manures with a reduction in the use of nitrogen fertilizer by 25 per cent. The study thus has succeeded in developing a comprehensive management package for concurrent growing of green manure crops in dry sown rice system.

5.1.4 Influence of residual and direct effects of treatments in the succeeding transplanted rice

Residual effect of preceding treatments on succeeding rice

The various sources of nitrogen applied to crops are known to leave considerable residual effect in the soil, which may influence the nitrogen requirement of the succeeding crop. There as been a lacuna in information on the effect of concurrent growing of green manure crops in dry seeded rice on the succeeding transplanted rice. The present investigation was, therefore, undertaken to study the residual effect of concurrent growing of green manure crops, its different methods of incorporation and N levels applied to dry seeded rice on the transplanted rice in the succeeding season along with the direct effect of N fertilization to that crop.

The system of concurrent growing of cowpea in the preceding season was found to significantly increase the grain yield of succeeding transplanted rice. Concurrent growing of cowpea along with application of 100 per cent N to the preceding crop produced significantly higher yield than other treatments such as concurrent growing of horse gram and pure crop of rice receiving 100 per cent N (Table 4.2.10). The highest grain yield (5093 kg ha^{-1}) was observed in the treatment with concurrent growing of cowpea receiving 100 per cent N and incorporated using conoweeder during the preceding season (Fig. 26). Residual effect of legumes in increasing the yield of succeeding rice was reported by Silsbury (1990) and Siddeswaran (1992).

Yield increase is due to the increased growth parameters, viz., production of leaves, and leaf area and leaf area index of succeeding rice in this treatment (Table 4.2.4, 4.2.5 and 4.2.6). Higher leaf area helped in tapping more solar radiation and has resulted in better expression of yield contributing characters like number of panicles, panicle weight, filled grains and test weight (Table 4.2.8 and 4.2.9). All the yield attributes of transplanted rice, though not significant, were found higher in treatments involving concurrent growing of green manure crops during the preceding crop. As a result of increased growth and yield attributes, the grain yield of succeeding transplanted rice was significantly increased after concurrent growing of green manure crops especially cowpea. The findings of Mishra and Giri (2004) corroborate the results of the present study.

Increased growth and yield attributes of succeeding rice was mainly due to the increased nutrient availability owing to the substantial build up of soil fertility, with respect to organic carbon, N, P and K status, noticed after the incorporation of intercropped green manure crops in the preceding season (Table 4.1.26). Increased contribution of N, P and K by cowpea caused an increase in soil available N, P and K in cowpea incorporated plots compared to horse gram. Danso and Papastylianou (1992) reported that the N benefit is due to lower uptake of soil N by legumes relative to cereals and a carry over of N from the legume residue, both leading to a greater uptake of soil N by the subsequent crop compared to crops grown after non legumes. In the initial growth stages, the nutrient content and uptake of transplanted rice was significantly higher in treatments involving concurrent growing of green manure crops during the preceding crop, compared to pure crop. Tiwari *et al.* (2004) reported carry over effect of green manuring in maize to the succeeding wheat, as the wheat crop showed higher uptake in green-manured treatments. But in the later growth stages, the variation in nutrient content and uptake of transplanted rice due to residual effect of treatments was not evident. The increased nutrient availability during the active growth stages resulted in increased nutrient contents of N, P and K reflecting on the improved development of growth and yield characters nutrient uptake and thereby enhanced grain yield. Increased grain yield might be due to the better partitioning of photosynthates to the grains than in straw in treatments involving concurrent growing of green manure crops in the preceding season and the resultant lower straw yield in these treatments.

The soil fertility status after the succeeding crop indicated a positive balance of all the nutrients in treatments involving concurrent growing of green manure crops during the preceding season (Fig. 27). Soil fertility, with respect to organic carbon, N, P and K status, was found to be sustained at a higher level in treatments involving concurrent growing of green manure crops during the preceding season, compared to the crop with out green manure crops (Table 4.2.17). The present study indicated the sustained effect of concurrent growing system even after the succeeding rice. Thus concurrent growing of green manure crops preferably cowpea along with *virippu* rice is the best practice for increasing the yield of dry seeded rice, with a positive effect on the yield of succeeding transplanted rice and a soil fertility build up in the rice-rice cropping system.

Economic analysis of the whole system showed that, concurrent growing of green manure crops during the preceding crop has positive influence on the profitability of the rice-rice cropping system. Concurrent growing of both green manure crops increased the net return and B: C ratio of the rice- rice system compared with rice grown alone during the previous season. Pure crop of rice with out any green manure crops during the previous season resulted in the least net return and B: C ratio. Concurrent growing of cowpea incorporated by conoweeder receiving100 per cent N registered the highest net return (Rs.43912 ha^{-1}) and B: C ratio (2.16). The better net return from the system of concurrent growing of cowpea is due to the better gross return realized from this system (Table 4.2.18). This higher gross return is a direct reflection of higher rice yield. The highest net return is also due to the reduced cost involved in weed management in the cowpea intercropping treatments. This indicated that the system of concurrent growing of green manure crops in the preceding dry seeded rice is an economically profitable practice compared to rice grown with out green manure crops. The highest system profitability is obtained with concurrent growing of cowpea during the preceding season with an increase in the net return of Rs.9269 ha^{-1} compared with concurrent growing of horse gram and Rs.18856 ha^{-1} compared with pure crop of rice during the preceding season.

Direct effect of nitrogen levels applied to succeeding rice

The extent of nutrient saving by concurrent growing of green manure crops to the succeeding crop has not been worked out earlier for dry seeded system. In this investigation a second crop of rice crop was raised in the same plots of concurrent growing of green manure crops during the previous season after dividing the plots equally into two sub plots. Sub plots received 100 and 75 per cent nitrogen doses to study the residual effect of the treatments imposed during the first crop. Levels of nitrogen applied to current transplanted rice significantly influenced growth parameters, viz. plant height, leaf $hill^{-1}$, leaf area, leaf area index and dry matter production (Table 4.2.1 to 4.2.7). All these growth parameters were significantly higher when the crop received 100 per cent of the recommended N. Direct application of N obviously made more nutrients available to the transplanted rice crop which reflected on better growth. Effect of direct application of N on growth parameters was reflected on yield attributes also. Though not significant, the entire yield attributes, viz. number of panicles, panicle weight, filled grains and test weight were higher when 100 per cent N was supplied to the transplanted crop (Table 4.2.8 and 4.2.9). This was attributed to the better partitioning of photosynthates from source to sink with the application of N to the current crop. Mishra and Giri (2004) reported similar results in Indian mustard. The improved growth and yield attributes resulted in significant increase in the grain yield of transplanted rice due to the application of 100 per cent N (Fig. 28). This result is in conformity with the findings of Patra *et al.* (2000)

Increased availability of N due to the application of 100 per cent N resulted in increased growth and yield attributes. This was mainly due to the increased plant

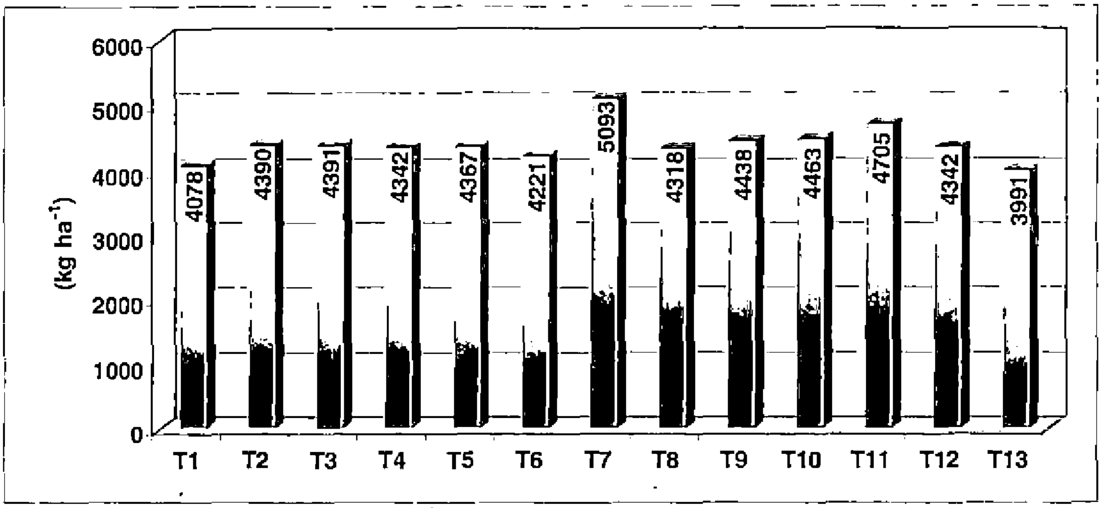


Fig. 26. Residual effect of concurrent growing of green manure crops in dry seeded rice on grain yield of succeeding transplanted rice

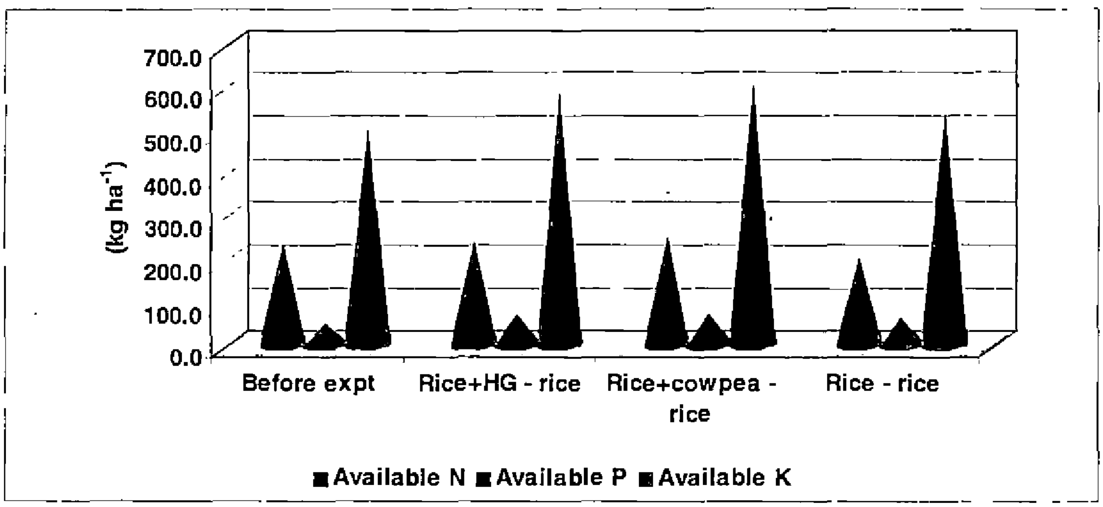


Fig. 27. Residual effect of concurrent growing of green manure crops in dry seeded rice on soil nutrient status of succeeding transplanted rice at harvest

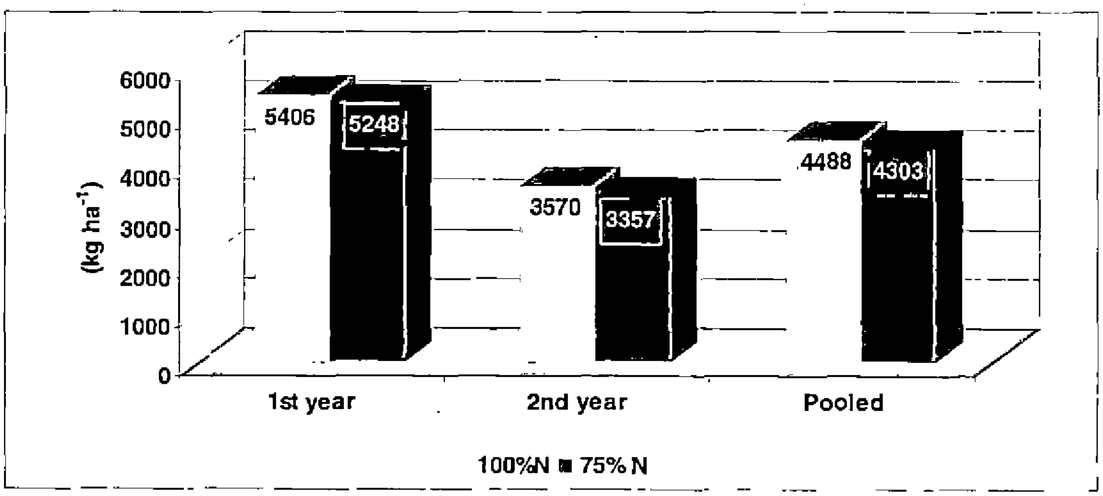


Fig. 28. Direct effect of levels of N on grain yield of rice crop succeeding the dry sown rice

content and uptake of N at 100 per cent N. The soil fertility status with respect to organic carbon, N, P and K after the residual crop was significantly higher with 100 per cent N (Table 4.2.17). The available N status after the residual rice was less than the initial N status in treatments receiving 75 per cent N. This indicated that to achieve the sustainability of the system the residual rice crop is to be supplied with 100 per cent N. The finding corroborates the results of Raju and Reddy (2000a). The profitability of the system was also higher when the residual rice crop was supplied with 100 per cent N (Table 4.2.18) as it registered the highest total net return (Rs.32456 ha^{-1}). Kumpawat (2004) reported maximum net return and benefit: cost ratio of maize – indian mustard by supplying 100 per cent NP to the residual mustard crop.

Concurrent growing of cowpea along with dry seeded rice is a viable system as it resulted in increased productivity, profitability and sustainability dry seeded rice. Among the two green manure crops tried in dry seeded rice, cowpea was the best in supplying the required quantity of green matter with 25 per cent savings of N fertilizer and a substantial reduction on weed incidence. Concurrent growing of cowpea along with dry seeded rice reduced the cost of production with increased productivity and profitability. All the three methods of incorporation were found equally effective hence in places where there is a difficulty in self decomposition, cowpea can be effectively incorporated by conoweeder or by spraying 2, 4-D. The cowpea variety used in this study was a short duration bush type variety and hence got an additional pod yield from cowpea before it was incorporated.

Concurrent growing of green manure crops along with dry seeded rice were effective in increasing the yield of succeeding transplanted rice and sustaining soil fertility status compared to pure crop of rice receiving 5 t ha^{-1} of FYM and 100 per cent of the recommended nitrogen during the previous season. But there was no savings of N fertilizer to the succeeding transplanted rice crop as the highest yield of succeeding rice was achieved only when it received 100 per cent of the recommended N. The profitability of the rice+ cowpea- rice cropping system was the highest compared to rice- rice system with out green manure crops.

It is concluded that resource poor farmers can get higher returns by concurrent growing of leguminous crops in rice based cropping systems, besides the sustainability in production and soil health.

5.2 CONCURRENT GROWING OF DAINCHA IN WET SEEDED RICE

Concurrent growing of daincha in wet seeded rice involves sowing of rice and daincha simultaneously into the puddled soil in alternate rows using a green manure cum rice seeder and subsequently incorporating the daincha using a conoweeder. Rajendran *et al.* (2002) observed an yield increase of 800 kg ha^{-1} by adopting concurrent growing of daincha and rice using rice cum green manure seeder and the subsequent incorporation of daincha by using conoweeder. In case intense rain is received immediately after sowing, it may adversely affect the establishment of rice and daincha in lines, thus posing problems in the incorporation of daincha by conoweeder. Information on the correct stage and method of incorporation of daincha as well as on the manurial requirement of the system is lacking. The present study is undertaken in this background to find out optimum stage and effective methods of incorporation of daincha, to work out the nutrient saving and to study the cost effectiveness of the system of concurrent growing of daincha in wet seeded rice.

5.2.1 Effect of stages of incorporation

Beneficial effect of concurrent growing of daincha in wet seeded rice was evident from the increased yield of rice in the present study compared to wet sowing of rice alone. Stages of incorporation of daincha had significant influence on yield (Fig. 29). Incorporation of daincha at 30 days after sowing resulted in significantly higher yield (5184 kg ha^{-1}) compared to 20 days after sowing (4907 kg ha^{-1}). It supports the findings of Jayadeva *et al.* (2004) who reported that inter cropping of daincha in drum seeded rice for *in situ* incorporation at 30 DAS and application of 100 per cent recommended N recorded significantly higher yield due to effective biomass incorporation into the soil. Incorporation of daincha at 30 DAS, though not significantly increased, registered higher values for all the growth parameters compared with 20 DAS (Table 4.3.1 to 4.3.7). These growth parameters positively reflected in the better expression of yield attributes and there by higher yield. Panicles hill^{-1}, panicle weight, filled grains and 1000 grain weight of rice was numerically higher when daincha was incorporated at 30 DAS compared with daincha incorporated at 20 DAS (Table 4.3.10 and 4.3.11). The yield increase due to the incorporation of daincha at 30 DAS might be due to the cumulative effect of all these yield attributes. The marked increase in grain yield could be owing to improvement in yield attributes and enrichment of soil fertility through green matter addition into the soil (Hemalatha *et al.*, 2000).

