STUDIES ON THE PERFORMANCE OF RICE VARIETY 'ASWATHY' UNDER DIFFERENT METHODS OF DIRECT SEEDING AND WEED CONTROL

BY

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THESIS

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COLLEGE OF HORTICULTURE

VELLANIKKARA, TRICHUR

1979

DECLARATION

I hereby declare that this thesis entitled "Studies on the performance of a rice variety 'Aswathy' under different methods of direct seeding and weed control" is a bonafide record of work done by me during the course of research work and 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 "Studies on the performance of rice variety 'Aswathy' under different methods of direct seeding and weed control" is a record of research work done independently by Kum. Sreedevi.P., 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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INTRODUCTION

INTRODUCTION

Rice is the most important food crop of Kerala occupying an area of 8.5 lakh hectares. Out of this, 3.98 lakh hectares are cultivated during the 'First Crop' season and more than 80 per cent of this area in the season is under semi dry system of cultivation. In this system of cultivation seeds are usually broadcasted or dibbled and the crop gets moisture from the frequent rains received during the growth period of the crop. The high temperature coupled with frequent showers that prevail in the early period of the crop growth are conducive for the emergence and growth of a variety of weeds. The grassy weeds appear along with the germinating seeds of the crop and constitute the major portion of the weed population. Hence heavy infestation of weeds is a serious problem confronting the rice growers during this crop season.

The average yield of rice in this season is reported to be lesser than that of 'Second' and 'Third' crop seasons. Among the many factors responsible for this low yield, the role played by weeds is quite substantial. This is clearly illustrated in the results of multilocational trials conducted in India which revealed that the reduction in yield of rice due to weeds alone is to the tune of 15-20 per cent for transplanted rice, 30-35 per cent for direct seeded rice under puddled condition and over 50 per cent for upland rice (Gopalakrishna Pillai and Rao, 1974). They also estimated the potential loss in production of rice in India on account of weed infestation

as 15 million tonnes per annum which is equivalent to 28 per cent of annual production of rice. From the 'First' crop alone the loss to farmers of Kerala due to weeds works out a staggering figure of 1.04 lakh metric tonnes of grains.

Aswathi, a medium duration strain is isolated from the cross between Ptb.10 and Dee-Gee-Woo-Gen released at the Rice Research Station, Pattambi during 1971. It yields as much as or even more than 'Jaya' under dry broadcasted sowing.

Plant population per unit area is one of the major factors deciding the grain yield. Experiments conducted at I.R.R.I. have shown that each variety of rice has an optimum spacing and that closer spacing is not conducive to obtain better yields especially for high yielding strains (Tanaka et al., 1966). The studies conducted by Nair (1968) showed a general trend in favour of closer spacing for dwarf indicas. In the flow line method of seeding experimental evidence for the variety Aswathy under Kerala conditions is inadequate. To maximise productivity under direct seeding it is necessary as a prelude to fix the optimum seed rate that is conducive for effective crop performance. The spacing should be such that it reduces weed population and promotes better yield.

The simultaneous growth of rice and weed seedlings considerably restricts the range of herbicides that could be effectively used against the weeds without causing harm to the rice seedlings. The selection of suitable method of weed control depends on the soil and environmental condition. Studies conducted on selective herbicidal weed control revealed that Machete and Stam F-34 were found effective in controlling weeds

in rice fields.(Rao et al., 1976 and Smith, 1966a).Gramoxone + Pernoxone as a combined spray is reported to be effective in controlling certain weeds in rice fields (Chandra Singh and Rao, 1977).

There is very little information regarding the use of herbicides in controlling weeds under semi dry system of cultivation of rice in Kerala. This investigation was therefore undertaken with the following objects in view.

1. To evaluate the performance of rice variety 'Aswathy' under different methods of direct seeding and weed control.
2. To compare the relative efficiency of the pre sowing herbicide Gramoxone + Pernoxone, the pre-emergent herbicide 'Machete' and post emergent herbicide Stam F-34.
3. To study the effect of weed control on yield and quality of rice.
4. To work out the economics of different methods of weed control.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Heavy infestation of weeds is a serious problem confronting the rice growers during the first crop season under semi-dry system of cultivation. Hand weeding is the usual practice of weed control which is costly, laborious and time consuming. Chemical method of weed control is now being widely adopted in rice fields as it is quick, efficient and labour saving. The results of some of the cultural and herbicidal weed control trials are reviewed hereunder.

1. Losses in rice production due to weeds.

Weed infestation causes considerable reduction in yield of rice. Weeds reduce the market value of the produce and increase the cost of harvesting, drying, cleaning etc.

According to Chang (1973) yield reduction caused by weeds ranged from 11-66 per cent depending on weed density in the rice fields of Taiwan. Gopalakrishna Pillai and Rao (1974) estimated that the extent of yield reduction in rice due to weeds alone was around 15-20 per cent for transplanted rice and over 50 per cent for upland rice. They also reported that the potential loss in production of rice in India was about 15 million tonnes per annum. Shetty and Gill (1974) revealed that grain yield declined by about 10 q/ha where the time of removal of weeds was extended from 6-8 weeks after transplanting. The extent of yield reduction, compared to grain yield in hand-weeded plots in transplanted rice, due to weeds alone amounted to 26 per cent (Mehta, 1975).

2. Crop-weed competition in rice.

Datta et al. (1968) reported that grass weeds were most influential in reducing grain yield, followed by broad leaved species and then by sedges. Echinochloa crusgalli and Cyperus difformis were more competitive with rice where fertility is high, whereas Monochoria vaginalis and Marsilea quadrifolia had similar effects at high and low fertility (Chang, 1972). Gavadia et al.(1973) concluded that the critical period of weed competition in rice CV.Naylamp was during the first 60-75 days after transplanting. According to Shetty and Gill (1974) the most critical period of crop-weed competition in transplanted rice was between 4-6 weeks after transplanting. Panchal and Sastry (1974) revealed that in rice, increases in the duration of the weed free period were accompanied by linear increases in grain yield from 5.02 to 5.74 t/ha.

High yielding and lodging resistant cultivars competed with barnyard grass for periods ranging from 10 days after emergence to the whole season. It was also found that the competition increased with increase in period required for crop maturity (Smith, 1974). Swain et al. (1975) proved that the adverse effect of Cyperus difformis on rice yields was linear from the time of appearance of the weed until the completion of rice tillering. Where high populations of Cyperus difformis competed with rice for the whole of the growing season, rice yields were reduced by 22-43 per cent particularly under conditions of high soil fertility.

3. Weed spectrum in rice fields.

Conditions favourable for growing rice are also favourable for the growth and reproduction of terrestrial, aquatic and semi aquatic weeds. Echinochloa crus-galli (L) Beauv and other annual moisture loving grasses constitute the serious weeds as stated by Smith and Shaw (1966) from United States, Swain (1967) from Australia and Mukhopadhyay et al. (1973) from India.