In the present study, incorporation of daincha both at 20 and 30 days after sowing significantly increased the yield compared to wet sowing of rice alone. The yield increase due to the incorporation of daincha was to the tune of 683 kg ha^{-1} at 30 days and 406 kg ha^{-1} at 20 days when compared with rice alone (Fig. 29). All the growth parameters of rice involving concurrent growing of daincha, was significantly higher than that of pure crop of rice. These better growth parameters resulted in tapping more solar radiation and have resulted in better yield attributes in rice by concurrent growing of daincha than pure crop of rice. Higher yield obtained by the concurrent growing of daincha is a positive reflection of the increased growth and yield attributes. Saravanapandian and Perumal (1994) stated that green manure had significant effect in improving the yield attributes of rice viz., productive tillers plant^{-1}, filled grains panicle^{-1} and 1000 grain weight as compared to FYM. Intercropping daincha, exclusively for *in situ* green manuring, promoted growth and yield attributes which in turn reflected positively on the grain and straw yield of rice than sole rice (TNAU, 2002). These results also confirm the findings of Anbumani *et al.* (2003) and Sankar *et al.* (2003). Concurrent growing of daincha effectively minimized the production of non productive tillers compared with pure crop and this decline of non productive tillers in the post flowering phase had contributed to the increased yield (Table 4.3.7). This result is in close agreement with Musthafa (1995). In the present study, concurrent growing of daincha significantly increased the number of panicles hill^{-1}, filled grain panicle-1 and 1000 grain weight compared to pure crop, there by higher yield of rice was realized in the system of concurrent growing of daincha. Sharma and Ghosh (2000) reported similar results. It is observed in the present study that, the better performances of growth and yield contributing characters were noticed when rice was grown along with daincha than grown alone. This implied that competition for rice due to concurrent growing of daincha was less. In addition, daincha is a leguminous plant that can fix atmospheric N for its need and as such may not compete with rice. Concurrent growing of daincha in wet seeded rice proved better in terms of productivity over sole crop.

Weed flora in the experimental field was mainly constituted by*Echinochloa* sp., *Isachne miliacea, Panicum repens, Ischaemum rugosum*, among grasses; *Monochoria vaginalis, Ludwigia parviflora, Marsilea quadrifoliata, Nymphaea nouchali, Spenoclea zeylanica* among broad leaved weeds; *Cyperus sp., Schoenoplectus sp.* and *Fimbristylis miliacea* among sedges. Concurrent growing of daincha along with wet seeded rice significantly reduced the count and dry weight of grasses, broad leaved weeds and sedges and thereby the total population and dry matter production of weeds in wet sown rice during both years compared with rice grown alone. Beneficial effect of concurrent growing of daincha in reducing the weed population and weed bio mass was reported by Weerakoon *et al.* (1992), Rajendran *et al.* (2002) and Sankar *et al.* (2003). The percentage decline of total weed count due to concurrent growing of daincha was 72 per cent in wet sown rice (Table 4.3.13 and Fig. 30). The percentage decline of total weed dry matter production due to concurrent growing of daincha was 57 per cent compared to rice grown alone (Table 4. 3.14). The reduction in weed population and weed dry matter in the system of concurrent growing of daincha may be attributed to shading effect exerted by the canopy of daincha. The co-cropping system reduced the weeding cost by 59 per cent due to saving in labour requirement by 38 man-days ha^{-1} (Appendix IV). Incorporation of daincha at 20 and 30 DAS had no significant influence on the weed population and weed dry matter production (Table 4.3.14 and Fig. 31). The decrease in the population and dry matter production of weeds brought about by concurrent growing of daincha indicated that daincha had grown only at the expense of weeds by using the growth resources which weeds would have otherwise utilized and may not have competed with rice for growth resources. Reduced weed population in treatments involving co-cropping of daincha created a competition free environment for growth resources for rice and might have resulted in increased nutrient uptake and yield of rice compared with pure crop of rice.

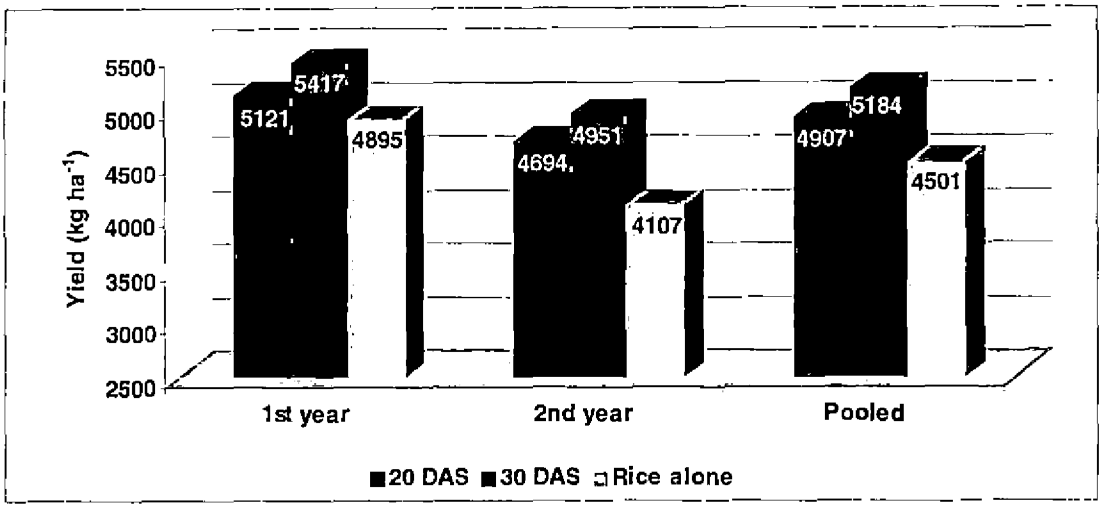


Fig. 29. Effect of stages of incorporation of daincha on the grain yield of wet seeded rice

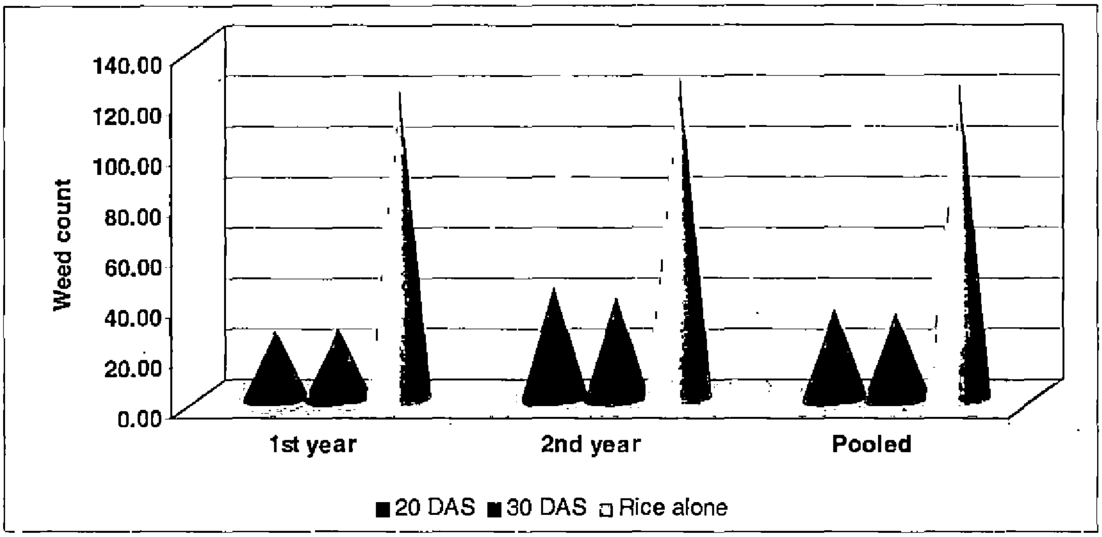


Fig. 30. Effect of stages of incorporation of daincha on the total weed count in wet seeded rice

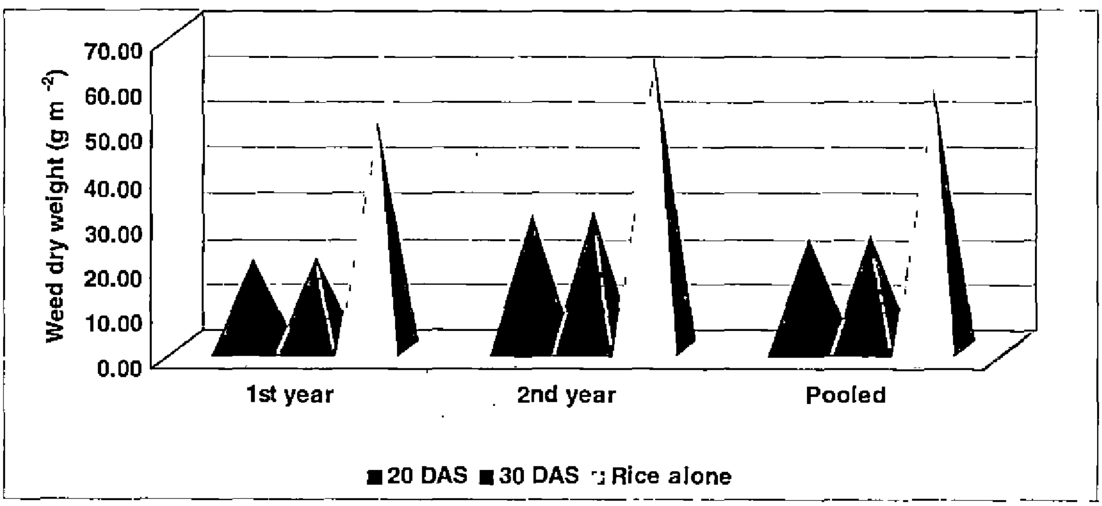


Fig. 31. Effect of stages of incorporation of daincha on the total weed dry weight in wet seeded rice

Concurrent growing of daincha and its subsequent incorporation in wet seeded rice is very effective in supplying the required quantity of organic manures to rice with minimum investment i.e. the cost of daincha seeds and its sowing charges alone. The green biomass addition at 30 DAS was 2.24 times more compared to incorporation of daincha at 20 DAS (Table 4.3.9 and Fig. 32). As suggested by Bhuiya and Salam (2002), the yield increase in rice was due to the incorporation of larger quantity of green biomass of *Sesbania*. Rajendran *et al.* (2002) opined that concurrent growing of daincha and rice using rice cum green manure seeder and the subsequent incorporation of daincha using conoweeder, yielded seven to nine tones of biomass per hectare within four to five weeks. The higher green biomass addition resulted in increased availability of nutrients especially nitrogen. This might be due to the increased nutrient content of daincha at 30 DAS than at 20 DAS (Table 4.3.21 and Fig.33). Higher biomass of daincha (13698 kg ha^{-1}) coupled with increased nutrient content significantly increased the nutrient contribution from daincha at 30 days of incorporation compared with incorporation at 20 days. Higher biomass production of daincha at 30 DAS was a positive reflection of increased height, leaf area and nodule count . The N, P and K contribution of 30 days old daincha was to the tune of 126.4, 8.86 and 139.2 kg ha^{-1} and the corresponding figures of 20 days old daincha was 40.1, 5.57 and 63.5 kg ha^{-1} (Table 4.3.22 and Fig.34). Singh *et al.* (1991a) reported that biomass production and N accumulation of *Sesbania* were mainly controlled by age factor. The increased growth of daincha led to better soil fertility and thus gave boost to yield attributes which in turn resulted in increased grain yield (Sah *et al.*, 2000). Increase in yield due to application of daincha might be due to addition of extra nutrients. Application of daincha exploits the fixed nutrients of soil in available form and regulates its supply to the crop through mineralization and prevents them from leaching and other losses (Dwivedi and Thakur, 2000).

Knowledge on the nitrogen mineralization pattern is of primary importance for efficient nitrogen management. Nitrogen release pattern was studied in terms of ammoniacal nitrogen (NH_4^+-N) and nitrate nitrogen (NO_3^--N) before and after incorporation of daincha up to harvest at periodic intervals. Release pattern of ammoniacal nitrogen (NH_4^+-N) suggests that release of nitrogen from daincha was fast. Stages of incorporation of daincha had significant influence on the ammoniacal

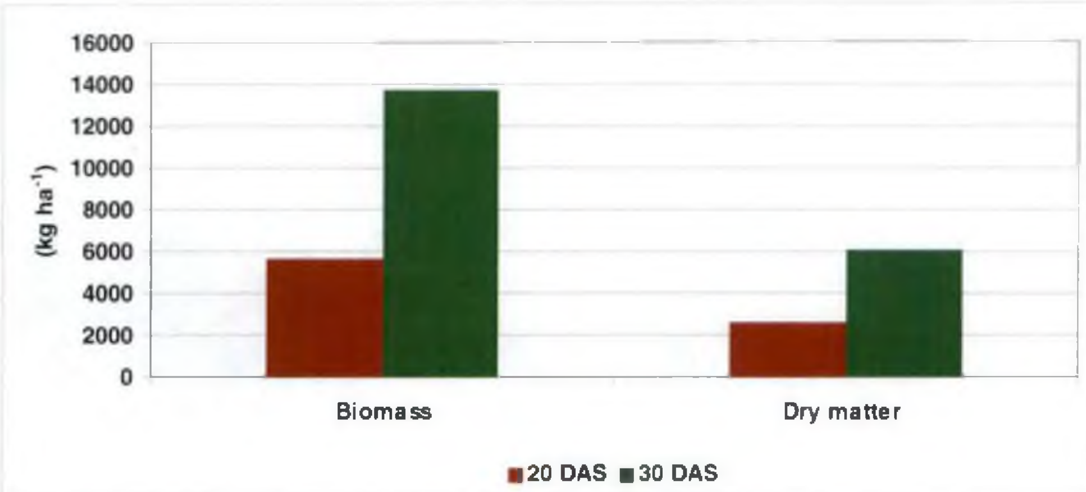


Fig.32. Effect of stages of incorporation of concurrently grown daincha on biomass production and dry matter addition in wet seeded rice

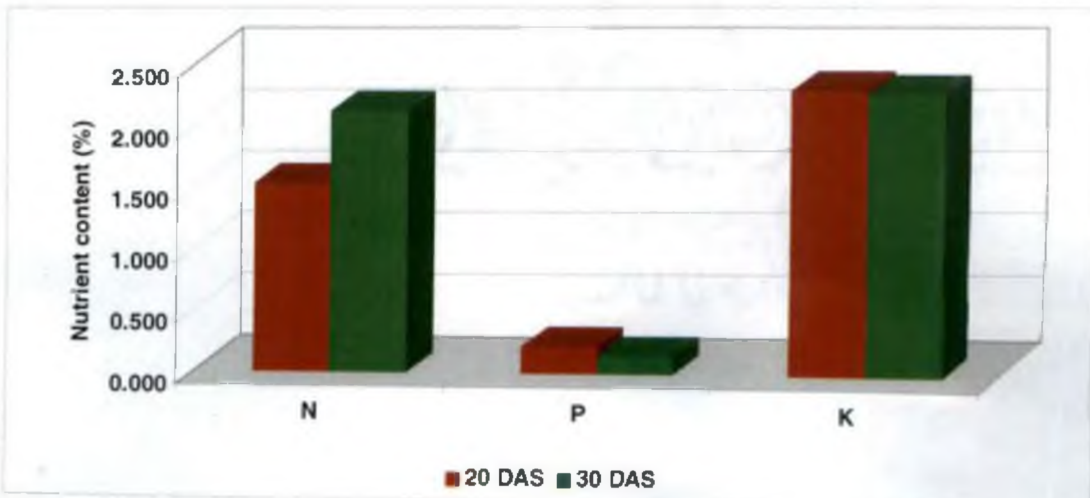


Fig.33. Nutrient content of concurrently grown daincha in wet seeded rice

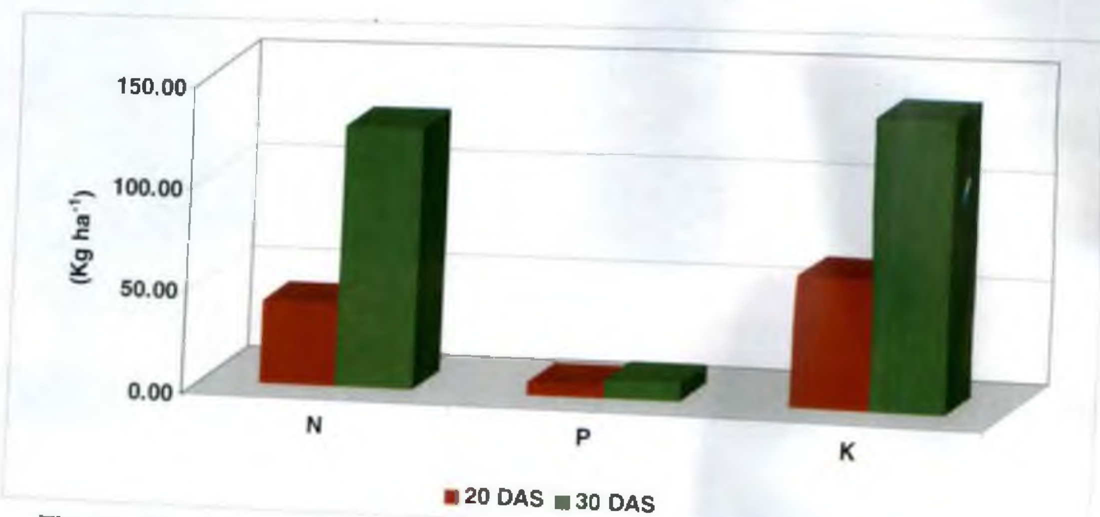


Fig.34. Nutrient contribution of concurrently grown daincha in wet seeded rice

nitrogen release from daincha. Release of ammoniacal nitrogen was found maximum at 30 DAI from both 20 and 30 days old daincha and then noticed a decline in the release of NH_4^+-N up to harvest ((Table 4.3.26 and Fig.35). The maximum release of NH_4^+-N from 20 days old daincha (157.02 kg ha^{-1}) was noticed at 50DAS *i.e.,* 30 DAI. Similarly the maximum release of NH_4^+-N from 30 days old daincha (176.53 kg ha^{-1}) was noticed at 60DAS *i.e.,* 30 DAI. The quantity of release of NH_4^+-N was significantly higher when daincha was incorporated at 30 DAS. This might be due to the higher biomass addition and nutrient content of daincha at 30 DAS than at 20 DAS. Soil NH_4^+-N content was much higher in daincha intercropped plots than sole crop of rice at any stage of estimation. Joseph *et al.* (2002) reported similar pattern of NH_4^+-N release by the incorporation of intercropped daincha. Incorporation of 30 days old daincha along with 100 per cent of nitrogen favoured the highest release of NH_4^+-N at 60 DAS. Increased release of NH_4^+-N ensured adequate availability N at the critical stage of 60-80 DAS enabling better nutrient uptake and higher yield by rice.

Intercropping and incorporation of *Sesbania aculeata* in wet seeded rice exerted a positive influence on NO_3^--N content of soil and the soil NO_3^--N content registered a steady and significant increase over pure crop of rice receiving 5 t ha^{-1} FYM as basal application (Table 4.3.29 and Fig.35). Similar was the findings of Joseph *et al.* (2002). However the quantity of release was less compared to NH_4^+-N. The nitrate content is expected to be minimum due to denitrification of the nitrate present initially and stopping of the nitrification due to anaerobic condition. The steady increase in NO_3^--N towards harvest may be due to the aerobic condition created by the draining of the field before harvest.

Concurrent growing of daincha enormously improved the soil nutrient status. Incorporation of daincha or FYM resulted in build up of soil organic carbon and available N, P and K and greater nutrient uptake by the rice crop (Table 4.3.23 and Fig.36). *Sesbania*, being a fast growing green manure, added higher green matter and hence the release of N, P and K could be more and recorded higher N, P and K content in rice (Dwivedi and Thakur, 2000) Organic carbon percentage of soil showed an increasing trend in daincha intercropped rice with the highest value in 30 days old daincha incorporated treatments compared with incorporation of daincha at 20 DAS and pure crop of rice; however the difference among the stages of incorporation did not reach the level of significance. Daincha incorporation at 30 DAS registered the highest available N status of soil (360.5 kg ha^{-1}) compared with incorporation at 20 DAS (323.9 kg ha^{-1}) and pure crop of rice (251.4 kg ha^{-1}). Sesbania might have helped to release N speedily which matched the stage of crop needs (Raju and Reddy, 2000b). Under anaerobic conditions, decomposition of turned down crop residue was fairly slowed and resulted in maintenance of soil- available N (Hemalatha *et al.* 2000). Similarly, the treatments receiving incorporation of daincha at 30 DAS registered the highest available P in the soil (79.2 kg ha^{-1}) compared with incorporation of daincha at 20 DAS (70.6 kg ha^{-1}) and pure crop of rice (61.6 kg ha^{-1}). Increase in available P with green manure might be attributed to P solubilizing capacity of green manure (Khind and Maskina, 1986). Organic acid and carbon dioxide liberated during the decomposition of green matter might have formed complex substances with metal ions and increased the concentration of P in the soil (Hemalatha *et al.* 2000). The available phosphorus content of soil decreased in pure crop of rice than the initial P status (66.1 kg ha^{-1}). The available K status of soil was improved over the initial status in all the treatments. The magnitude of increase was higher in daincha incorporated treatments. Incorporation of daincha at 30 DAS registered the highest available K in the soil (831.8 kg ha^{-1}) compared with incorporation of daincha at 20 DAS (782.4 kg ha^{-1}) and pure crop of rice (730.3 kg ha^{-1}). The green manure registered significantly higher K availability in soil due to their easy decomposition of mineral constituents and their effect in dislodging the exchangeable K into the soil solution (Mahapatra and Jee, 1993). Increased organic matter content and N, P and K content of post harvest soil is due to the increased biomass addition and thereby increased nutrient contribution resulted by the incorporation of daincha. The build up of N, P and K is also attributed to the solubilization of nutrients from their native sources during decomposition process and mineralization of organic manures as reported by Yadav *et al.* (2006). A positive build up of all the nutrients was observed in daincha intercropped plots. Raju and Reddy (2000b) noticed maximum nutrient balance when 50 per cent NPK was substituted through *Sesbania* green manuring. This could be attributed to fast decomposition and steady supply of N through out crop growth with *Sesbania*. Incorporation of 30 days old daincha receiving 100 per cent N recorded the highest N, P and K status of soil. The actual build up of the soil nutrient status compared with the initial soil nutrients was the least in pure crop of rice receiving 5 t ha^{-1} of farm yard manure and recommended nutrients. In daincha intercropped treatments, build up of all the soil nutrients was much higher compared to the nutrient status of the soil of pure crop receiving 5 t ha^{-1} of farm yard manure and recommended nutrients. Build up of all the soil nutrients revealed the sustainability of the system of concurrent growing of daincha in wet seeded rice.

Economic analysis revealed the profitability of concurrent growing of daincha in wet seeded rice. Net return was found to be the highest when daincha was incorporated at the age of 30 days (Rs.27473 ha^{-1}) compared daincha incorporation at 20 DAS (Table 4.3.30 and Fig. 37). Pure crop of rice recorded the least net return (Rs.16135 ha^{-1}). This might be due to the highest gross return (Rs.43332 ha^{-1}) obtained by incorporating daincha at 30 DAS compared with incorporation of daincha at 20DAS and pure crop. The higher gross return is a direct reflection of higher rice yield. The highest net return is also due to the reduced weeding cost in treatments involving daincha intercropping. The B: C ratio showed a similar trend as that of net return. Cost effectiveness of concurrent growing of daincha and rice using rice cum green manure seeder and the subsequent incorporation of daincha using conoweeder has been reported by Johnkutty and Prasanna (2002), Nadanassababady *et al.* (2002) and Rajendran *et al.* (2002). System of concurrent growing of daincha in wet seeded rice is economically profitable with an increase in net return by Rs.5502 ha^{-1} and Rs.3264 ha^{-1} when daincha was incorporated at 30 and 20 DAS respectively compared with pure crop of rice. Concurrent growing of daincha and wet seeded rice and the subsequent incorporation of daincha is a low cost technology because it avoids the need for exclusive cultivation of green manure crop as well as the need for raising the nursery and transplanting, thus saving considerable labour and cost (Rajendran *et al.*, 2002).

5.2.2 Effect of methods of incorporation

Concurrent growing of daincha and rice using rice cum green manure seeder and the subsequent incorporation of daincha using conoweeder is a low cost technology because it avoids the need for exclusive cultivation of daincha as well as the raising of

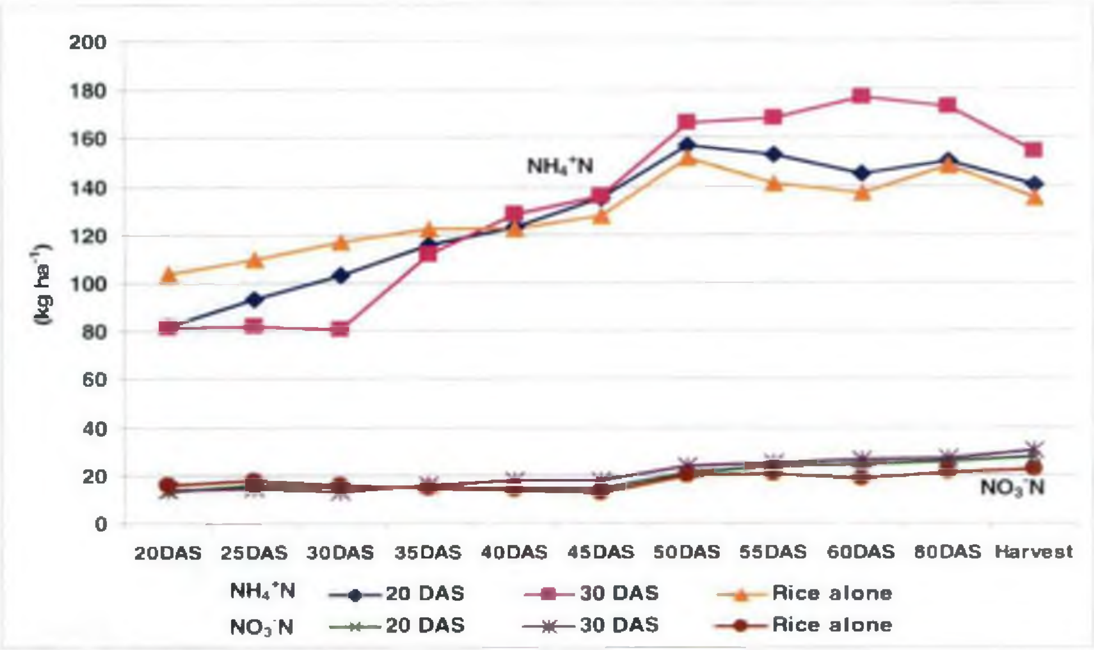


Fig. 35. Effect of stages of incorporation of concurrently grown daincha on the ammoniacal and nitrate nitrogen release pattern in wet sown rice

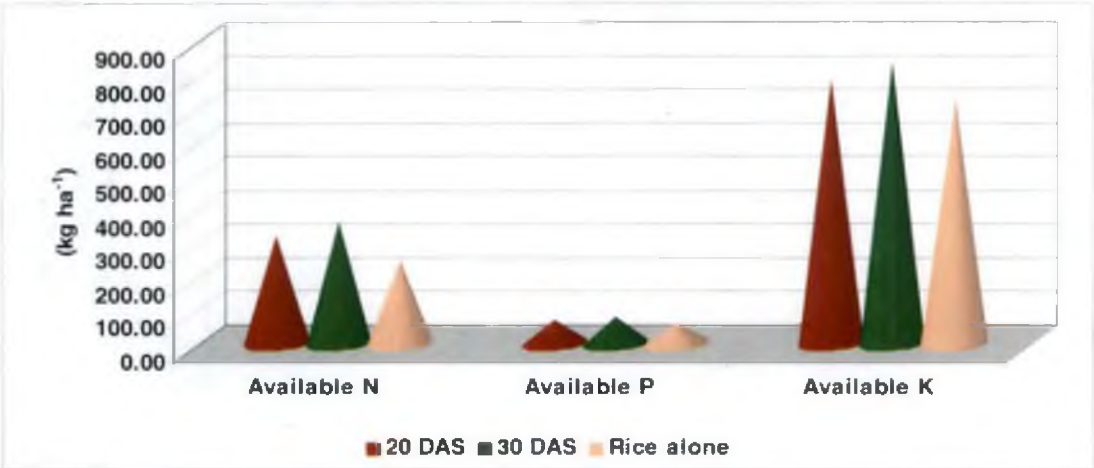


Fig. 36. Effect of stages of incorporation of concurrently grown daincha on the soil available N, P and K status after harvest of wet sown rice

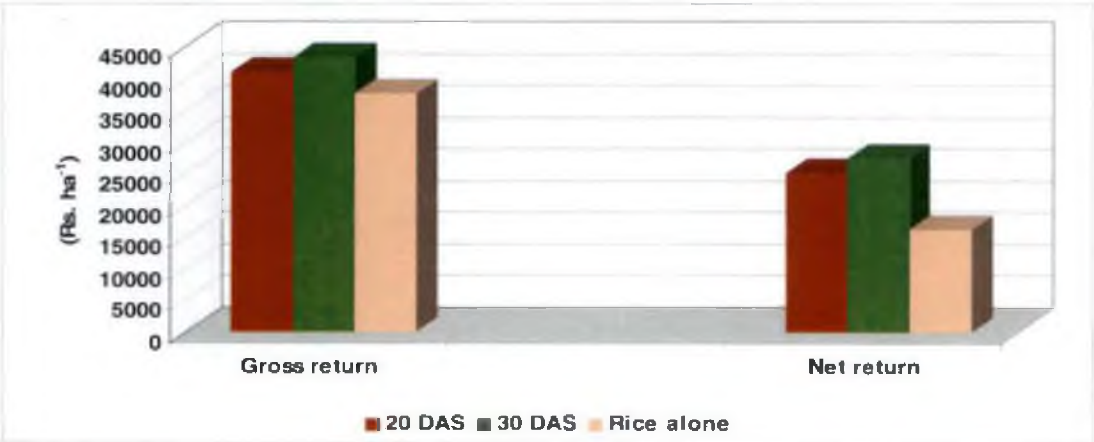


Fig. 37. Effect of stages of incorporation of concurrently grown daincha on the gross return and net return of wet sown rice

nursery and transplanting, saving considerable labour and cost. The possibility of intense rainfall immediately after sowing may adversely affect the establishment of rice and daincha in lines, thus posing problems in the incorporation of daincha by using conoweeder. It is because conoweeder can only be operated between lines. Thus it is highly essential to identify alternate methods of incorporation of daincha without any adverse effects on the system. In this investigation, daincha was incorporated at 20 and 30 days after sowing by using one of the three methods of incorporation viz., using cono weeder, spraying 2,4-D @1.0 kg ha^{-1}, and spraying either Chlorimuron ethyl + met sulfuron methyl (Almix) spray @ 4.0 g ha^{-1} or Metsulfuron methyl (Algrip)spray @ 5 .0 g ha^{-1}. Chlorimuron ethyl + met sulfuron methyl spray @ 4.0 g ha^{-1} was used during the 1st year of the study to incorporate the daincha. But the desiccation of daincha was found to be very poor. Hence in the 2nd year, Metsulfuron methyl spray @ 5 .0 g ha^{-1} was used instead of Chlorimuron ethyl + met sulfuron methyl spray @ 4.0 g ha^{-1} after verifying its effectiveness in a microplot study (Plates 6a to 6j). All the three methods of incorporation of daincha were found to be equally effective, as it had no significant difference on the rice yield (Table 4.3.12 and Fig. 38). This is because none of the growth parameters and yield attributes of rice was significantly affected by the incorporation methods.