Patro et al(1970) reported that Eragrostis major, Cyperus amabilis, Cyperus exaltatus, Fimbristylis diphylla, Marsilea quadrifolia, Oxalis corniculata etc. were the important weeds found in the Agricultural University Farm, Bhubaneswar. It was reported that Brachiaria mutica and Heteranthera reniformis were the two dominant weed species on the CIAT Farm (Anon,1971). Datta and Lacsina (1974) reported that Scirpus maritimus was a serious weed of flooded rice fields in Philippines and other Asian countries. Gopalakrishna Pillai and Rao (1974) reported that the common weeds found in the wet land rice fields of Moncompu were Echinochloa colonum, Fimbristylis miliacea, Cyperus rotundus etc. According to Chouhan and Patil (1975) the predominant weeds found on the experimental farm Raipur were Cyperus pilosus, Cyperus iria, Cyperus bulbosus, Echinochloa crusgalli, Eleusine indica, Dichanthium annulatum, Commelina benghalensis etc. Mohamed Ali and Sankaran (1975) observed that Echinochloa crusgalli, Echinochloa colonum, Cyperus difformis, Cyperus iria and Marsilea quadrifolia were the predominant weeds found at Coimbatore. According to

Nair et al.(1975) the most important weeds found at Rice Research Station, Pattambi were Echinochloa crusgalli, Brachiaria species, Cleome species, Fimbristylis miliacea etc. The most troublesome weeds of rice in Punjab were different species of Echinochloa and Cyperus (Shetty and Gill, 1975). Zahran and Ibrahim (1975) observed that barnyard grass was the most predominant weed in Mansoul in the Nile Delta.

4. Efficiency of herbicides in relation to environment.

Souza and Dos Santos (1969) revealed that gracide was the best herbicide for the control of weeds on wet low land and upland soil. Dalapon at the rate of 15-22.5 kg/ha gave satisfactory control of perennial red rice (Oryza longistaminata) on fallow land in Senegal river delta rice fields (Booken, 1972). Datta (1972) observed that for direct seeded, flooded rice, granular formulations of several new herbicides such as butachlor, benthiocarb and Ce288 were highly selective in controlling barnyard grass and other annual weeds under tropical conditions. Chang and Mao (1973) reported that in pot trials incorporation of straw ashes into paddy soil considerably reduced the effect of Saturn, Tok (nitrofen) M0-401 but not that of Machete. The initial effectiveness of herbicides (especially against Echinochloa crusgalli)was reduced by straw ashes but residual activity was not much affected.

At high temperatures (95°F) MCPA killed young rice tissues while older and more mature tissues were not injured. Molinate applied post-emergence into the water, caused injury to rice plants at temperatures over 95°F especially if they were completely submerged (Bayer, 1974).

5. Methods of weed control.

Effective weed control systems combine preventive, mechanical, cultural and chemical methods. Non-chemical method may combine some or all the following practices, planting weed free seed, crop rotation, levelling land, thorough seed bed preparation, selecting the proper seeding method and managing water and fertilisers properly. Chemical method involve the use of herbicides that selectively control weeds in rice when applied correctly (Smith and Seaman, 1973).

5.1. Non chemical methods.

5.1.1. Preventive.

Practices that help to prevent weed infestations or their spread in clean fields include the use of high quality seed that is free of weed seeds, irrigation with water free of weed seeds or other weed propagules and cultivation with clean equipment. According to Smith and Shaw (1966), red rice is usually spread by contaminated seed.

5.1.2. Mechanical.

Weed control by hoeing is an efficient method but laborious, costly, time consuming and unsuitable for large farms (Ahlgren et al. 1951). According to Patel (1965) the use of rotary weeder has been found to give increase yields by 3 per cent of those obtained with hand weeding. Grist (1975) also reported that Japanese rotary weeder provided a favourable environment for rice.

5.1.3. Water management.

Smith (1967) recommended draining the field soon after seeding to control aquatic weeds and algae. Further he reported

that land levelling and the proper construction of leaves permitted uniform depth of water and reduced the weed infestations. Crafts and Robbins (1973) reported flooding as an efficient method of weed control.

5.1.4. Cultural weed control.

Cultural methods of weed control have been practiced since man first realised the beneficial effects of weeding. In rice fields, the general method is only hand weeding. Weeding will have to be more thorough in broadcast rice fields. than in transplanted fields as the weed growth is much heavier in the former.

Grist (1953) suggested that hand weeding was the best method of controlling weeds in rice. Haynes (1955) and Pisco (1955) also recommended hand weeding as an efficient method of weed control in rice fields. Vachhani and Choudhari (1963) from Central Rice Research Institute, Cuttack reported that hand weeding and weeding with Japanese rotary weeder were as good as herbicidal spray.

Experiments conducted at the International Rice Research Institute revealed that a single hand weeding at about twenty five days after seeding gave maximum yield in upland paddy (Anon, 1965). It was also found that postponing the weeding by twenty days from twenty fifth to fortyfifth day of sowing reduced the yield at the rate of 43 kilograms per hectare per day and sharply increased labour requirements.

In rice culture, mechanical weeding is practised only under dry sown conditions in U.S.A. (Smith and Shaw, 1966). According to them repeated cultivation in spring before seeding could control grasses including Echinochloa species. However, it was ineffective against Heteranthera species.

5.2. Chemical weed control.

A number of herbicides are reported to be very useful in controlling weeds in cereal crops. Among them the efficiency of Stam F-34 (Propanil), Machete (Butachlor), and Gramoxone (Paraquat) + Fernoxone (2,4-D) in controlling weeds in rice fields have been evaluated by several scientists.

5.2.1. Stam F-34.

Stam F-34 is known as an effective herbicide in controlling weeds in rice fields (Smith, 1960).

Dowit (1961), Van Rejin (1963) and several others reported that Stam F-34 offer a great promise in controlling both grass and non-grass weeds in rice soils.

Nair et al.(1964) observed that 'Kavada'(Echinochloa crusgalli) a major weed found in rice fields of 'Kuttanadu' could be controlled with Stam F-34. Ometto, Sedd and Gilveria (1964) found that Stam F-34 reduced infestation of weed flora composed chiefly of Cynodon dactylon, Portulaca oleracene and Pyrostegia ingnea by 47 per cent in rice fields. Sajo (1965) studying the relative efficiency of certain propanil formulations obtained 89 per cent control of weeds mainly Echinochloa crusgalli. Manna and Choudhari (1966) from trials carried out at Central Rice Research Institute, Cuttack reported that

Stam F-34 suppressed graminaceous weeds in upland rice. Sahu and Jena (1968) from their investigations on the control of weeds in paddy fields observed that grasses especially barnyard grass were controlled much better by Stam F-34 than either by MCPA or 2,4-D. It was also noted that Stam F-34 was more effective under drained conditions and older weeds were resistant to this chemical. Higher yield of grain and straw was also obtained from plots treated with Stam F-34.

Sajo loc. cit. found that Stam F-34 caused no injury to rice plants when applied at 4.6 kilogram per cad. strol (0.57 ha) viz. at three times the normal rate. Verma and Mani (1967) reported that Stam F-34, 2 kilogram a.i. per hectare controlled monocot weeds in rice fields.

Mukhopadhyay et al.(1967) from a study on the effect of Stam F-34 in controlling weeds in upland rice observed that this herbicide at the rate of 3 kilograms per hectare gave good control of weeds when applied two weeks after planting rice. But there was regeneration of plots so treated. Sapelkin et al. (1967) reported that Stam F-34 gave effective control of weeds when applied at two to three leaf stage of the weeds.

Gill et al.(1977) showed that propanil applied plots gave an average of 6.87 t/ha grain yield against 6.81 and 0.32 t/ha for the hand weeded (twice) and unweeded plots respectively.

Kaushik and Mani (1977) found that propanil and hand weeding were equally effective in controlling weeds in direct seeded and transplanted rice. Both gave an increase of 2780,

2290 and 5060 kg/ha in grain, straw and total dry matter respectively over the unweeded check. Propanil as Stam F-34 at 2 l/ha also reduced the dry matter accumulation of monocot and dicot weeds to an extent of 56 and 48 per cent respectively as compared with the unweeded check.

Mustafee et al.(1977) reported that a combination of bifenox (1 kg/ha) with propanil (0.7 kg/ha) increased the crop yield in rice considerably over the hand weeded control.

According to Roy and Ram (1977) hand weeding was the best treatment in the control of weeds. The most promising herbicide next to hand weeding was propanil (3 kg/ha).

Singh and Chauhan (1977) showed that the weeds in upland paddy could be effectively controlled with the application of propanil at 1.4 kg/ha + one hand weeding as compared to control.

Singlachar (1977) found that among the liquid formulations of different herbicides tested, propanil gave results comparable with the hand weeding.

Tosh (1977) reported that propanil when applied at 2.24 kg/ha in 4 per cent urea solution, 15 days after rice emergence gave the least weed growth in upland rice. Split application of propanil at 1.5 kg/ha each at 15 days and 30 days after rice emergence recorded the highest grain yield.

5.2.2. Machete.

Experiments conducted at Kanpur revealed that pre-emergence application of machete granules at the rate of 1 kg a.i/ha was found to be the best treatment for controlling weeds (Anon, 1972).

Salcedo and Reyes (1972) concluded that pre-emergence application of granular herbicides 2,4-D ester, butachlor and trifluralin at 3 days after transplanting gave the best weed control and a significantly higher paddy yield. It was reported that effective control of Scirpus maritimus was obtained when butachlor was applied as pre-emergence followed by MCPP post-emergence in flooded rice fields of Philippines (Datta and Lascina, 1974). Rangiah et al. (1974) revealed that Machete (butachlor) granular at 25 kg a.i/ha applied 4 days after transplanting provided effective weed control.

According to Rao et al. (1976) the weed control efficiency of butachlor was 83-89 per cent in an experiment on upland direct seeded rice.

Balu and Sankaran (1977) reported significant reduction in the number and dry matter production of weeds in the herbicide treated plots compared with the unweeded control. Among the herbicide treatments, weed control efficiency was in the order of penoxalin, butachlor and oxadiazon at 1 kg/ha.

Durey and Rao (1977) showed that efficient weed control as well as yield compared to hand weeding could be obtained in transplanted rice with butachlor.

Gill et al.(1977) revealed that butachlor (1.5 and 2.5 kg/ha) applied 3-4 days after transplanting gave effective control of barnyard grass (Echinochloa crusgalli).

Kakat and Mani (1977) reported that butachlor reduced the dry matter accumulation in weeds from 170 grams to

19[illegible] grams/sq.m. in both direct seeded and transplanted rice. The grain and straw yields were also increased by 1190 and 1290 kg/ha respectively due to weed control measures in the direct seeding method.

Kaushik and Mani (1977) found that butachlor was the best in controlling weeds for both direct seeded and transplanted rice variety 'Improved Sabarmathi'.

Mukhopadhyay and Sen (1977) showed that butachlor individually and in combination with insecticides was more efficient in suppressing weed population than nitrofen or bentazon applied alone or in combination with insecticides.

Mandal (1977) revealed that pre-emergence application of butachlor at 3.6 kg/ha controlled all annual grasses, sedges and broad leaved weeds through out the crop period in dry land rice.

According to Mustafee and Ray (1977) a combination of bifenox (1 kg/ha) with butachlor (0.85 kg/ha) increased considerably, the yield of two rice varieties Pusa 2-21 and Jaya over the hand weeded control.

Parthasarathi (1977) reported that the highest yield in rice was obtained with butachlor 1.25 kg/ha with an increase of 10 per cent over the hand weeded plots.

Roy and Ram (1977) concluded that among the different herbicides tested, butachlor (1.5 kg/ha) and propanil (3 kg/ha) were found most promising which gave yield comparable to that of hand weeded plots.

Singh and Chauhan (1977) showed that weeds in the upland paddy could be effectively controlled by the application of butachlor granules at 2 kg/ha + one hand weeding.

Singh et al. (1977) reported that butachlor (0.5 kg/ha) applied pre-plant + propanil (2 kg/ha) applied post emergence gave the best control of weeds and the maximum yield of rice over the control which was given one hand weeding.

Balu and Sankaran (1978) concluded that the relative weed control efficiency of butachlor and penoxalin on two varieties of rice ADT-31 and CO-37 were on par and were found to be significantly superior to the rest of the herbicides tested both during monsoon and summer seasons.

Balu et al.(1978) revealed that the minimum uptake of N, P and K by weeds was registered in butachlor treated plots followed by avirosan while the maximum crop uptake and yield was found in butachlor and penoxalin.

5.2.3. Gramoxone + Fernoxone.

Singh and Rao (1977) reported that a combined spray of Gramoxone (0.5 kg/ha) + Fernoxone (2-4 kg/ha) was found to be very efficient in the control of water hyacinth (Eichhornia crassipes Solms) a pestiferous and free floating aquatic weed. Chandra Singh and Rao (1977) revealed that a combined spray of gramoxone + Fernoxone gave the best control of Typha angustata.

According to Singh and Gupta (1977) post emergent application of Gramoxone at the rate of 0.5 kg/ha along with Fernoxone 3 kg/ha gave promising acceptable weed control in sugarcane.

Singh and Gupta (1978) concluded that Gramoxone + Fernoxone was the best in controlling the weeds in sugarcane.

Balasubramanian and Sankaran (1977) showed that the residues of fluchloralin - paraquat/Stam F-34 combination affected the growth of lab-lab. Alachlor - paraquat/Gramoxone and fluchloralin - paraquat/Gramoxone combinations were reported to be phytotoxic to sorghum.

Singh et al. (1977) reported that paraquat/Gramoxone is the best post emergence herbicide in cotton. It can be sprayed at the rate of 0.5 kg/ha 25 days after sowing provided that the spray droplets do not fall on the crop plants.

Malik et al. (1978) in a study on the effect of herbicidal treated water on the yield of various kharif and rabi crops concluded that Gramoxone had neither any phytotoxic effect on the crop tested nor it reduced the crop yields.

6. Influence of spacing on growth and yield of rice.

Yamada (1961) has reported that higher planting density within limits produced more total dry matter and grain per unit area when rice was grown on less fertilized soil. Under fully fertilized condition, the growth of the plant was accelerated, the space was covered with leaves, and the total yield of the dry matter per unit area at harvest time become constant regardless of its density. Thus was observed the "law of constant final yield in plant growth" (Kira et al., 1959).

Murata et al. (1957) found that the narrower the spacing the greater the photosynthetic ability at the early to middle

stage of growth. However, the relationship was reversed in the later stages.

Bhan (1967) reported very little difference in the nutrient content of plant tissue as influenced by spacing and population, but dry matter production increased with an increase in spacing.

Vachhani et al. (1961) have recorded increased plant height on increased spacing while Lei and Xi (1967) reported greater plant height in closer spacings. Nishizawa (1967) on the other hand have observed greater plant height under dense stands in the initial stages but increased height under low density and maturity.

Hidayatullah and Sen (1944) reported that productive tillers and panicle length were functions of spacing. Bhaktal (1960) observed better tillering under wider spacing. Vachhani et al.(1961) found maximum number of tillers and ear bearing tillers under wider spacing, showing a linear trend in tillering. According to Mandal and Mahapatra (1968) maximum number of effective tillers were obtained under closer spacing.