Population and dry matter production of all types of weeds were significantly less in the system of concurrent growing of daincha as compared to rice grown alone (Fig. 39a and 39b). The grass weed count and dry matter production was found significantly less in conoweeded treatments. Broad leaved weeds and sedges were found significantly higher in conoweeded plots compared to other method of incorporation but less than control. Accordingly incorporation of daincha by conoweeder resulted in a reduction of total weed count by 65 per cent and total weed dry matter production by 55 per cent compared to control (Table 4.3.13 and 4.3.14). Rajendran *et al.* (2002) reported that weeds were substantially controlled by the adoption of concurrent growing of daincha and rice using rice cum green manure seeder and the subsequent incorporation of daincha by using conoweeder. Incorporation of daincha using 2,4-D significantly reduced the population and dry matter production of broad leaved weeds and sedges compared to other methods of incorporation and pure crop. Incorporation of daincha by spraying 2,4- D resulted in

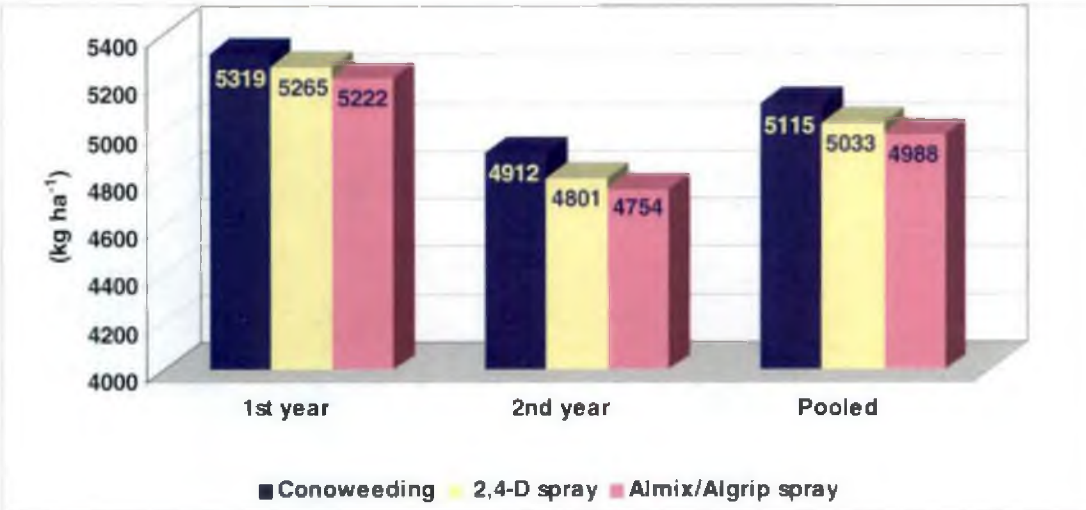


Fig. 38. Effect of methods of incorporation of daincha on the yield of wet sown rice

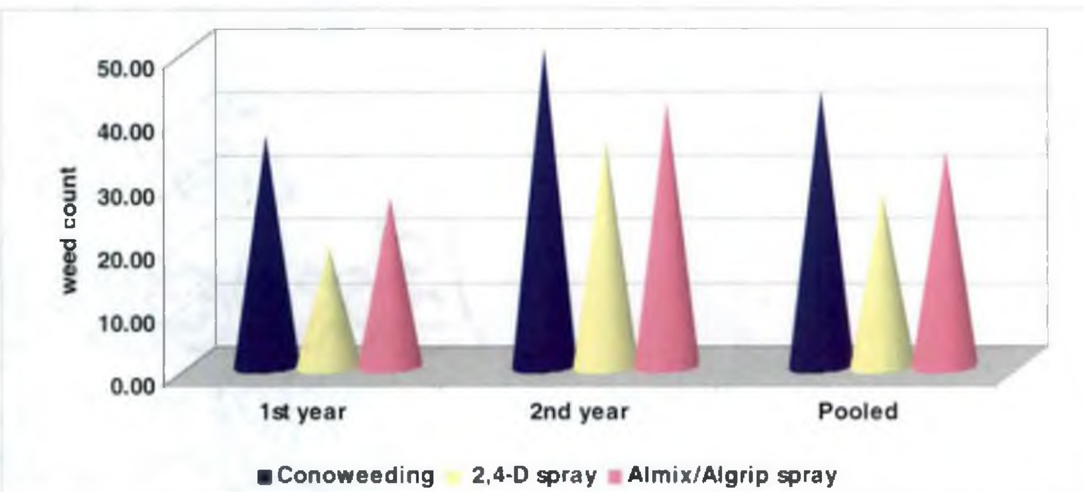


Fig. 39a. Effect of methods of incorporation of daincha on the total weed count of wet sown rice

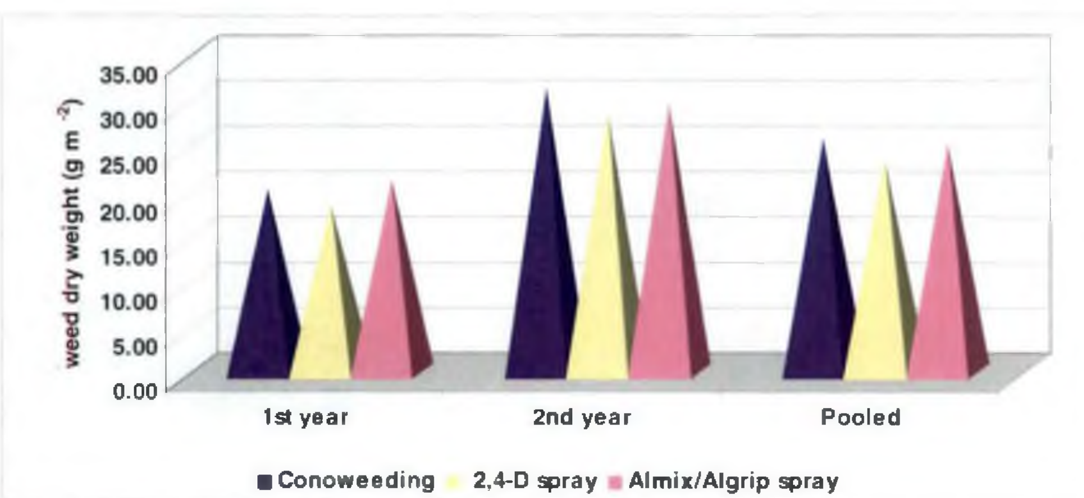


Fig. 39b. Effect of methods of incorporation of daincha on the total weed dry weight of wet sown rice

78 per cent reduction of total weed count and 59 per cent reduction in weed dry matter production. Incorporation of daincha by spraying 2,4- D resulted in the highest reduction of total weed count and dry matter production. Application of 2, 4-D for incorporation of daincha by desiccation controlled broad leaved weeds and sedges substantially because 2, 4-D is a selective herbicide recommended for broad leaved weeds and sedges in rice. As a result these treatments recorded the lowest count and dry matter of broad leaved weeds and sedges. Accordingly the highest reduction of total weed count and dry matter production was noticed when daincha was incorporated by 2,4- D spray. Gupta *et al*. (2006) reported that co-culture of *Sesbania* in rice and its subsequent knock down by 2, 4-D ester reduced the weed population by nearly half with out any adverse effect on rice yield. Reduction in total weed population and weed dry matter by the incorporation of daincha by almix/ algrip spray was 72 and 56 per cent respectively. Weedicides almix and algrip are selective herbicides for broad leaved weeds and sedges in rice. Accordingly their application controlled broad leaved weeds and sedges and resulted in reduced count and dry matter of total weeds. In plots, where infestation of weeds like *Marsilea quadrifoliata* and *Ludwigia parviflora* is serious, application of algrip effectively controlled it. It is an added advantage of algrip over 2,4-D.

Daincha incorporated using different methods behaved similarly in the biomass addition and thereby in the nutrient contribution of green manure crops. Nutrient content and nutrient uptake of rice was also similar under different methods of incorporation (Fig.40a to 40f). Nitrogen mineralization pattern of daincha was not significantly affected by the methods of incorporation (Fig.41). Different methods of incorporation of daincha showed no significant variation on the soil organic carbon per cent and available N, P and K status of the soil (Fig. 42).

Economic analysis of different methods of incorporation showed no significant difference. All the three methods of incorporation of daincha resulted in significant reduction in weeding cost compared to pure crop of rice. Cost involved in the chemical incorporation of daincha was less compared to conoweeding. This is due to the reduction in labour requirement for weed management when the daincha was incorporated using weedicides compared to conoweeding. The labour requirement for weed management is less when the green manure crops were incorporated using

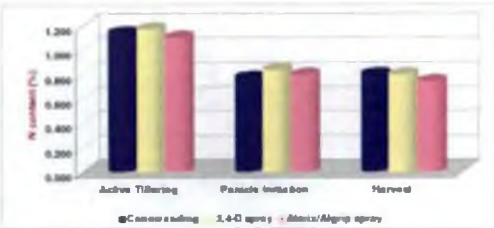


Fig. 40a. Effect of methods of incorporation of daincha on the N content of wet sown rice at different growth stages

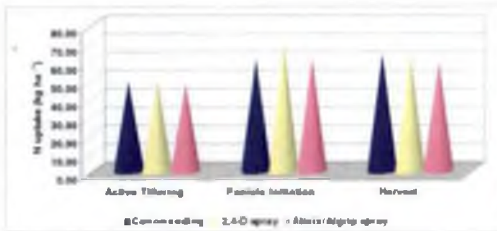


Fig. 40b. Effect of methods of incorporation of daincha on the N uptake of wet sown rice at different growth stages

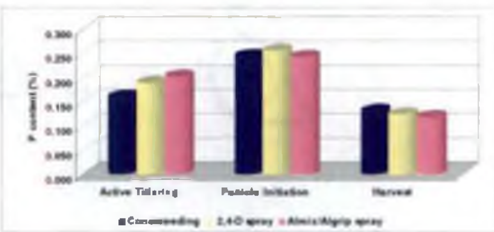


Fig. 40c. Effect of methods of incorporation of daincha on the P content of wet sown rice at different growth stages

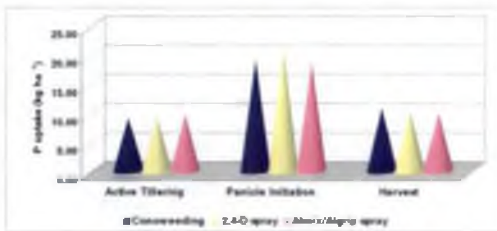


Fig. 40d. Effect of methods of incorporation of daincha on the P uptake of wet sown rice at different growth stages

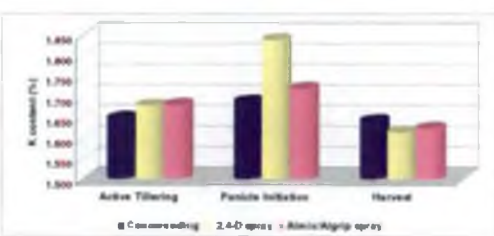


Fig. 40e. Effect of methods of incorporation of daincha on the K content of wet sown rice at different growth stages

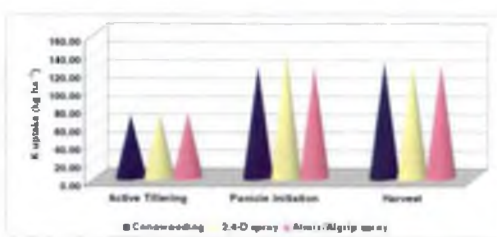


Fig. 40f. Effect of methods of incorporation of daincha on the K uptake of wet sown rice at different growth stages

weedicides (18 man-days ha^{-1}) compared with conoweeding (28 man-days ha^{-1}). Even though the cost involved is less, the gross return did not reach the level of significance mainly because the grain and straw yield of rice was not significantly affected by the methods of incorporation. Thus the net return and B: C ratio was not significantly affected by the methods of incorporation (Fig. 43).

All the methods of incorporation of daincha resulted in significant weed control with out much variation in the yield of rice and nutrient availability. Hence in places where it is difficult to use cono weeder for incorporation of daincha, it can be effectively incorporated by spraying 2, 4 –D or Metsulfuron methyl without affecting the yield or nutrient content of soil. This suggests the possibility of establishment of the concurrent growing system by broadcasting of daincha and rice rather than line sowing by using rice cum green manure seeder and incorporating daincha by conoweeder. This, however, requires further investigation.

5.2.3 Effect of nitrogen levels

Information on the extent of nutrient saving obtained by incorporation of concurrently grown daincha at 20 and 30 DAS either by conoweeding or by application of weedicides has been lacking. Understanding the extent of nutrient savings is important in formulating an efficient nitrogen management schedule for wet seeded lowland rice. In the present study two levels of nitrogen i.e., 100 and 75 per cent of the recommended dose of N were tested in the system of concurrent growing of daincha. These treatments were compared with pure crop of rice which received 5 t ha^{-1} of FYM and 100 per cent of the recommended nitrogen. Nitrogen levels had significant influence on the yield. Concurrent growing of daincha in wet seeded rice, which received 100 per cent of recommended nitrogen, recorded significantly higher yield (5165 kg ha^{-1}), compared with 75 per cent N (Table 4.3.12 and Fig. 44). This indicates the beneficial effect of daincha green manuring. The results corroborate the findings of Tiwari *et al.* (2004). Nitrogen at 100 per cent level registered higher values for all the growth and yield attributes though the variations were non significant. The cumulative effect of all the growth and yield attributes resulted in

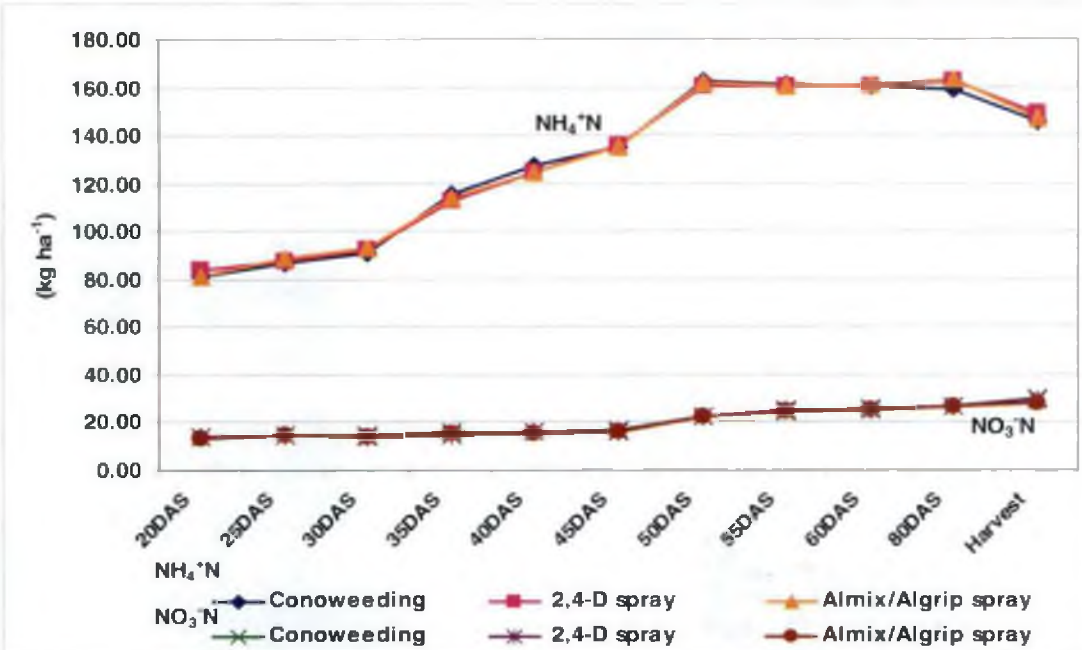


Fig. 41. Effect of methods of incorporation of daincha on the ammoniacal and nitrate nitrogen release pattern in wet sown rice

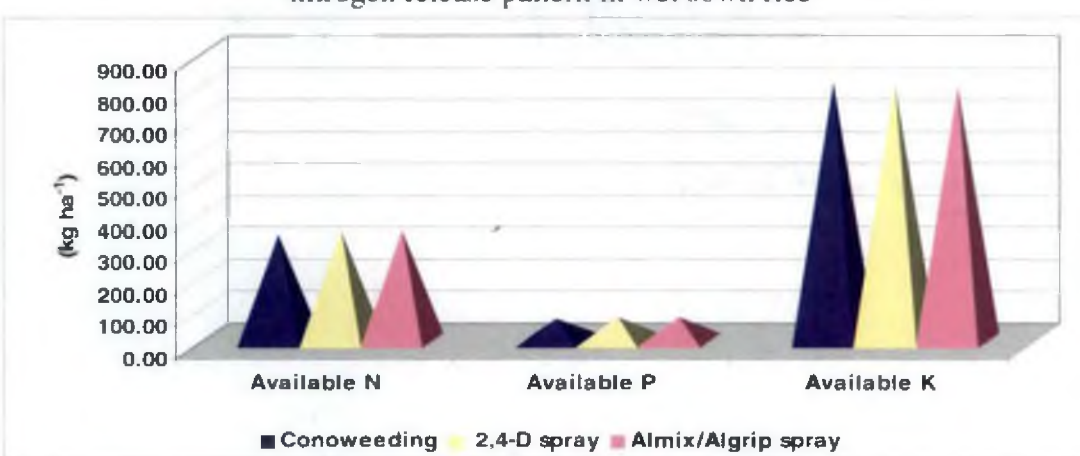


Fig. 42. Effect of method of incorporation of daincha on the soil available N, P and K status after harvest of wet sown rice

Fig. 43. Effect of methods of incorporation of daincha on the gross return and net return of wet sown rice

higher yield in treatments receiving 100 per cent N. The increased growth and yield attributes at 100 per cent N is obviously due to the increased nutrient availability. Application of both levels of nitrogen to rice grown along with green manure crops has increased the N content and N uptake of plant through out the growth of rice (Fig 45a and 45b). This increase in N levels had brought about a corresponding increase in the yield of rice compared with pure crop of rice. The result showed the direct effect of N in increasing the yield through an increase in the content of this element in the plant.