Increase in the number of grain per panicle and number of spikelets per panicle with wider spacing were also reported (Anon, 1964; Matsuo, 1965; Ahmed and Rao, 1966). On the other hand number of panicles and the total number of spikelets per unit area increased and the weight per panicle and mean grain weight decreased with an increase in plant density (Yamada 1961; Anon 1964; Tanaka, et al. 1964).

Trials conducted at C.R.R.I., Cuttack for four seasons with high yielding varieties indicated that spacing effect or interactions with other factors were not significant in the majority of the seasons, with the result that specific plant population requirements could not be conclusively defined. Wider spacing for dwarf indica appeared to have a better advantage in nitrogen response (Rao, 1968).

Results of the experiments conducted under the A.I.C.R.I.P during Rabi 1968 showed that a spacing of 20 cm x 15 cm to be good for IR-8 (Anon, 1968).

7. Uptake of nutrients by weeds and crops.

Boerema (1963) reported that the reduction of weed competition due to application of propanil resulted in an increased absorption of nitrogen by rice, almost 3 times. It is reported that barnyard grass in rice fields removed 60-80 per cent nitrogen from the soil (Swain, 1967). Verma and Mani (1970) reported that unchecked weed growth depleted soil nutrients to the extent of 20.0, 11.8 and 20.0 kg/ha of N, P and K respectively. A single application of Stam F-34 (2 kg/ha) brought down the nutrient depletion by weeds to 1.6, 1.0 and 2.4 kg/ha of N, P and K respectively. Shetty and Gill (1974) revealed that both the weeds and the crops competed for the nutrients to the maximum during the early period of growth. The competition for soil nitrogen was maximum during 4-8 weeks after transplanting. Weeds were more efficient in nitrogen uptake than the crop, whereas rice was more efficient in absorbing phosphate

and potash. The total uptake of nutrients by the crop and the weeds together in unweeded plots was less than the uptake of nutrients by the crop alone in weed free treatments. Mani (1975) found that herbicide use affected an appreciable decrease in nitrogen depletion by weed growth, as a consequence of which considerable improvement in nitrogen uptake of the crop plants and enhancement in crop yields occured.

8. Herbicide residual studies.

Wicks, et al.(1969) concluded that atrazine applied to sorghum at recommended rates did not persist long enough to cause losses of winter wheat in a winter wheat - sorghum - fallow rotation. RP - 17623 alone or mixtures of propanil or butachlor or benthiocarb gave a residual control which lasted 4-6 weeks whereas grasses quickly invaded plots that has received the standard treatments, propanil and molinate (Smith, 1972). Vamadevan and Patil (1972) in an experiment to study the residual effect of herbicides, ronstar, EMD-60-70 and tavron (G) under three water management practices in rice found that tavron (G) appeared to have the greatest residual effect under saturated condition. In general, it was observed that the toxicity of all the chemicals tried was completely reduced within the third week after application. Trials conducted at Taiwan revealed that one application of herbicides such as butachlor, MO-401, nitrofen and benthiocarb in rice

does not leave residues in amounts toxic to several upland rice crops that follow rice (Anon, 1973). In the experiments conducted by Rangiah et al.(1974), it was found that Machete (C) at 2-5 kg a.i/ha applied 4 days after transplanting and Stam F-34 at 3 kg a.i/ha applied 3 weeks after transplanting followed by one hand weeding five weeks after planting provided effective weed control but the chemicals themselves lacked adequate residual activity against perennial weed growth.

MATERIALS AND METHODS

MATERIALS AND METHODS

A field experiment designed to study the performance of rice variety 'Aswathy' under direct seeding in relation to method of sowing and weed control was conducted during the first crop season of 1978 at the Rice Research Station and Instructional Farm, Mannuthy. The field selected for the experiment was under bulk crop of paddy for the previous two seasons. Weedicidal trials had not been conducted in the experimental site for the last five years.

1. Materials.

1.1. Site, climate and soil.

The Farm is situated at 12°32'N Latitude and 74°20'E Longitude at an altitude of 22.25 m above MSL. This area enjoys a typical humid tropical climate.

The details of the meteorological observations for the period are presented in Table 1.1.1 and figure 1.

The soil of the experimental area was moderately well drained, medium clay loam in texture, the chemical characteristics of which are presented in Table 1.1.2.

1.2. Season.

The experiment was conducted during the period from May to October, 1978.

1.3. Seeds.

The variety ' Aswathy ' selected for the study is isolated from the cross between Ptb.10 and Dee-Geo-Woo-Gen. It is a dwarf variety having a duration of 125 days. This variety was found suitable for dry sowing in the first crop season.

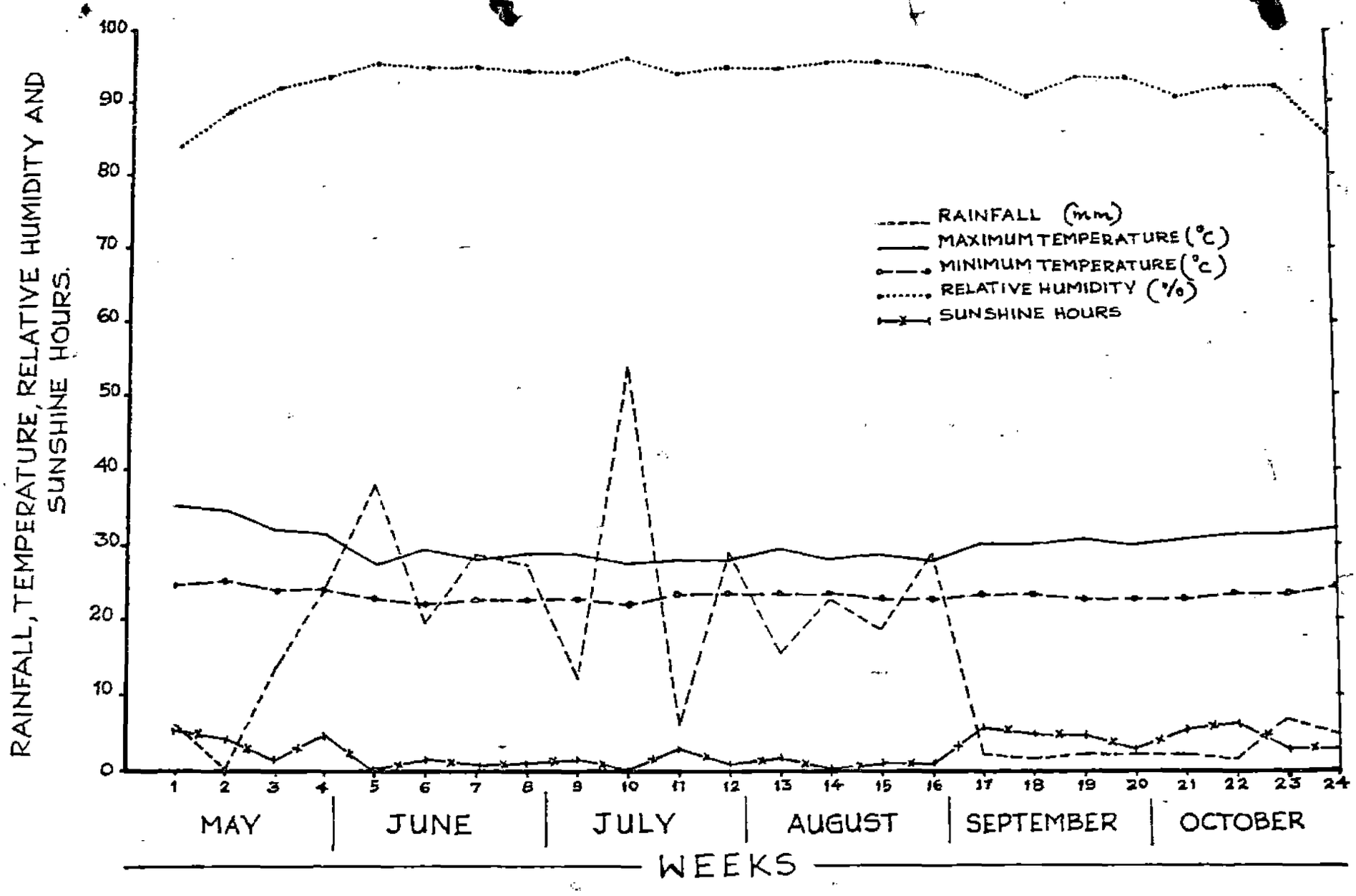


Fig-1. WEATHER CONDITIONS DURING THE CROP SEASONS 1st. MAY 1978 TO 31st. OCTOBER 1978

Table 1.1.1.