The yield of rice in daincha intercropped plots which received either 100 per cent or 75 per cent of recommended nitrogen fertilizer was significantly higher compared to control plots which received 5 t ha^{-1} of FYM and full dose of nitrogen fertilizer. The growth and yield attributes of rice grown along with daincha receiving 100 and 75 per cent N was higher than the pure crop of rice. This might be the reason for increased yield of rice in association with daincha. Anbumani *et al.* (2002) opined that intercropping of *Sesbania* in wet seeded rice added higher biomass, thereby supplementing the N need for rice crop and imparting a synergistic effect between organic source of N and fertilizer N. By growing of daincha along with rice and its subsequent incorporation helped to reduce the use of nitrogen fertilizer by 25 per cent with out affecting the yield. But to obtain the highest yield 100 per cent N was required along with concurrent growing of daincha. The 25 per cent (38 kg N ha^{-1}) saving of nitrogenous fertilizers in the 1st crop of rice and 50 per cent saving in the residual crop due to green manuring of *Sesbania rostrata* was reported by MSSRF, (1995).

Nitrogen application at 100 and 75 per cent of the recommended dose had no significant influence on the count and dry matter of weeds like grasses, broad leaved weeds and sedges at 50 DAS. Concurrent growing of daincha receiving both levels of nitrogen registered lower weed population and weed dry matter production compared with rice grown alone receiving 5 t ha^{-1} of FYM and 100 per cent of the recommended nitrogen (Fig. 46a and 46b).

Nitrogen mineralization pattern of daincha was significantly affected by the levels of N. Release pattern of NH_4^+-N was significantly higher in treatments receiving 100 per

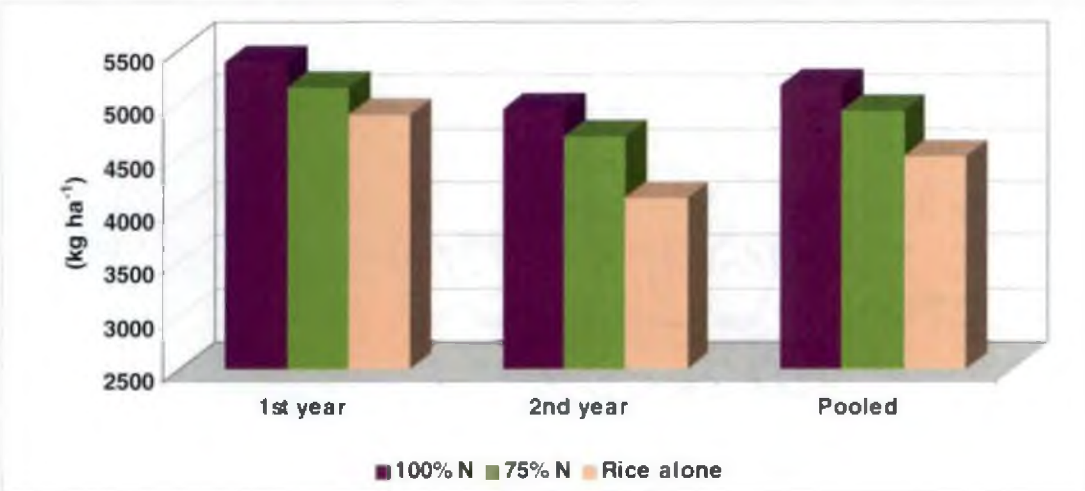


Fig. 44. Effect of levels of nitrogen on the yield of wet sown rice

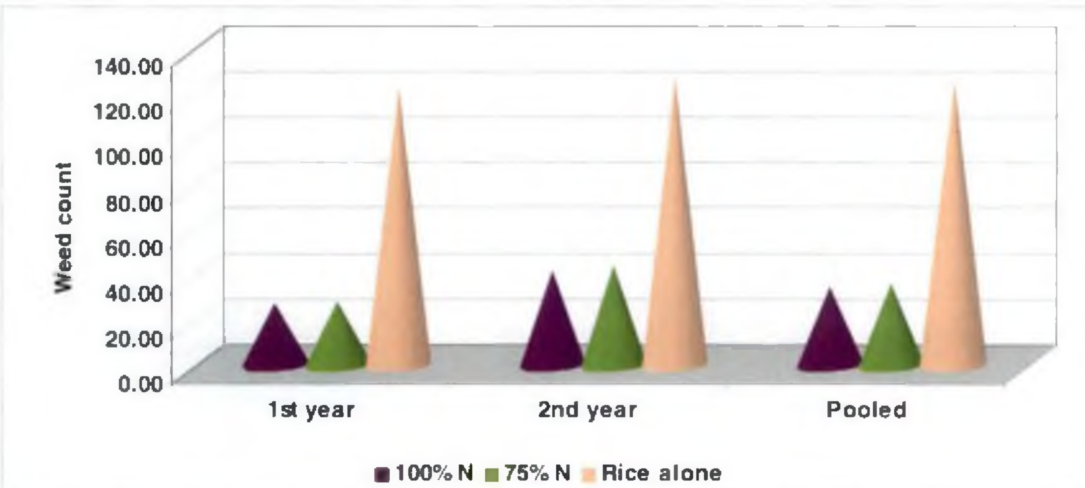


Fig. 46a. Effect of levels of nitrogen on the total weed count of wet sown rice

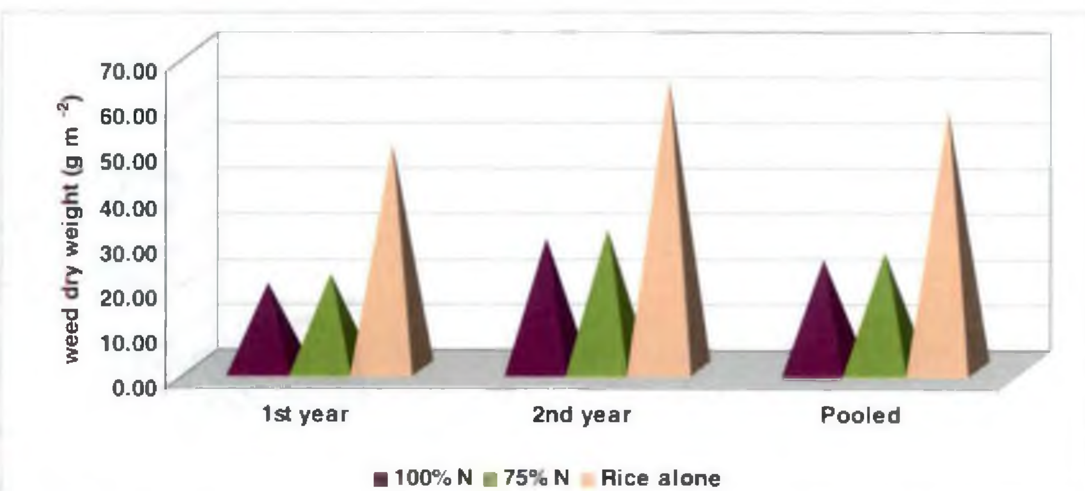


Fig. 46b. Effect of levels of nitrogen on the total weed dry weight of wet sown rice

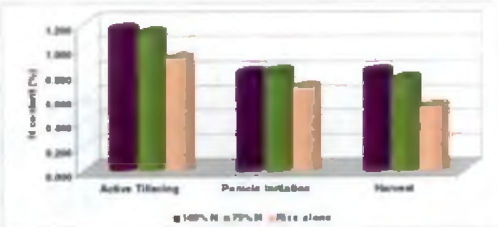


Fig. 45a. Effect of levels of nitrogen on the N content of wet sown rice at different growth stages

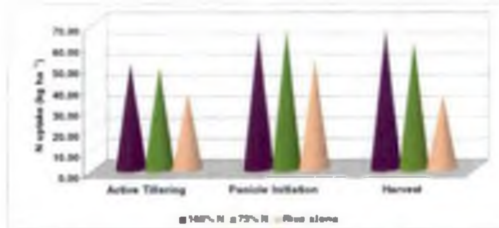


Fig. 45b. Effect of levels of nitrogen on the N uptake of wet sown rice at different growth stages

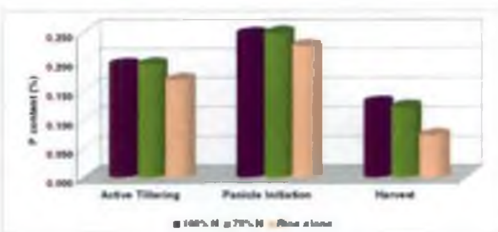


Fig. 45c. Effect of levels of nitrogen on the P content of wet sown rice at different growth stages

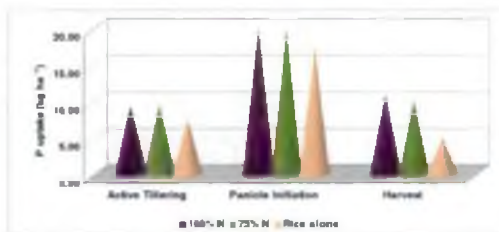


Fig. 45d. Effect of levels of nitrogen on the P uptake of wet sown rice at different growth stages

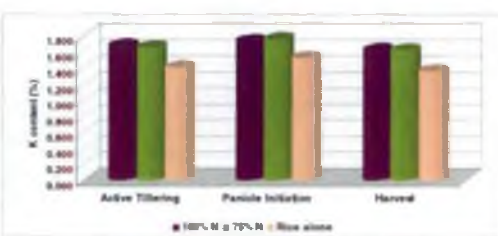


Fig. 45e. Effect of levels of nitrogen on the K content of wet sown rice at different growth stages

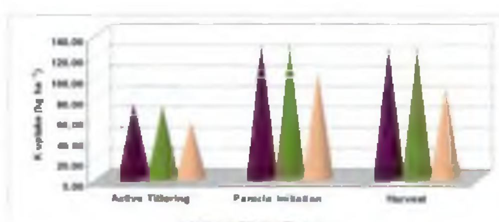


Fig. 45f. Effect of levels of nitrogen on the K uptake of wet sown rice at different growth stages

cent N through out the growth period followed by 75 per cent N (Fig. 47). Release pattern of NO_3^--N also showed a similar trend. The results indicated that release of N was more when fertilizer N was applied along with daincha than with FYM.

The build up of organic carbon, N, P and K status, was found higher in the system of concurrent growing of daincha receiving both 100 and 75 per cent of the recommended N compared to pure crop of rice receiving 5 t ha^{-1} of FYM and 100 per cent of the recommended nitrogen dose (Fig. 48). This is due to increased biomass addition of daincha which in turn resulted in higher contribution of N, P and K. But the difference between the nitrogen levels on organic carbon, N, P and K status of soil is non significant. Daincha N contribution was unaffected regardless of fertilizer N dose to rice indicating its insensitivity to external sources of nitrogen (Selvi, 2001).

Economic analysis of the treatments indicated that different levels of N applied to the system of concurrent growing of daincha significantly increased the net return and B: C ratio. The net return and B: C ratio at 100 and 75 per cent N was significantly higher than pure crop of rice (Fig. 49). The highest net return and B: C ratio was registered at 100 per cent level of N. The increased net return was due to the increased gross return which is a clear reflection of higher grain yield.

Increased yield and net return of concurrent growing of daincha both at 100 and 75 per cent N suggested that concurrent growing of daincha in wet seeded rice could save 25 per cent N to the current season crop with out any adverse effect on the productivity and profitability of the system. However to realize the maximum yield from the system of concurrent growing of daincha, wet seeded rice should be supplied with 100 per cent of the recommended nitrogen dose.

5.2.4 Influence of residual and direct effects of treatments in the succeeding transplanted rice

Residual effects on succeeding rice

Organic sources of nutrients applied to the preceding crop benefit the succeeding crop to a great extent (Singh *et al.*, 1996 and Hegde, 1998). Information on the extent of nitrogen saving if any, due to the residual effect of concurrent growing of daincha

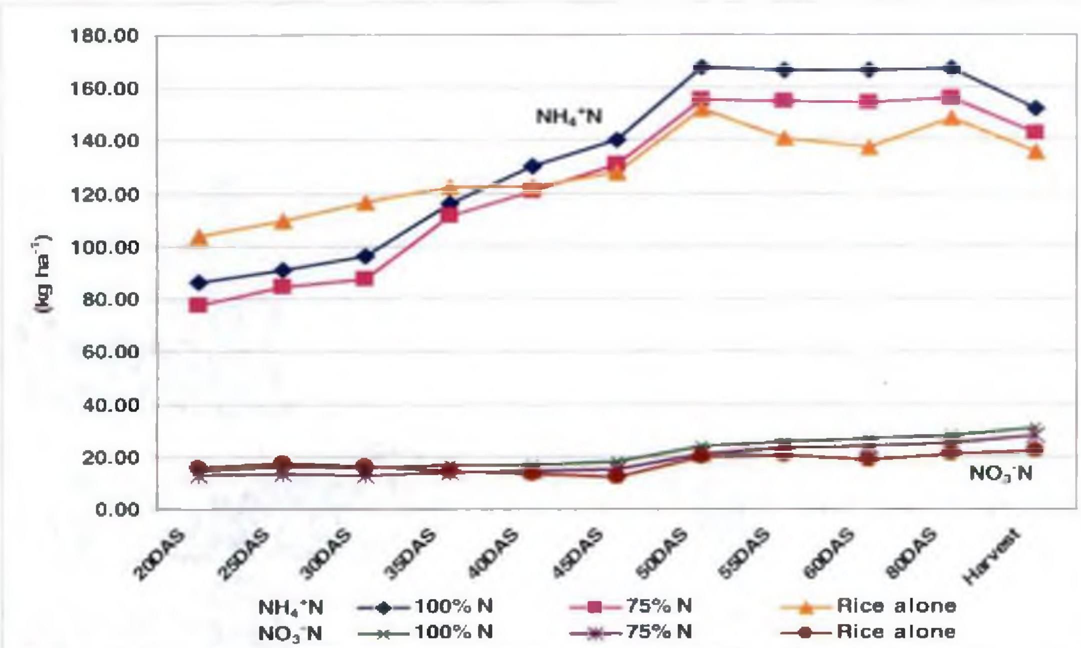


Fig. 47. Effect of levels of N on the ammoniacal and nitrate nitrogen release pattern in wet sown rice

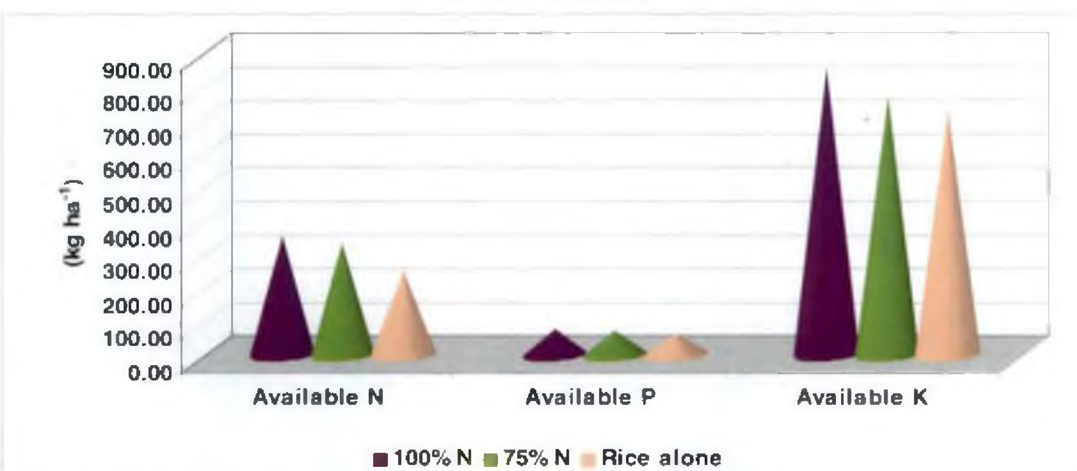


Fig. 48. Effect of levels of N on the soil available N, P and K status after harvest of wet sown rice

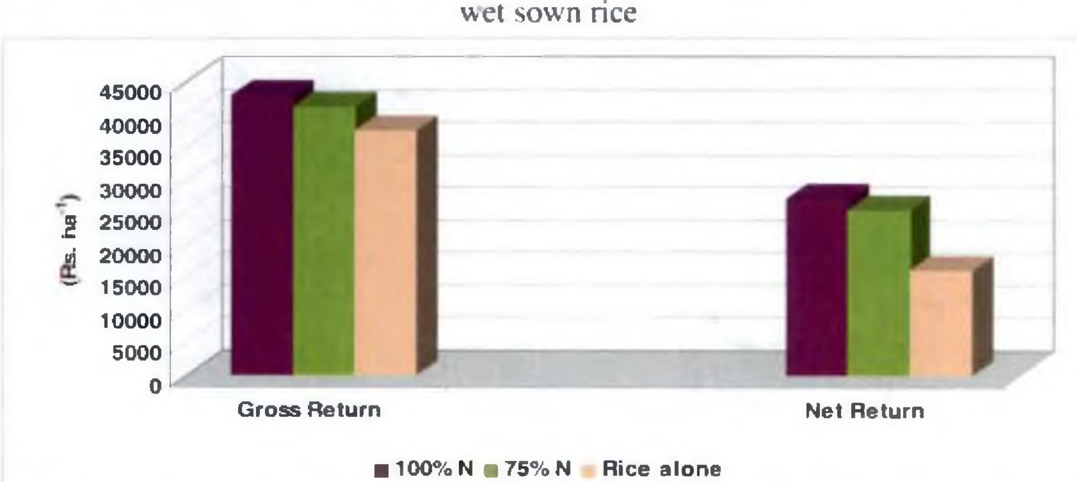


Fig. 49. Effect of levels of N on the gross return and net return of wet sown rice

incorporated at different stages by using different methods of incorporation in wet seeded rice has been lacking. The present investigation was, therefore, undertaken to study the residual effects of concurrent growing of daincha and direct effect of N levels.

Residual effects of the practice of concurrent growing of daincha have significantly increased the grain yield of succeeding transplanted rice. Residual effects of incorporation of daincha both at 20 and 30 DAS in the preceding crop produced significantly higher yield in second crop than pure crop of rice (Table 4.4.10 and Fig 50). Sah *et al.* (2000) also reported that green manuring with daincha increased the yield of wheat crop and there was also a significant difference in the succeeding crop. Treatments receiving incorporation of daincha at 30 DAS during the preceding season registered significantly higher grain yield of succeeding rice than incorporation of daincha at 20 DAS. The highest yield of succeeding rice was noticed when daincha was incorporated at 30 DAS using conoweeder and received 100 per cent N. Incorporation of 30 days old daincha using all the three methods of incorporation and receiving both 100 and 75 per cent of N was found equally effective in the yield expression of the succeeding rice. Similarly incorporation of 20 days old daincha using all the three methods of incorporation and receiving both 100 and 75 per cent of N behaved similarly in the yield of succeeding rice. Tiwari *et al.* (2004) reported that *Sesbania* green manuring in maize crop significantly increased the grain yield of succeeding wheat crop. Results of the study indicated that the methods of incorporation of daincha and levels of nitrogen applied to the preceding crop had no significant influence on the yield of succeeding rice but as evident from the results, the stages of incorporation of daincha had significant influence on the yield of succeeding rice.

All the growth parameters and yield attributes of the second crop of rice, though not significant, were found higher in treatments involving concurrent growing of daincha during the preceding crop (Tables 4.4.1 to 4.4.9). As a result of increased growth and yield attributes, the grain yield of succeeding transplanted rice was significantly increased after concurrent growing of daincha especially when it was incorporated at the age of 30 days. Increased growth and yield attributes of succeeding rice after the incorporation of daincha in the preceding season was mainly by the increased nutrient availability due to the substantial build up of soil fertility, with respect to organic carbon, N, P and K status, noticed after the incorporation of intercropped daincha (Table 4.3.23). Increased biomass addition of 30 days old daincha resulted in increased contribution of N, P and K and thereby causing an increase in soil available N, P and K when daincha was incorporated at 30 DAS compared to 20DAS. Even after the harvest of the preceding rice, the incorporated green manure would have contributed to the mineralizeable N, which would add to the soil N (Bouldin, 1987) and thus helped in maintaining the soil available N (Hemalatha *et al*., 2000).

In the initial growth stages, the nitrogen content and uptake of transplanted rice was significantly higher in treatments where daincha was incorporated during the preceding crop than in pure crop (Tables 4.4.11 to 4.4.16). Incorporated green manure in lowland rice might have scavenged soil mineralization, prevented the nitrogen losses through denitrification or leaching when the soil was flooded and also helped effective recycling of soil N for succeeding rice (Hemalatha *et al*., 2000). This increased nitrogen availability during the active growth stages resulted in an increased N content and uptake by the succeeding transplanted rice, reflecting on the improved development of growth and yield characters and thereby final yield. Increased grain yield might be due to the better partitioning of photosynthates to the grains than to straw, resulting in lower straw yield in transplanted rice preceded by concurrent growing of daincha. According to Solaiappan *et al*. (1996), various green manures raised during pre-season rice gave higher yield of succeeding rice than rice following pre-season fallow by increasing the values of yield determinants viz., grains panicle^{-1} and 1000 grain weight. The straw yield, though not significant, was higher in treatments without daincha incorporation. This led to significantly higher values of harvest index in treatments where daincha was incorporated at 30 days during the preceding season.

The soil fertility status after the succeeding crop indicated a positive build up of all the nutrients by the concurrent growing of daincha along with the preceding wet sown rice. Soil available N after the second crop was found reduced than the initial soil N status, when the preceding crop was pure crop of rice (Table 4.4.17 and Fig 51). Concurrent growing of daincha significantly increased the soil available N. Ladha *et al*. (1989) reported that green manuring minimized the loss of nitrogen and 80 per

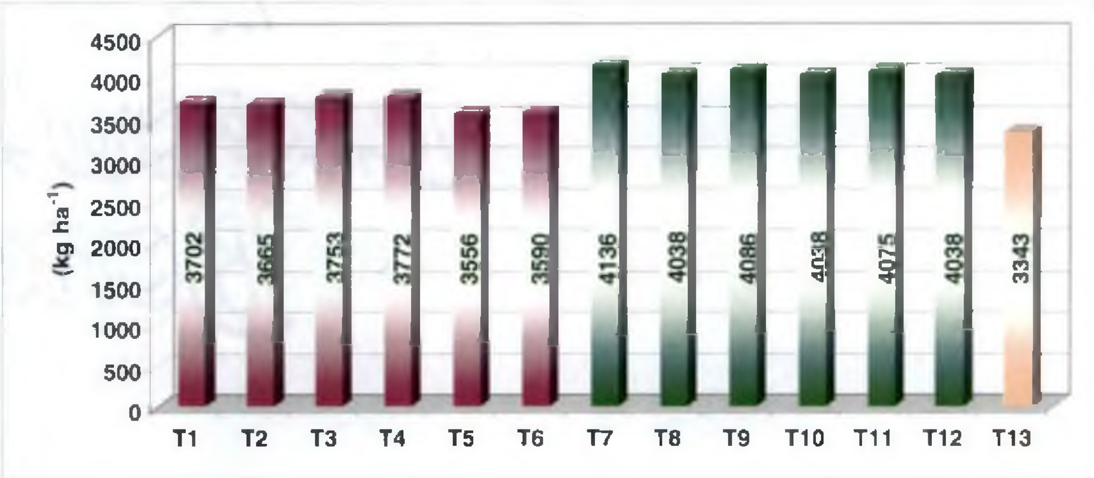


Fig. 50. Residual effect of concurrent growing of daincha in wet seeded rice on grain yield of succeeding transplanted rice

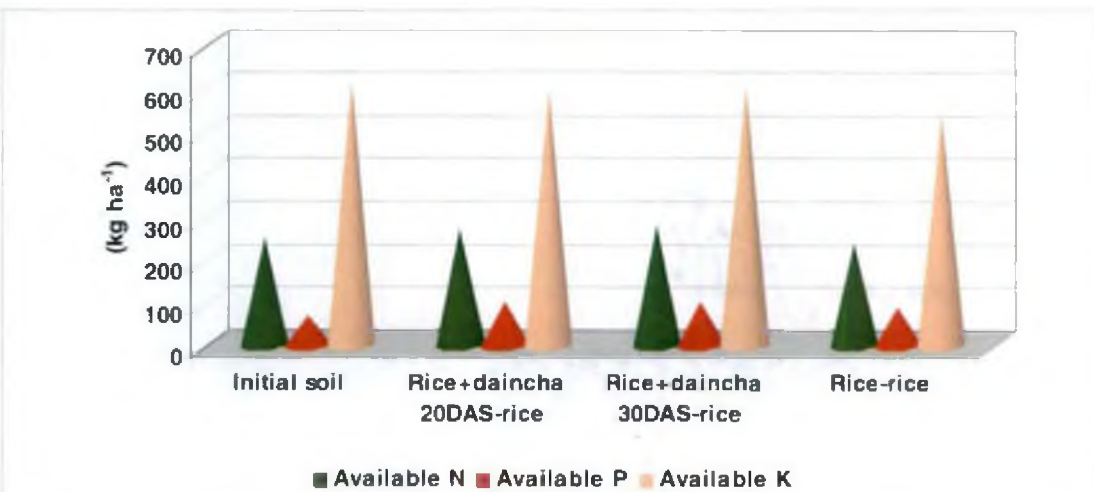


Fig. 51. Residual effect of concurrent growing of daincha in wet seeded rice on soil nutrient status after the harvest of succeeding transplanted rice

cent of the N is made available to the two succeeding crops. Soil available P and K was not significantly affected by the treatments imposed in preceding season. The present study thus indicated the positive effect of the concurrent growing of daincha in the sustainability of the rice- rice system.

Economic analysis of the total system revealed the profitability of concurrent growing of daincha in the wet sowing system. Concurrent growing of daincha increased the net return and B: C ratio of the wet sowing system compared with rice grown alone during the previous season (Table 4.4.18). Pure crop of rice with out daincha during the previous season resulted in the least net return and B: C ratio. The results corroborate the findings of Patra *et al.* (2000). The increased net return from the system of concurrent growing of cowpea is due to the better gross return realized from this system. Concurrent growing and incorporation of 30 days old daincha with rice during the previous season registered the highest gross return compared with incorporation of 20 days old daincha and rice grown alone. The gross return (Rs.66034 ha^{-1}) of pure crop of rice was significantly less compared with daincha intercropped rice. Incorporation of 30 days old daincha using conoweeder and receiving 100 per cent N recorded the highest gross return (Rs.80954 ha^{-1}) compared with other treatments. The higher gross return is a direct reflection of higher rice yield. MSSRF (1995) reported increase in yield and net income of 1st crop of rice due to green manuring of *Sesbania rostrata* to the tune of 6 and 16 per cent, in the residual crop the respective figures were 95 and 22 per cent and the saving of nitrogenous fertilizers were 25 per cent (38 kg N ha^{-1}) and 50 per cent respectively. The highest net return is the resultant of the reduced cost involved in weed management in the daincha intercropping treatments. As per TNAU (2002), drum seeding of hybrid rice CoRH-2 along with daincha and incorporating daincha at 45 DAS and recommended level of N (150kg ha^{-1}) registered highest net return of Rs. 29597 ha^{-1} and B: C ratio of 3.25 during 1999-00 and Rs. 27329 and 3.08 during 2000-01. System of concurrent growing of daincha in the preceding wet seeded rice is an economically viable practice compared to rice grown with out daincha as it increases the profitability by 68 per cent. The highest profitability is obtained with concurrent growing of daincha incorporated at 30 DAS. Increase in net return of the wet seeded rice system due to the incorporation of concurrently grown daincha at 30 days was Rs.5396 ha^{-1}

compared to the incorporation of concurrently grown daincha at 20 days and Rs.17088 ha^{-1} compared with pure crop of rice (Fig. 52).

Direct effect of N levels applied to succeeding rice

The information on the residual effect of concurrent growing of daincha in wet seeded rice to the succeeding rice crop has found to be lacking and present study was conducted to fill this lacunae. In this investigation a second crop of rice was raised in the same plots of concurrent growing of daincha in the previous season after dividing the plots equally into two sub plots. Sub plots received 100 and 75 per cent nitrogen doses to study the residual effects of the treatments imposed during the first crop.

Levels of nitrogen applied to the second crop of rice significantly influenced the growth parameters viz., plant height, tiller production, leaf $hill^{-1}$, leaf area, leaf area index and dry matter production (Tables 4.4.1 to 4.4.7). All these growth parameters were significantly higher at panicle initiation stage when the current crop had received 100 per cent of the recommended N. These growth parameters, though not significant, were also higher at 100 per cent N at active tillering and harvest stages. Direct application of N might have made more nutrients available to the current crop which reflected on better growth. Effect of direct application of N on growth parameters was reflected on yield attributes also. Except panicle weight, the other yield attributes viz., number of panicles, filled grains and test weight though not significant, was higher when the crop received 100 per cent N (Tables 4.4.8 and 4.4.9). This was because of the better partitioning of the photosynthates from source to sink with the application of N to the current crop. The better growth and yield attributes resulted in a significant increase in the grain yield of the current crop due to the application of 100 per cent N (Fig. 53).

Increased availability of N due to the application of 100 per cent N resulted in increased growth and yield attributes. This was mainly due to the increased content and uptake of N at 100 per cent N (Tables 4.4.11 and 4.4.14). The soil fertility status with respect to organic carbon, N, P and K after the second crop was significantly higher with 100 per cent N (Table 4.4.17). The available N status after the second crop which received 75 per cent N was less than the initial N status. This indicated

Fig. 52. Concurrent growing of daincha in wet seeded rice on the gross and net return of the rice+daincha -rice system

Fig. 53. Direct effect of levels of N on grain yield of rice crop succeeding the wet sown rice

that to achieve the sustainability of the system, the rice crop succeeding wet seeded crop concurrently grown with daincha is also to be supplied with 100 per cent N. The profitability of the system was higher when the second crop was supplied with 100 per cent N as it registered the highest net return (Rs.38397 ha^{-1}). Studies on the impact of the application of organic manures / *in situ* green manuring (daincha) before rice in conjunction with inorganic fertilizer for 10 years on the productivity of rice-wheat system showed that the highest yield of both the crops was obtained with 100 per cent NPK combined with green manure/FYM (Yaduvanshi and Swarup, 2006).

Concurrent growing of daincha along with the crop of wet seeded rice ensured increased productivity, profitability and sustainability of the rice- rice system. The residual effects of incorporation of concurrently grown daincha at 30 DAS using different methods of incorporation and which received both 100 and 75 was almost similar. Yaduvanshi and Swarup (2006) reported that highest yield of both crops were obtained with 100 per cent N, P and K combined with green manure. The results further showed that rice and wheat yields could be maintained even at 50 per cent of NPK with application of adequate quantity of green manure or FYM. The results are in conformity with those of Raju and Reddy (2000b). The study indicated that to realize the maximum yield from succeeding transplanted rice, 100 per cent of the recommended N should be supplied to the succeeding rice in the rice-rice system.

Concurrent growing of daincha can be successfully practiced in wet seeded rice for improving the productivity. Incorporation of 30 days old daincha employing any of the three methods of incorporation was equally effective in increasing the productivity and profitability of wet seeded rice. Incorporation of daincha at 30 DAS could add about 14 t ha^{-1} green matter with minimum investment and resulted in 70 per cent weed suppression. Concurrent growing of daincha receiving both 100 and 75 per cent of recommended N produced significantly higher yield than pure crop of rice receiving 5 t ha^{-1} of FYM and 100 per cent of the recommended nitrogen. The highest yield was obtained when 100 per cent of recommended N was applied to the system. Concurrent growing of daincha in wet seeded rice is economically viable as it reduced the cost of cultivation sizably compared to sole crop of rice.

Concurrent growing of daincha and its incorporation at 30 DAS in wet seeded rice was effective in increasing the yield of succeeding transplanted rice and sustaining soil fertility status compared to pure crop of rice receiving 5 t ha^{-1} of FYM and 100 per cent of the recommended nitrogen. The highest yield of succeeding rice was achieved only when it received 100 per cent of the recommended N hence there was no savings of N fertilizer to the succeeding transplanted rice crop. The productivity and profitability of the rice+ daincha- rice system was higher compared to rice - rice cropping system.

SUMMARY

An investigation entitled 'Concurrent growing of green manure crops in dry and wet seeded rice' was undertaken at the Agricultural Research Station, Mannuthy during 2004 to 2006 to study the suitability, productivity and profitability of raising green manure crops along with dry and wet seeded rice. The salient findings of the study are summarized below:-

CONCURRENT GROWING OF GREEN MANURE CROPS IN DRY SEEDED RICE

In dry seeded rice, the suitability of raising horse gram and a short duration bush type variety of cowpea as green manure crops was studied. These green manure crops were incorporated at 45 DAS using conoweeder, by spraying 2, 4- D and allowing self decomposition due to flooding at the onset of monsoon. Two levels of nitrogen (100% N and 75% N) were super imposed over them. Rice grown alone, with 5 t ha^{-1} of FYM and 100 per cent NPK as per Package of Practices Recommendations of KAU, was taken as control. The residual effect of concurrent growing of green manure crops in dry seeded rice was studied by dividing each experimental plot into two and applied 100 and 75 per cent N to the subplot.

Between the green manure crops tried, cowpea resulted in higher biomass addition compared to horse gram. The system of concurrent growing of cowpea could generate 12 t green matter ha^{-1} with minimum investment. Here the cost involved is only for green manure seed and sowing cost. Green matter addition by cowpea was more than double the recommended dose of 5 t ha^{-1} of organic manure. The nutrient addition by cowpea was 30 kg N ha^{-1}, 4 kg P ha^{-1} and 40 kg K ha^{-1}. The contribution of N, P and K by cowpea was almost double than that of horse gram.