Mean weekly weather parameters for the entire rice growing period

Duration period	Temperature (°C) Max.	Min.	Humidity (%)	Total rainfall (mm)	Sunshine (hours)
1.5.78 to 7.5.78	35.5	24.8	84.5	6.6	5.0
8.5.78 to 14.5.78	34.6	25.7	88.4	--	4.2
15.5.78 to 21.5.78	32.0	24.4.	91.8	13.5	1.7
22.5.78 to 31.5.78	31.3	24.4	93.6	24.3	4.0
1.6.78 to 7.6.78	27.1	22.6	95.5	38.0	0.1
8.6.78 to 14.6.78	29.2	22.3	94.5	19.5	1.1
15.6.78 to 21.6.78	28.2	22.7	94.4	28.4	0.5
22.6.78 to 30.6.78	28.7	22.7	94.2	27.3	0.5
1.7.78 to 7.7.78	28.8	22.7	94.2	12.0	1.0
8.7.78 to 14.7.78	27.1	22.2	96.2	54.1	--
15.7.78 to 21.7.78	28.3	23.0	94.1	6.1	3.2
22.7.78 to 31.7.78	28.2	23.0	94.9	29.1	0.7
1.8.78 to 7.8.78	29.1	23.4	94.4	15.1	1.4
8.8.78 to 14.8.78	28.1	23.1	95.4	22.8	0.1
15.8.78 to 21.8.78	28.4	22.5	95.1	18.5	0.3
22.8.78 to 31.8.78	28.2	22.9	94.7	28.4	0.8
1.9.78 to 7.9.78	29.9	23.1	93.4	2.0	5.5
8.9.78 to 14.9.78	30.1	23.3	90.7	1.7	4.5
15.9.78 to 21.9.78	30.4	22.9	93.0	2.2	4.9
22.9.78 to 30.9.78	29.8	22.9	92.7	2.2	2.9
1.10.78 to 7.10.78	30.4	22.6	90.5	2.2	5.3
8.10.78 to 14.10.78	32.2	23.5	91.8	1.2	5.7
15.10.78 to 21.10.78	31.3	23.6	91.8	6.4	2.9
22.10.78 to 31.10.78	31.7	23.8	85.5	4.4	2.9

Table 1.1.2.

Chemical characteristics of soil

Constituent	Content in soil	Method used
Organic carbon	0.837%	Walkley and Black's titration method
Total nitrogen	0.1008%	Microkjeldahl method
Available P_2O_5	0.0004%	In Bray I extract, Chlorostannous - reduced molybdophosphoric blue colour method.
Available K_2O	0.0047%	The neutral ammonium acetate extract, flame-photometric.
Total P_2O_5	0.0524%	In HCl extract as ammonium phosphomolybdate, volumetric.
Total K_2O	0.3841%	In HCl extract flame photometric.
pH	5.1	1:2 soil solution ratio using a pH meter.

1.4. Manures and fertilizers.

Farmyard manure at the rate of 5000 kilograms per hectare was applied uniformly as basal dressing. It was of the following composition.

Nitrogen	0.41 per cent
Phosphorus	0.23 per cent
Potassium	0.39 per cent

In addition, lime (54.3 per cent CaO) was applied uniformly at the rate of 600 kilograms per hectare about 4 days prior to sowing.

The fertilizers with the following analysis were used in the experiment at the rate of 90 kilograms of nitrogen, 45 kilograms of phosphate and 45 kilograms of potash per hectare.

Ammonium sulphate	- 20.1 per cent nitrogen.
Superphosphate	- 16.5 per cent P_2O_5 (phosphorus pentoxide)
Muriate of potash	- 55 per cent K_2O (Potassium oxide)
Urea	- 45.5 per cent nitrogen

1.5. Herbicides.

1.5.1. Butachlor (Machete)

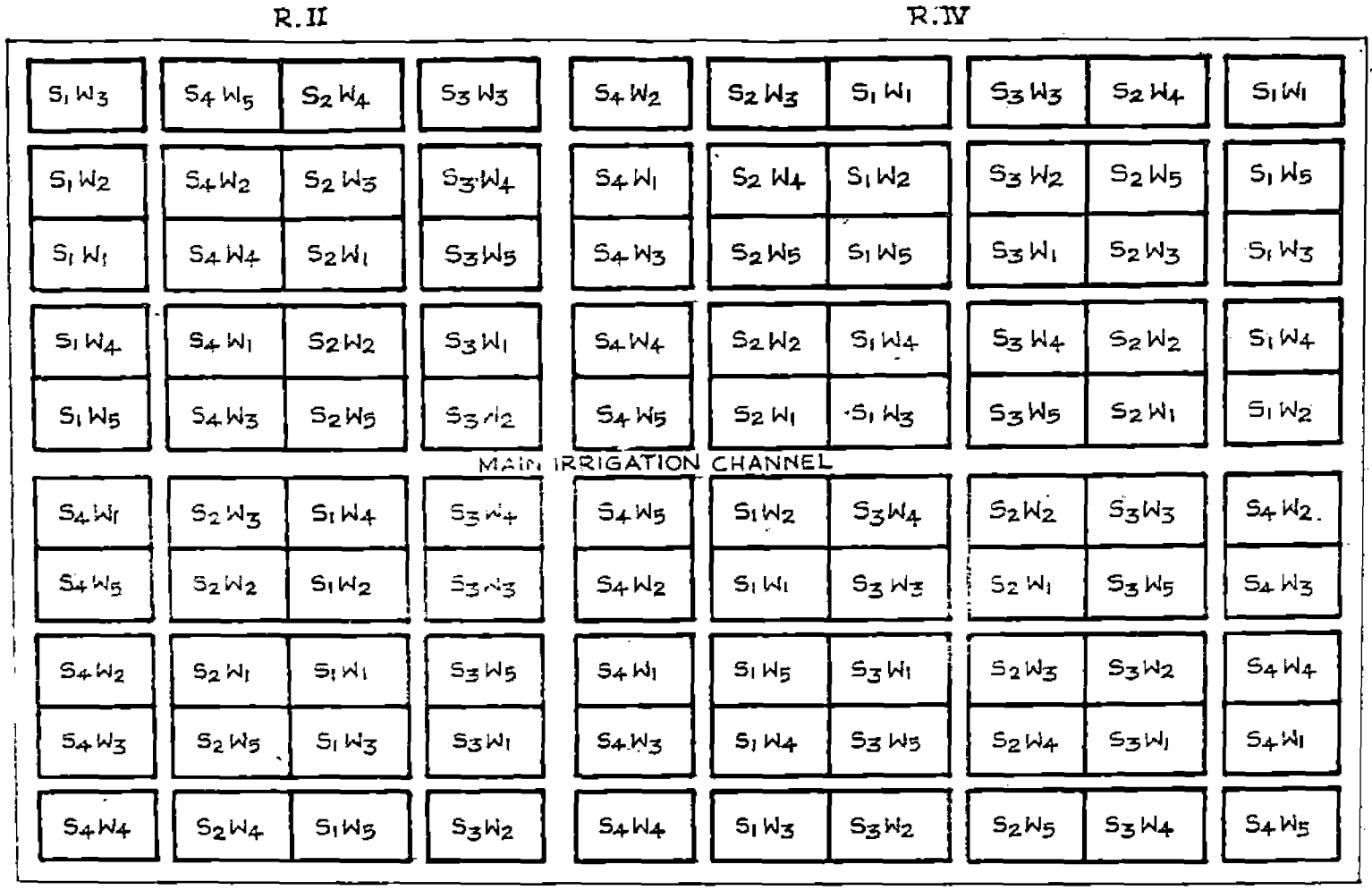
Machete is a proprietary product of Monsanto Chemicals of India (Private) Limited. The product containing the active ingredient butachlor, (2-chloro-2'6' diethyl-N-Butoxymethyl acetanilide), is available in the form of 50 per cent EC and 5 per cent G. It is a pre-emergence herbicide with good efficiency for controlling annual grasses and broad leaved weeds.