Concurrent growing of green manure crops significantly reduced the weed population (75%) and weeds dry matter (58%) than sole cropping of rice. Between the two green manure crops, cowpea was more effective in suppressing weeds and recorded the minimum weed population and weed dry matter.

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Concurrent growing of green manure crops significantly reduced the weed population (75%) and weeds dry matter (58%) than sole cropping of rice. Between the two green manure crops, cowpea was more effective in suppressing weeds and recorded the minimum weed population and weed dry matter.

Methods of incorporation of green manure crops significantly influenced the weed count and weed dry matter production at 50 DAS. Conoweeding resulted in 22 per cent reduction in weed count and 18 per cent reduction in weed dry matter. Application of 2, 4-D for desiccation of green manure crops caused 35 % reduction in weed count and 24 % reduction in weed dry matter compared to self decomposition. Nitrogen application at 100 and 75 per cent of the recommended dose had no significant influence on the count and dry matter of weeds like grasses, broad leaved weeds and sedges at 30 DAS and 50 DAS.

Nitrogen release studies revealed that the decomposition of both the green manure crops was fast and they have rapidly released nitrogen. An increase in soil NH_4^+-N was noticed up to 30 days after incorporation (DAI) followed by a slight decline up to harvest. From 10 DAI onwards the release of NH_4^+-N was significantly higher under cowpea incorporated treatments compared to horse gram incorporated treatments. The release of NO_3^--N was less compared to NH_4^+-N. But an increasing trend was noticed in the release of NO_3^--N up to harvest. Nitrogen mineralization pattern of green manure crops was not significantly affected by the methods of incorporation of green manure crops. Release pattern of NH_4^+-N and NO_3^--N was more, when fertilizer N was applied along with green manure crops than with FYM.

Concurrent growing of green manure crops along with dry seeded rice and its subsequent incorporation had no adverse effect on the growth and development of rice at any of the growth stages. Concurrent growing of green manure crops significantly increased the yield of rice compared to pure crop of rice. Rice, in association with cowpea recorded the highest yield of 3633 kg ha^{-1}, which was six per cent more than the yield of rice realized in association with horse gram. All the three methods were found to be equally effective in incorporating the green manure crops. The yield of rice in concurrent growing of green manure crops receiving both 100 and 75 per cent of the recommended N registered higher yield compared to pure crop of rice receiving 5 t ha^{-1} of FYM and 100 per cent of the recommended nitrogen.

Increase in yield was brought about by the improvement in better growth parameters like height, tillers, leaves, leaf area, leaf area index and dry matter production and thereby yield contributing characters like number of panicles, filled grains and 1000 grain weight of rice, in the system of concurrent growing of green manures. Methods of incorporation had no significant influence on the growth and yield attributes of rice. The growth and yield attributes of rice grown along with green manure crops receiving 100 and 75 per cent N was higher than the pure crop of rice. But the difference among the nitrogen levels on the growth and yield attributes was non significant.

The content and uptake of N, P and K was found to be higher in rice intercropped with green manure crops compared to pure crop of rice. Nutrient content and nutrient uptake of rice was also similar under different methods of incorporation. Application of both levels of nitrogen to rice grown along with green manure crops has increased the N content and N uptake of the crop through out the growth of rice.

A substantial build up of soil fertility, with respect to organic carbon, N,P and K status, was noticed after the incorporation of intercropped green manure crops like cowpea and horse gram. Cowpea incorporation registered the highest available N status of soil compared with horse gram incorporation and pure crop of rice. Concurrent growing of cowpea registered the highest N, P and K status of soil. Methods of incorporation showed no significant variation on the soil organic carbon content and available N, P and K status of the soil. The build up of soil fertility, with respect to organic carbon, N, P and K status, was higher in the system of concurrent growing of green manure crops receiving both 100 and 75 per cent of the recommended N compared to pure crop of rice receiving 5t ha^{-1} of FYM and 100 per cent of the recommended nitrogen.

There was an added advantage from the concurrent growing of cowpea as it gave additional returns from green pod yield (573 kg ha^{-1}). System of concurrent growing of green manure crops in dry seeded rice is economically profitable with an increase in net return by four times when rice is grown along with cowpea (Rs.19133 ha^{-1}) and two times with horse gram (Rs.11991 ha^{-1}) compared with pure crop of rice (Rs.4737 ha^{-1}). The net return and B: C ratio was not significantly affected by the methods of incorporation. Concurrent growing of green manure crops in dry seeded rice could save 25 per cent N to the current season rice crop with positive effects on the productivity and profitability of the system.

Concurrent growing of green manure crops during the previous season significantly increased the yield of succeeding transplanted rice crop compared to rice grown alone during the previous season. Highest yield of succeeding rice was achieved only when it received 100 per cent of the recommended N. The soil fertility status after the succeeding crop indicated a positive balance of all the nutrients in treatments involving concurrent growing of green manure crops during the preceding season.

The highest system profitability is obtained with concurrent growing of cowpea during the preceding season. Increase in net return of rice+ cowpea – rice system was Rs.9269 ha^{-1} compared with rice+ horse gram – rice and Rs.18856 ha^{-1} compared with rice- rice with out green manure crops.

CONCURRENT GROWING OF DAINCHA IN WET SEEDED RICE

In wet seeded rice, daincha was grown along with rice and incorporated at 20 and 30 days after sowing by using one of the three methods of incorporation viz., using cono weeder, spraying 2, 4-D @1.0 kg ha^{-1}, and spraying met sulfuron methyl spray @ 5 .0 g ha^{-1}. Two levels of nitrogen (100% N and 75% N) were super imposed over them. Rice grown alone, with 5 t ha^{-1} of FYM and 100 per cent NPK as per Package of Practices Recommendations of KAU, was taken as control. The residual effect of concurrent growing of daincha in wet seeded rice was studied by dividing each experimental plot into two and applied 100 and 75 per cent N to the subplot.

Concurrent growing of daincha and its subsequent incorporation at 30 DAS could add about 13 t ha^{-1} green matter to rice with minimum investment. Incorporation of daincha at 20 DAS added 5.6 t ha^{-1} of green matter and it was also higher than the recommended dose of 5 t ha^{-1} of organic manure. The N, P and K contribution of 30 days old daincha was to the tune of 126.4, 8.86 and 139.2 kg ha^{-1} and the corresponding figures of 20 days old daincha were 40.1, 5.57 and 63.5 kg ha^{-1}.

Concurrent growing of daincha along with wet seeded rice significantly reduced the count and dry weight of grasses, broad leaved weeds and sedges and thereby the total population and dry matter production of weeds compared to wet sown rice. Incorporation of daincha by conoweeder, by spraying 2, 4- D and met sulfuron methyl resulted in significant reduction in weed count and weed dry matter. Nitrogen levels had no significant influence on the count and dry matter of weeds like grasses, broad leaved weeds and sedges at 50 DAS.

Release of ammoniacal nitrogen was found maximum at 30 DAI from both 20 and 30 days old daincha and then noticed a decline up to harvest. The quantity of release of NH_4^+-N was significantly higher when daincha was incorporated at 30 DAS. Soil NO_3^- -N content registered a steady and significant increase over pure crop of rice receiving FYM (5 t ha^{-1}) as basal application. Nitrogen mineralization pattern of daincha was not significantly affected by the methods of incorporation. Nitrogen mineralization pattern of daincha was significantly affected by the levels of N. Release pattern of NH_4^+-N was significantly higher in treatments receiving 100 per cent N through out the growth period followed by 75 per cent N. Release pattern of NO_3^--N also showed a similar trend.

Beneficial effect of concurrent growing of daincha in wet seeded rice was evident from the increased yield of rice compared to wet sowing of rice alone. Stages of incorporation of daincha had significant influence on yield. Incorporation of daincha at 30 days after sowing resulted in significantly higher yield (5184 kg ha-^{1}) compared to 20 days after sowing (4907 kg ha^{-1}). All the three methods of incorporation of daincha were found equally effective, as it had no significant difference on the yield of rice. Concurrent growing of daincha in wet seeded rice, receiving 100 per cent of recommended nitrogen recorded significantly higher yield (5165 kg ha^{-1}), compared with 75 per cent N. The yield of rice in daincha intercropped plots which received either 100 per cent or 75 per cent of recommended nitrogen fertilizer was significantly higher, compared to control plots which received 5 t ha^{-1} of FYM and full dose of nitrogen fertilizer.

Incorporation of daincha at 30 DAS, though not significant, registered higher values of all the growth parameters compared with 20 DAS. These growth parameters positively reflected in the better expression of yield attributes and there by higher yield. Methods of incorporation of daincha had no significant influence on the growth parameters and yield attributes of rice. The growth and yield attributes of rice grown along with daincha receiving 100 and 75 per cent N was higher than the pure crop of rice.

N, P and K content and uptake of rice with daincha was higher than rice grown alone. Nutrient content and nutrient uptake of rice was similar under different methods of incorporation. Nitrogen at 100 per cent resulted in higher nutrient content and nutrient uptake compared to pure crop of rice.

Incorporation of daincha at 30 DAS resulted in build up of soil organic carbon and registered the highest available N, P and K in the soil compared with incorporation of daincha at 20 DAS and pure crop of rice. Different methods of incorporation of daincha showed no significant variation on the soil organic carbon per cent and available N, P and K status of the soil. The build up of organic carbon, N, P and K status, was found higher in the system of concurrent growing of daincha receiving both 100 and 75 per cent of the recommended N compared to pure crop of rice receiving 5 t ha^{-1} of FYM and 100 per cent of the recommended nitrogen dose.

System of concurrent growing of daincha in wet seeded rice is economically profitable. Net return was found to be the highest when daincha was incorporated at the age of 30 days (Rs.27473 ha^{-1}) compared with daincha incorporation at 20 DAS. The gross return, net return and B: C ratio was not significantly affected by the methods of incorporation. The net return and B: C ratio of system of concurrent growing of daincha receiving both 100 and 75 per cent of the recommended N was significantly higher than pure crop of rice. The highest net return and B: C ratio was registered at 100 per cent level of N.

Incorporation of daincha at 30 DAS during the preceding season registered significantly higher grain yield of succeeding rice than incorporation of daincha at 20 DAS. Methods of incorporation of daincha and levels of nitrogen applied to the preceding crop had no significant influence on the yield of succeeding rice but the stages of incorporation of daincha had significant influence on the yield of succeeding rice. To realize the maximum yield from succeeding transplanted rice, 100 per cent of the recommended N should be supplied to the succeeding rice in the rice-rice system. The soil fertility status after the succeeding crop indicated a build up of all the nutrients by the concurrent growing of daincha along with the preceding wet sown rice.

The highest system profitability is obtained by incorporating concurrently grown daincha at 30DAS. Increase in net return of the rice + daincha- rice system due to the incorporation of 30 days old daincha was Rs.5396 ha^{-1} compared to the incorporation of 20 days old daincha and Rs.17088 ha^{-1} compared with rice –rice system with out daincha.

Concurrent growing of green manure crops in dry and wet seeded rice and its subsequent incorporation is a management alternative to increase the productivity, profitability and sustainability of rice – rice cropping system and it can solve the major problems faced by the rice farmers of Kerala.

Future line of work

Further investigations are required to refine the technology of concurrent growing system in broadcasted wet sown rice rather than line sowing by using rice cum green manure seeder.

The possibilities of concurrent growing of daincha in transplanted rice as well as under the System of Rice Intensification (SRI) are to be explored.

The long term sustainability of concurrent growing system under different agro-ecological and rice establishment systems are to be investigated.

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*Originals not seen

APPENDIX-I

Meteorological data (weekly average) for the experimental period (from 02-04-2004 to 04-03-2005)

Standard week No.	Date and month	Temperature Max.°C	Temperature Min.°C	Relative humidity (%)	Total rainfall (mm)	No. of rainy days
14	2/4-8/4	33.6	24.2	71	15.8	3
15	9/4-15/4	35.4	25.8	67	0	0
16	16/4-22/4	35.2	25.8	69	28.2	1
17	23/4-29/4	34.8	25.1	69	6.4	2
18	30/4-6/5	31.6	23.8	81	42.5	6
19	7/5-13/5	31	23.3	81	98.5	4
20	14/5-20/5	30.1	24.1	85	138.6	7
21	21/5-27/5	29.3	23.4	87	97.6	5
22	28/5-3/6	30.3	24	68	79.4	6
23	4/6-10/6	28.6	22.4	86	450.8	7
24	11/6-17/6	29.3	23.3	88	176	7
25	18/6-24/6	30.8	23.4	80	17.2	5
26	25/6-1/7	29.8	22.9	78	118.2	7
27	2/7-8/7	29.9	23.4	85	46.8	5
28	9/7-15/7	28.6	22.9	85	83.3	7
29	16/7-22/7	29.5	22.8	84	55.9	7
30	23/7-29/7	29	22.9	87	151.1	7
31	30/7-5/8	28.6	22.7	87	242	6
32	6/8-12/8	29.3	23	84	86	5
33	13/8-19/8	29.3	22.8	84	54.8	6
34	20/8-26/8	30.4	23.5	79	12	2
35	27/8-2/9	30.5	23.5	77	0.2	1
36	3/9-9/9	30.3	23.5	81	37.9	3
37	10/9-16/9	30.2	24	81	39.6	4
38	17/9-23/9	30.7	23.6	81	89.5	3
39	24/9-30/9	31.9	23.4	80	51.8	5
40	1/10-7/10	29.5	22.5	84	364.5	5
41	8/10-14/10	31.9	23	79	24.7	2
42	15/10-21/10	32	23.8	77	5.9	2
43	22/10-28/10	32.3	24.1	65	0	0
44	29/10-4/11	30.2	23	74	77.9	3
45	4/11-11/11	31.3	23.7	71	52	2
46	12/11-18/11	31.2	24	68	9.4	2
47	19/11-25/11	31.8	23.7	57	0	0
48	26/11-2/12	31.6	23.5	58	0	0
49	3/12-9/12	31.9	23.1	58	0	0
50	10/12-16/12	31.9	24.2	57	0	0
51	17/12-23/12	32	20.3	55	0	0
52	24/12-31/12	32.5	23.2	53	0	0
1	1/1-7/1	32.8	23.1	55	0	0
2	8/1-14/1	32.8	21.2	48	0	0
3	15/01-21/01	33.5	22.3	57	0	0
4	22/01-28/01	34.3	23.2	58	0	0
5	29/01-04/01	33.2	23.2	65	0	0
6	05/01-11/02	34.5	20.4	46	0	0
7	12/02-18/02	34.9	21.1	51	0	0
8	19/02-25/02	34.4	23.6	58	0	0
9	26/02-04/03	37	22.2	52	0	0

APPENDIX-II

Meteorological data (weekly average) for the experimental period (from 02-04-2005 to 04-03-2005)

Standard week No.	Date and month	Temperature Max.°C	Min.°C	Relative humidity (%)	Total rainfall (mm)	No. of rainy days
14	02/04-08/04	33.1	24.1	73	99.2	4
15	09/04-15/04	33	25	78	35.3	4
16	16/04-22/04	34.4	24.7	74	40.4	2
17	23/04-29/04	34.3	25	74	0	0
18	30/04-06/05	33.5	24.8	75	4	1
19	07/05-13/05	33.6	24.9	74	21.8	1
20	14/05-20/05	34	25.4	73	0	0
21	21/05-27/05	34.4	25.6	73	47.8	1
22	28/05-03/06	31.9	24.1	81	39.8	5
23	04/06-10/06	31.7	24.2	83	45.1	5
24	11/06-17/06	31.1	23.8	82	146.7	7
25	18/06-24/06	27.6	22.8	90	281	6
26	25/06-01/07	29.2	22.7	88	203.6	7
27	02/07-08/07	28.4	23.1	89	223.7	7
28	09/07-15/07	29.3	22.7	85	86	6
29	16/07-22/07	28.5	23.2	89	89.9	7
30	23/07-29/07	29.1	23.6	89	146.5	7
31	30/07-05/08	27.5	22.4	90	302.6	7
32	06/08-12/08	30.1	23.2	82	32.9	5
33	13/08-19/08	29.9	23.1	83	122.4	5
34	20/08-26/08	30.6	23.7	79	14.8	2
35	27/08-02/09	30.6	24.4	82	10.6	2
36	03/09-09/09	28.2	23.5	91	215.3	7
37	10/09-16/09	29.6	23.5	87	119.4	5
38	17/09-23/09	30.2	23.1	80	68.6	4
39	24/09-30/09	31.1	23.2	76	2.2	1
40	01/10-07/10	31.5	22.9	78	58	1
41	08/10-14/10	30.6	23.1	82	63.7	4
42	15/10-21/10	31.4	23.3	80	19.3	3
43	22/10-28/10	30.7	23.5	79	34.6	5
44	29/10-4/11	30.2	23.2	81	6.9	6
45	05/11-11/11	31.3	23.7	75	4.1	3
46	12/11-18/11	30.9	22.2	71	6.4	1
47	19/11-25/11	29.6	22.7	70	0	0
48	26/11-02/12	30.7	22.7	68	0	0
49	03/12-09/12	31.7	22.3	66	0.8	1
50	10/12-16/12	30.6	23.6	68	2.4	2
51	17/12-23/12	32.3	22	69	0	0
52	24/12-31/12	31.1	20.8	59	0	0
1	01/01-07/01	31.4	23.1	55	0	0
2	08/01-14/01	32	24.4	57	0	0
3	15/01-21/01	33.6	22	57	0	0
4	22/01-28/01	33	21	60	0	0
5	29/01-04/02	32.3	22.9	54	0	0
6	05/02-11/02	33.5	22.7	45	0	0
7	12/02-18/02	34.7	21.3	51	0	0
8	19/02-25/02	35.6	22.2	50	0	0
9	26/02-04/03	34.7	23.1	70	20	1

Appendices

APPENDIX-I

Meteorological data (weekly average) for the experimental period (from 02-04-2004 to 04-03-2005)

Standard week No.	Date and month	Temperature Max.°C	Min.°C	Relative humidity (%)	Total rainfall (mm)	No. of rainy days
14	2/4-8/4	33.6	24.2	71	15.8	3
15	9/4-15/4	35.4	25.8	67	0	0
16	16/4-22/4	35.2	25.8	69	28.2	1
17	23/4-29/4	34.8	25.1	69	6.4	2
18	30/4-6/5	31.6	23.8	81	42.5	6
19	7/5-13/5	31	23.3	81	98.5	4
20	14/5-20/5	30.1	24.1	85	138.6	7
21	21/5-27/5	29.3	23.4	87	97.6	5
22	28/5-3/6	30.3	24	68	79.4	6
23	4/6-10/6	28.6	22.4	86	450.8	7
24	11/6-17/6	29.3	23.3	88	176	7
25	18/6-24/6	30.8	23.4	80	17.2	5
26	25/6-1/7	29.8	22.9	78	118.2	7
27	2/7-8/7	29.9	23.4	85	46.8	5
28	9/7-15/7	28.6	22.9	85	83.3	7
29	16/7-22/7	29.5	22.8	84	55.9	7
30	23/7-29/7	29	22.9	87	151.1	7
31	30/7-5/8	28.6	22.7	87	242	6
32	6/8-12/8	29.3	23	84	86	5
33	13/8-19/8	29.3	22.8	84	54.8	6
34	20/8-26/8	30.4	23.5	79	12	2
35	27/8-2/9	30.5	23.5	77	0.2	1
36	3/9-9/9	30.3	23.5	81	37.9	3
37	10/9-16/9	30.2	24	81	39.6	4
38	17/9-23/9	30.7	23.6	81	89.5	3
39	24/9-30/9	31.9	23.4	80	51.8	5
40	1/10-7/10	29.5	22.5	84	364.5	5
41	8/10-14/10	31.9	23	79	24.7	2
42	15/10-21/10	32	23.8	77	5.9	2
43	22/10-28/10	32.3	24.1	65	0	0
44	29/10-4/11	30.2	23	74	77.9	3
45	4/11-11/11	31.3	23.7	71	52	2
46	12/11-18/11	31.2	24	68	9.4	2
47	19/11-25/11	31.8	23.7	57	0	0
48	26/11-2/12	31.6	23.5	58	0	0
49	3/12-9/12	31.9	23.1	58	0	0
50	10/12-16/12	31.9	24.2	57	0	0
51	17/12-23/12	32	20.3	55	0	0
52	24/12-31/12	32.5	23.2	53	0	0
1	1/1-7/1	32.8	23.1	55	0	0
2	8/1-14/1	32.8	21.2	48	0	0
3	15/01-21/01	33.5	22.3	57	0	0
4	22/01-28/01	34.3	23.2	58	0	0
5	29/01-04/01	33.2	23.2	65	0	0
6	05/01-11/02	34.5	20.4	46	0	0
7	12/02-18/02	34.9	21.1	51	0	0
8	19/02-25/02	34.4	23.6	58	0	0
9	26/02-04/03	37	22.2	52	0	0

APPENDIX-II

Meteorological data (weekly average) for the experimental period (from 02-04-2005 to 04-03-2005)

Standard week No.	Date and month	Temperature Max.°C	Min.°C	Relative humidity (%)	Total rainfall (mm)	No. of rainy days
14	02/04-08/04	33.1	24.1	73	99.2	4
15	09/04-15/04	33	25	78	35.3	4
16	16/04-22/04	34.4	24.7	74	40.4	2
17	23/04-29/04	34.3	25	74	0	0
18	30/04-06/05	33.5	24.8	75	4	1
19	07/05-13/05	33.6	24.9	74	21.8	1
20	14/05-20/05	34	25.4	73	0	0
21	21/05-27/05	34.4	25.6	73	47.8	1
22	28/05-03/06	31.9	24.1	81	39.8	5
23	04/06-10/06	31.7	24.2	83	45.1	5
24	11/06-17/06	31.1	23.8	82	146.7	7
25	18/06-24/06	27.6	22.8	90	281	6
26	25/06-01/07	29.2	22.7	88	203.6	7
27	02/07-08/07	28.4	23.1	89	223.7	7
28	09/07-15/07	29.3	22.7	85	86	6
29	16/07-22/07	28.5	23.2	89	89.9	7
30	23/07-29/07	29.1	23.6	89	146.5	7
31	30/07-05/08	27.5	22.4	90	302.6	7
32	06/08-12/08	30.1	23.2	82	32.9	5
33	13/08-19/08	29.9	23.1	83	122.4	5
34	20/08-26/08	30.6	23.7	79	14.8	2
35	27/08-02/09	30.6	24.4	82	10.6	2
36	03/09-09/09	28.2	23.5	91	215.3	7
37	10/09-16/09	29.6	23.5	87	119.4	5
38	17/09-23/09	30.2	23.1	80	68.6	4
39	24/09-30/09	31.1	23.2	76	2.2	1
40	01/10-07/10	31.5	22.9	78	58	1
41	08/10-14/10	30.6	23.1	82	63.7	4
42	15/10-21/10	31.4	23.3	80	19.3	3
43	22/10-28/10	30.7	23.5	79	34.6	5
44	29/10-4/11	30.2	23.2	81	6.9	6
45	05/11-11/11	31.3	23.7	75	4.1	3
46	12/11-18/11	30.9	22.2	71	6.4	1
47	19/11-25/11	29.6	22.7	70	0	0
48	26/11-02/12	30.7	22.7	68	0	0
49	03/12-09/12	31.7	22.3	66	0.8	1
50	10/12-16/12	30.6	23.6	68	2.4	2
51	17/12-23/12	32.3	22	69	0	0
52	24/12-31/12	31.1	20.8	59	0	0
1	01/01-07/01	31.4	23.1	55	0	0
2	08/01-14/01	32	24.4	57	0	0
3	15/01-21/01	33.6	22	57	0	0
4	22/01-28/01	33	21	60	0	0
5	29/01-04/02	32.3	22.9	54	0	0
6	05/02-11/02	33.5	22.7	45	0	0
7	12/02-18/02	34.7	21.3	51	0	0
8	19/02-25/02	35.6	22.2	50	0	0
9	26/02-04/03	34.7	23.1	70	20	1

APPENDIX -III

Cost of cultivation of concurrent growing of green manure crops in dry seeded rice

Items	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	T_{13}
Materials													
Paddy seed (60 kg ha^{-1})	600	600	600	600	600	600	600	600	600	600	600	600	800
Cowpea seed (20 kg ha-1)							500	500	500	500	500	500	
Horse gram seed (20 kg ha-1)	300	300	300	300	300	300							
FYM													2500
FYM application													400
Fertilizers													
Urea	990	743	990	743	990	743	990	743	990	743	990	743	990
Mussorie phos	1260	1260	1260	1260	1260	1260	1260	1260	1260	1260	1260	1260	1260
Muriate of potash	345	345	345	345	345	345	345	345	345	345	345	345	345
Application cost	300	300	300	300	300	300	300	300	300	300	300	300	300
PP Chemicals													
Carbayl 50 WP	400	400	400	400	400	400	400	400	400	400	400	400	400
Application cost	300	300	300	300	300	300	300	300	300	300	300	300	300
Land preparation													
Tractor- 6hrs	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Men	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
Women	400	400	400	400	400	400	400	400	400	400	400	400	400
Sowing													
Men	600	600	600	600	600	600	600	600	600	600	600	600	600
Women	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	800
Incorporation of GM													
conoweeding	1300	1300					1300	1300					
2, 4 D spray			210	210					210	210			
self decomposition													
Spraying cost			450	450					450	450			
Weeding													
Women	1500	1500	1500	1500	3000	3000	1500	1500	1500	1500	3000	3000	6000
Harvesting													
Women	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Threshing													
Women	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Cleaning & winnowing													
Women	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Harvesting cowpea pods							1000	1000	1000	1000	1000	1000	
TOTAL COST	**16995**	**16748**	**16355**	**16108**	**17195**	**16948**	**18195**	**17948**	**17555**	**17308**	**18395**	**18148**	**22795**

Cost of inputs					
Seeds		**Fertilizers**		**Herbicide**	
Rice	Rs. 10 kg^{-1}	Urea	Rs. 5 kg^{-1}	2, 4- D	Rs. 210 kg^{-1}
Cowpea	Rs. 25 kg^{-1}	Mussorie phos	Rs. 5.6 kg^{-1}	**PP Chemicals**	
Horse gram	Rs. 15 kg^{-1}	Muriate of potash	Rs. 4.8 kg^{-1}	Carbayl 50 WP	Rs. 400 kg^{-1}
		FYM	Rs. 500 t^{-1}		

Labour cost		Price of produce	
Men	Rs. 150 day^{-1}	Paddy	Rs. 8 kg^{-1}
Women	Rs. 100 day^{-1}	Straw	Rs. 0.5 kg^{-1}
Tractor	Rs. 200 h^{-1}	Cowpea pods	Rs. 12 kg^{-1}

APPENDIX - IV

Cost of cultivation of concurrent growing of daincha in wet seeded rice

Items	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	T_{13}
Materials													
Paddy seed	600	600	600	600	600	600	600	600	600	600	600	600	800
Daincha seed (20kg ha^{-1})	500	500	500	500	500	500	500	500	500	500	500	500	
FYM													2500
FYM application													400
Fertilizers													
Urea	990	743	990	743	990	743	990	743	990	743	990	743	990
Mussorie phos	1260	1260	1260	1260	1260	1260	1260	1260	1260	1260	1260	1260	1260
Muriate of potash	345	345	345	345	345	345	345	345	345	345	345	345	345
Application cost	300	300	300	300	300	300	300	300	300	300	300	300	300
PP Chemicals													
Carbayl 50 WP	400	400	400	400	400	400	400	400	400	400	400	400	400
Application cost	300	300	300	300	300	300	300	300	300	300	300	300	300
Land preparation													
Tractor- 6hrs	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Men	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
Women	400	400	400	400	400	400	400	400	400	400	400	400	400
Sowing													
Men	750	750	750	750	750	750	750	750	750	750	750	750	300
Incorporation of GM													
conoweeding	1300	1300					1300	1300					
2, 4 D			210	210					210	210			
Almix / Algrip					400	400					400	400	
Spraying cost			450	450	450	450			450	450	450	450	
Weeding													
Women	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	6000
Harvesting													
Women	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Threshing													
Women	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Cleaning & winnowing													
Women	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
TOTAL COST	16345	16098	15705	15458	15895	15648	16345	16098	15705	15458	15895	15648	21695

Cost of inputs				Herbicide		Labour cost		Price of produce	
Seeds		Fertilizers		2, 4 D	Rs. 210 kg^{-1}	Men	Rs. 150 day^{-1}		
Rice	Rs. 10 kg^{-1}	Urea	Rs. 5 kg^{-1}	Almix	Rs. 15 kg^{-1}	Women	Rs. 100 day^{-1}	Paddy	Rs. 8 kg^{-1}
Daincha	Rs. 25 kg^{-1}	Mussorie phos	Rs. 5.6 kg^{-1}	Algrip	Rs. 20 g^{-1}	Tractor	Rs. 200 h^{-1}	Straw	Rs. 0.5 kg^{-1}
FYM	Rs. 500 t^{-1}	Muriate of potash	Rs. 4.8 kg^{-1}	Carbayl	Rs. 400 kg^{-1}				

CONCURRENT GROWING OF GREEN MANURE CROPS IN DRY AND WET SEEDED RICE

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ABSTRACT OF THE THESIS

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ABSTRACT

An investigation entitled 'Concurrent growing of green manure crops in dry and wet seeded rice' was conducted at Agricultural Research Station, Mannuthy to develop a comprehensive technology package for the system of concurrent growing of green manure crops in direct seeded rice. The investigation consisted of four experiments viz., Experiment Ia - Concurrent growing of green manure crops in dry seeded rice, Experiment Ib - Residual effect of concurrent growing of green manure crops in dry seeded rice, Experiment IIa - Concurrent growing of daincha in wet seeded rice and Experiment IIb - Residual effect of concurrent growing of daincha in wet seeded rice.

The experiment on concurrent growing of green manure crops in dry seeded rice consisted of two green manure crops (horse gram and cowpea), three methods of incorporation (Incorporation by cono weeder, desiccation by 2,4 - D spray @1.0 kg ha^{-1} and allowing for self decomposition) and two levels of nitrogen (100 and 75% of recommended N) and a control without green manure crops .

Among the two green manure crops, cowpea was the best in supplying the required quantity of green matter with 25 per cent savings of N fertilizer and a substantial reduction in weed incidence. All the three methods of incorporation were found to be equally effective. Hence in places where there is a difficulty in self decomposition, cowpea can be effectively incorporated by conoweeder or by spraying 2, 4-D. The cowpea variety used in this study was a short duration bush type variety facilitating additional pod yield from cowpea before it was incorporated. Concurrent growing of cowpea along with dry seeded rice is a viable system as it resulted in increased productivity, profitability and sustainability dry seeded rice.

In the experiment to study the residual effect of concurrent growing of green manure crops in dry seeded rice, the main plots of dry seeded rice crop during the 1^{st} crop season were divided into two sub plots and applied 100 and 75 per cent N to the subplots. The results revealed that concurrent growing of green manure crops were effective in increasing the yield and sustaining soil fertility status compared to pure crop of rice receiving 5 t ha^{-1} of FYM and 100 per cent of the recommended nitrogen. But there was no savings of N fertilizer to the succeeding transplanted rice crop as the highest yield of succeeding rice was achieved only when it received 100 per cent of

the recommended N. The profitability of the rice- rice cropping system was the highest with concurrent growing of cowpea in dry seeded rice.

The experiment on concurrent growing of daincha in wet seeded rice consisted of two stages of incorporation of daincha (20 DAS and 30DAS), three methods of incorporation (Incorporation by cono weeder, desiccation by 2, 4 - D spray @1.0kg ha^{-1} and Desiccation by Chlorimuron ethyl+ met sulfuron methyl spray @ 4.0 g ha^{-1} met sulfuron methyl spray @ 5 g ha^{-1}) and two levels of nitrogen (100 and 75% of recommended N) and a control without daincha.

Results indicated that concurrent growing of daincha can be successfully practiced in wet seeded rice with improved productivity. Incorporation of 30 days old daincha employing any of the three methods of incorporation was equally effective in increasing the productivity and profitability of wet seeded rice. Incorporation of daincha at 30 DAS could add about 14 t ha^{-1} of green matter with minimum investment and resulted in 70 per cent weed suppression. Concurrent growing of daincha receiving both 100 and 75 per cent of recommended N produced significantly higher yield than pure crop of rice receiving 5 t ha^{-1} of FYM and 100 per cent of the recommended nitrogen. Hence there was a saving of 25 per cent N without affecting the yield. The highest yield was obtained when 100 per cent of recommended N was applied to the system.

The treatments for the experiment to study the residual effect of concurrent growing of daincha in wet seeded rice were similar to that of dry seeded rice. The results showed that concurrent growing of daincha and its incorporation at 30 DAS was effective in increasing the yield of succeeding rice and sustaining soil fertility status compared to pure crop of rice receiving 5 t ha^{-1} of FYM and 100 per cent of the recommended nitrogen. The highest yield of succeeding rice was achieved only when it received 100 per cent of the recommended N hence there was no savings of N fertilizer to the succeeding transplanted rice crop. Concurrent growing of daincha in wet seeded rice increased the profitability of the rice- rice cropping system.

Concurrent growing of green manure crops in dry and wet seeded rice is a management alternative to reduce the production cost and to increase the yield of rice and is a practical model for sustainable rice production.