1.5.2. Propanil (Stam F-34).

Stam F-34 is a proprietary product of Messrs Indofil Chemicals Limited. The product containing the active ingredient propanil, (3,4 - Dichloro propionanilide) is available in the form of 35 per cent EC. It is a post-emergent contact herbicide recommended for selective weed control in paddy crop.

1.5.3. Paraquat (Gramoxone)

Gramoxone is a broad spectrum contact herbicide based on paraquat suitable for crop and non crop situations. Gramoxone containing 20 per cent active ingredient - paraquat is a



	TREATMENTS	
	WEED CONTROL	SPACING
TREATMENTS : 20	W_1 - STAM F-34	S_1 - 30cm. FLOWLINE
REPLICATION : 5	W_2 - MACHETE	S_2 - 45 cm. FLOWLINE
GROSS PLOT SIZE : 5.4x6 Sq.M.	W_3 - GRAMOXONE+FERNOXONE	S_3 - 60 cm. FLOWLINE
NET PLOT SIZE : 5.4x5 Sq.M.	W_4 - HAND WEEDING	S_4 - 20x15cm. DIBBLING
	W_5 - UNWEEDED CONTROL	

Fig-2. LAYOUT PLAN SPLIT PLOT EXPERIMENT IN RANDOMISED BLOCK DESIGN

product of The Alkali and Chemical Corporation of India Limited.

1.5.4. 2,4-D (Fernoxone)

Fernoxone is a selective weedicide. The formulation used was 80 per cent water soluble sodium salt of 2,4-D. Supplied by Chemo mineral Industries, Thana.

2. Methods.

2.1. Layout.

Split plot experiment in randomised block design was adopted. The experiment comprised of 20 treatments with spacing in the whole plots and weed control treatments in sub plots. The treatments were replicated 5 times. The layout plan is given in Figure 2.

Treatments

Whole plot treatments (Spacing)	Abbreviations
1. 30 cm flow line	S1
2. 45 cm flow line	S2
3. 60 cm flow line	S3
4. 20 x 15 cm control	S4
Sub plot treatments (Weed control)	
1. Stam F-34	W1
2. Machete	W2
3. Gramoxone + Fernoxone	W3
4. Hand weeding	W4
5. Unweeded control	W5

The details of the layout plan are furnished below:

Total number of treatments in one block	: 20
Number of blocks	: 5
Total number of plots	: 100
Gross plot size	: 5.4 x 6 sq.M
Net plot size	: 5.4 x 5 sq.M
Total experimental area	: 0.441 ha.

2.2. Rate of dilution and method of application.

The herbicides were dissolved in water as given below according to the recommendation of the manufacturers.

Machete	: 2 kg a.i. in 500 litres of water per hectare.
Stam F-34	: 1.5 kg a.i. in 500 litres of water per hectare.
Gramoxone + Fernoxone	: 2½ litres of Gramoxone + 700 gms of fernoxone in 500 litres of water per hectare.

The solutions of Machete - the pre-emergent herbicide and Stam F-34 - the post emergent herbicide were applied uniformly as a blanket spray in the respective plots using a hand operated knapsack sprayer in the early hours to avoid spray drift. The pre-sowing weedicide Gramoxone, was applied two days before sowing. The field was thoroughly drained off prior to the application of Stam F-34 on the 14th day after sowing. Machete solution was sprayed on the sixth day after sowing.

2.3. Hand weeding.

The first hand weeding was done on the 30th day and the second one on the 40th day after sowing.

2.4. Field culture.

The cultivation practices recommended for 'Aswathy' by the Kerala Agricultural University were followed. The land was ploughed twice, clods were broken and all the weeds and

stubbles were removed. Farm yard manure was uniformly spread all over the field before the second ploughing. Lime was applied at the rate of 600 kg per hectare in two split doses; the first dose at 350 kg per hectare as basal dressing at the time of final ploughing and the second dose at 250 kg per hectare as top dressing about one month after sowing. The fertilizers for basal dressing were applied as per the schedule of treatments a day before sowing and mixed with soil by hand raking.

The entire dose of phosphorus and potassium and half the dose of nitrogen were applied as basal dressing. The remaining half the dose of nitrogen was applied as top dressing on the 45th day after sowing.

The seeds were sown on 17th May, 1978. The seed rate used was 80 kg per hectare. Controlled irrigation and drainage were done as and when required. Two protective spraying with Ekalux on 20th day after sowing and Lebaycid and Hinosan on 50th day after sowing were given. The stand of the crop was good. There was no lodging or serious attack of pests and diseases. The crop was harvested on 125th day after sowing.

2.5. Observations.

2.5.1. Observation on weeds.

(a) Weed count.

The weed counts were made from the sampling unit in each plot. The mean number of weeds per quadrate was worked out. The weed counts were made at 4 stages; 30, 40, 50 and 60 days

after sowing the crop. Total monocot and dicot weed populations were recorded.

(b) Dry matter of weeds.

Dry weight of weeds collected on 30th, 40th, 50th and 60th day after sowing and at harvest were recorded.

Observations on the germination of the crop seeds were taken for the treatments which received pre-sowing and pre-emergent herbicidal application.

2.5.2. Crop growth characters.

(a) Height of plants.

The plant height in cm was recorded at 30th, 45th, 60th day after sowing and at harvest. Heights of plants were measured from the bottom of the culm to the tip of the longest leaf or tip of the earhead whichever was tallest.

(b) Number of tillers.

The tillers from each sampling unit were counted on the above dates and the values per square metre were computed.

2.5.3. Yield characters.

(a) Productive tillers.

Number of productive tillers from each sampling unit were counted and the values per square metre were calculated.

(b) Percentage of productive tillers.

Number of productive tillers from each sampling unit were counted and the percentage worked out on the total number of tillers at maximum tillering stage.

(c) Length of panicle.

Length of in centimetres from the neck to the tip of panicle was measured.

(d) Number of grains per panicle.

Number of grains in each panicle were recorded.

(e) Thousand grain weight.

One thousand grains were counted from the cleaned produce from each plot, weighed and recorded in grams.

(f) Grain yield.

The grain harvested from each net plot was dried, cleaned, winnowed and weighed. From this yield of grain in kilograms per hectare was calculated and recorded.

(g) Straw yield.

The weight of sun dried straw was recorded plotwise and from this the yield of straw in kilograms per hectare was computed.

2.6. Chemical analysis.

2.6.1. Soil analysis.

Composite soil samples collected prior to the commencement of the experiment were analysed for total nitrogen, available P_2O_5, available K_2O and pH.

2.6.2. Weed analysis.

The NPK content of weed samples were estimated at the 40th day after sowing. From this NPK uptake by weeds per hectare were worked out.

2.6.3. Plant analysis.

The N, P and K content of rice plants at harvest were determined.

2.6.4. Protein content of grains.

The nitrogen content of whole grains was estimated by the microkjeldahl method and the protein content of grains was computed by multiplying the nitrogen content by a factor 6.25 (Simpson et al., 1965).

2.7. Statistical analysis.

The data relating to each character were analysed by applying the analysis of variance technique as suggested by Panse and Sukhatme (1954) for split plot design.

RESULTS

RESULTS

The results of the experiment conducted to study the performance of rice variety 'Aswathy' under different methods of sowing and weed control are furnished below.

I. Observations on weed.

A. Weed Species.

The different species of weeds found in the experimental area were collected and identified prior to the start of the experiment. The weed growth in the field comprised of grasses, sedges and broad leaved weeds. Weed species found in the experimental fields are classified in Table 1.

Table 1.

Classification of weeds in the experimental field

Scientific name	Family
I. Grasses	
1. *Alloteropsis cimicina*	Graminae
2. *Brachiaria ramosa*	Graminae
3. *Cynodon dactylon*	Graminae
4. *Echinochloa colonum*	Graminae
5. *Eleucine indica*	Graminae
6. *Eragrostis* sp.	Graminae
7. *Oplismenus burmannii*	Graminae

8. *Panicum repens*	Gramineae
9. *Paspalum scorbiculatum*	Gramineae
10. *Setaria* sp.	Gramineae
II. Sedges	
1. *Bulbostylis barbata*	Cyperaceae
2. *Cyperus difformis*	Cyperaceae
3. *Cyperus distans*	Cyperaceae
4. *Cyperus iria*	Cuperaceae
5. *Cyperus rotundus*	Cyperaceae
III. Broad leaved weeds.	
1. *Chloroxylus sorcurialis*	Euphorbiaceae
2. *Cleome viscosa*	Capparidaceae
3. *Euphorbia hirta*	Euphorbiaceae
4. *Hybanthus enneaspermus*	Violaceae
5. *Hyptis suaveolens*	Labiatae
6. *Ludwigia parviflora*	Onagraceae
7. *Melochia corchorifolia*	Sterculiaceae
8. *Merremia tridentata*	Convolvulaceae
9. *Mollugo pentaphylla*	Molluginaceae
10. *Oldenlandia* sp.	Rubiaceae
11. *Peperomia pellucida*	Piperaceae
12. *Phyllanthus debilis*	Euphorbiaceae
13. *Scoparia dulcis*	Scrophulariaceae
14. *Sebastiana chamaka*	Euphorbiaceae
15. *Sida retusa*	Malvaceae
16. *Sida rhombifolia*	Malvaceae
17. *Stachytarpheta indica*	Verbenacea

From the Table presented above, it can be seen that weed species found in the experimental field include not only the wet land weeds but also dry and garden land weeds.

B. Weed count.

a. Total weed population per square metre.

The observations on total number of weeds taken on 30th, 40th, 50th and 60th day after sowing were analysed separately and the analysis of variance tables presented in Appendix I, II, III and IV respectively. The mean values corresponding to different treatments are given in Tables 2, 3, 4 and 5.

1. 30th day after sowing.

From the analysis of variance tables (Appendix I), it was found that the effect due to various methods of weed control was significant. The unweeded control plot recorded the highest total number of weeds (102.15/m^2). Machete applied plots recorded the least weed count (53.75/m^2) when compared to other treatments. Gramoxone + Fernoxone was as efficient as Stam F-34 in controlling weeds.

The effect due to various spacing was also significant. Among the treatments 45 cm flow line gave the lowest value of total weed population (66.72/m^2). There was no significant difference between S1, S3 and S4.

Table 2

Total weed population/m^2 on 30th day.

	W_1	W_2	W_3	W_4	W_5	Mean
S_1	68.0	56.2	69.6	88.6	108.6	78.20
S_2	58.0	46.6	60.0	74.4	94.6	66.72
S_3	67.4	56.2	65.6	84.4	102.2	75.16
S_4	64.6	56.0	65.4	86.6	103.2	75.16
Mean	64.5	53.75	65.15	83.5	102.15	

C D(0.05) Spacing : 4.849.

C D(0.05) Weed control : 3.8579.

Table 3

Total weed population/m^2 on 40th day.

	W_1	W_2	W_3	W_4	W_5	Mean
S_1	81.6	69.8	84.2	105.4	124.6	93.12
S_2	72.0	59.0	74.6	98.2	113.2	83.40
S_3	82.2	68.0	79.8	100.2	114.0	88.84
S_4	81.4	71.5	83.2	98.2	116.0	90.08
Mean	79.3	67.1	80.45	100.5	116.95	

C D (0.05) Spacing : 5.5880

C D (0.05) Weed control : 3.17606

Table 4

Total weed population/m^2 on 50th day.

	W_1	W_2	W_3	W_4	W_5	Mean
S_1	106.0	86.0	104.6	124.8	141.0	112.48
S_2	90.2	74.4	91.4	113.4	128.6	100.20
S_3	95.2	85.6	98.4	118.2	130.4	105.56
S_4	96.2	87.2	96.4	113.6	133.8	105.44
Mean	96.90	84.05	97.70	117.5	133.45	

C.D. (0.05) Spacing : 6.3967

C.D. (0.05) Weed control : 3.4549

Table 5

Total weed population/m^2 on 60th day.

	W1	W2	W3	W4	W5	Mean
S1	122.0	103.4	121.0	143.8	170.4	132.12
S2	104.0	93.8	103.8	128.8	149.6	116.00
S3	116.6	101.2	115.4	128.0	148.0	121.84
S4	115.0	105.2	112.8	133.0	152.0	123.60
Mean	114.40	100.90	113.25	133.4	155.0	

C.D. (0.05) Spacing : 9.5309

C.D. (0.05) Weed control : 5.9360.

2. 40th day after sowing.

The effect due to different methods of weed control was significant. The unweeded control plots recorded the maximum total number of weeds (116.95/m^2). Machete treated plots recorded the lowest value for total weed population (67.1/m^2). Stam F-34 was on par with Gramoxone + Fernoxone.

The effect due to different treatments in spacing was also significant. 45 cm flowline recorded the lowest number of total weeds (83.4/m^2).

3. 50th day after sowing.

There was significant difference between the effect due to different methods of weed control. Maximum number of total weeds was observed in the unweeded control plot (133.45/m^2). Machete treated plots recorded the lowest number of total weeds (84.05/m^2). Gramoxone + Fernoxone and Stam F-34 were on par in controlling weeds.

The effect due to different treatments in spacing was also significant. 45 cm flowline recorded the lowest number of total weeds (100.2/m^2).

4. 60th day after sowing.

The effect due to different methods of weed control was significant. The unweeded control plot recorded the highest number of total weeds (155/m^2). Machete was significantly superior to all other herbicides in controlling weeds. Stam F-34 was on par with Gramoxone + Fernoxone in controlling weeds.

The effect due to different spacing treatments was also found to be significant. Among the treatments 45 cm flow line gave the lowest value for total number of weeds (116/m^2)

5. Monocot weed population per square metre.

The analysis of variance tables corresponding to the observations on monocot weed populations per square metre on 30th, 40th, 50th and 60th day after sowing are furnished in Appendix V to VIII. The mean values of monocot weed population at each observation are given in Tables 6 to 9.

1. 30th day after sowing.

The effect of weed control treatment alone was significant. Control plot recorded the highest number of monocot weeds (53.4/m^2). Machete applied plots gave the lowest number of monocot weeds (23.05/m^2). Stam F-34 was as efficient as Gramoxone + Fernoxone in controlling monocot weeds.

2. 40th day after sowing.

The effect due to different methods of weed control was found to be significant. Monocot weed population was highest in the control plot (60.65/m^2). Machete treated plots recorded the lowest number of monocot weeds (28.9/m^2). Stam F-34 and Gramoxone + Fernoxone were on par.

The effect due to various spacing was also significant. Among the treatments 45 cm flow line gave the lowest value of monocot weed population (42.0/m^2).

Table 6

Monocot weed population on 30th day.

	W1	W2	W3	W4	W5	Mean
S1	37.8	24.8	38.2	47.4	57.2	41.08
S2	33.8	19.2	33.2	41.8	53.8	36.36
S3	35.0	23.8	35.8	45.4	51.2	38.24
S4	31.8	24.4	36.4	45.8	51.4	38.96
Mean	35.8	23.05	35.9	45.1	53.4	

C.D. (0.05) Weed control : 2.60.

Table 7

Monocot weed population on 40th day.

	W1	W2	W3	W4	W5	Mean
S_1	45.6	30.8	43.6	56.6	65.8	48.48
S_2	38.0	23.6	38.0	52.6	57.6	42.00
S_3	45.2	31.0	43.6	53.0	59.2	46.40
S_4	43.4	30.2	30.2	54.2	59.8	43.56
mean	43.05	28.9	38.85	54.1	60.65	

C.D. (0.05) Spacing : 2.90

C.D. (0.05) Weed control : 3.54

Table 8

Monocot weed population on 50th day.

	W1	W2	W3	W4	W5	Mean
S1	57.0	38.6	57.0	68.0	75.2	59.16
S2	45.4	32.8	46.8	61.8	66.4	50.64
S3	52.2	40.0	52.6	65.8	69.8	56.08
S4	50.6	36.4	50.4	58.2	69.8	53.08
Mean	51.30	36.95	51.70	63.45	70.3	

C.D. (0.05) Spacing : 4.224

C.D.(0.05) Weed control : 2.575

Table 9

Monocot weed population on 60th day.

	W1	W2	W3	W4	W5	Mean
S1	64.0	49.0	65.2	75.0	88.8	68.40
S2	57.2	41.8	55.8	66.6	79.0	60.08
S3	61.2	47.4	61.0	66.8	76.4	62.56
S4	61.0	45.6	61.0	69.8	78.4	63.16
Mean	60.85	45.95	60.75	69.55	80.65	

C.D. (0.05) Weed control = 3.219

3. 50th day after sowing.

The effect due to different methods of weed control was significant. The unweeded control recorded the maximum number of monocot weeds (70.3/m^2). The lowest number of monocot weeds was observed in plots treated with Machete (36.95/m^2).

The effect due to different spacing treatments was also significant. The lowest number of monocot weeds was observed in 45 cm flow line and was on par with 20 x 15 cm dibbling.

4. 60th day after sowing.

The effect due to different weed control treatments was significant. The unweeded control plot recorded the maximum number of monocot weeds (80.65/m^2). Machete applied plots gave the lowest value of monocot weed populations (45.95/m^2). Stam F-34 was as efficient as Gramoxone + Fernoxone in controlling monocot weeds.

The effect due to various treatments in spacing and interaction were not significant.

c. Dicot weed population per square metre.

The analysis of variance table corresponding to the observations on dicot weed population on 30th, 40th, 50th and 60th day after sowing are furnished in Appendix IX to XII. The mean values of dicot weeds per square metre at each observation are given in Tables 10 to 13.

Table 10

Dicot weed population on 30th day.

	W_1	W_2	W_3	W_4	W_5	Mean
S_1	30.8	27.6	32.0	41.6	53.8	37.16
S_2	27.6	23.2	28.0	34.4	43.8	31.40
S_3	33.8	28.8	32.0	42.0	52.2	37.76
S_4	30.6	26.0	31.8	42.4	54.0	36.96
Mean	30.7	26.4	30.9	40.1	50.9	

C.D. (0.05) Spacing : 2.178

C.D. (0.05) Weed control : 1.80

Table 11

Dicot weed population on 40th day

	W_1	W_2	W_3	W_4	W_5	Mean
S_1	40.2	35.6	39.2	50.8	59.6	45.08
S_2	37.6	32.4	37.6	47.6	53.8	41.80
S_3	39.8	35.6	38.2	50.4	56.0	44.00
S_4	39.4	35.2	40.4	47.2	56.2	43.68
Mean	39.25	34.70	38.85	49.00	56.40	

C.D. (0.05) Weed control : 1.925

Table 12

Dicot weed population on 50th day

	W1	W2	W3	W4	W5	Mean
S1	49.8	45.0	49.8	62.2	68.6	55.08
S2	46.4	42.2	46.0	56.2	65.2	51.20
S3	48.6	44.6	46.8	55.0	62.6	51.52
S4	49.4	45.2	48.2	57.6	66.8	53.44
Mean	48.55	44.25	47.70	57.75	65.8	

C.D. (0.05) Weed control : 1.79.

Table 13

Dicot weed population on 60th day.

	W1	W2	W3	W4	W5	Mean
S1	60.8	53.2	58.2	70.2	79.0	64.28
S2	50.6	46.4	54.0	62.2	70.6	56.76
S3	56.4	52.0	56.4	63.8	72.2	60.16
S4	55.4	51.8	57.0	64.4	74.2	60.56
Mean	55.80	50.85	56.40	65.15	74.00	

C.D. (0.05) Spacing : 4.297

C.D. (0.05) Weed control : 1.748

1. 30th day after sowing.

The effects due to weed control and spacing treatments were found to be significant while the interaction effect was not significant. Control plot recorded the maximum number of dicot weeds (50.95/m^2). The lowest value for the total dicot weed population was observed in Machete treated plots. Stam F-34 treatment was found to be on par with the Gramoxone + Fernoxone treatment. Among the spacing treatments, lowest number for dicot weed population was observed in 45 cm flowline. All the other spacing treatments were on par.

2. 40th day after sowing.

The effect due to weed control treatments alone was found to be significant. The unweeded control recorded the highest dicot weed population (56.4/m^2). Machete treated plots showed the lowest number of dicot weeds, while Gramoxone + Fernoxone and Stam F-34 treatments were on par. There was no significant difference between the spacing treatments. However 45 cm flowline gave the minimum number of dicot weeds.

3. 50th day after sowing.

The effect due to weed control treatments alone was found to be significant. Control plot recorded the highest dicot weed population. The lowest number for dicot weeds was observed in Machete treated plots while Gramoxone + Fernoxone and Stam F-34 were on par. Though the spacing

treatments did not show any significant difference, 45 cm flowline gave the minimum dicot weed population.

4. 60th day after sowing.

The effect of weed control and spacing treatments were found to be significant. Among the weed control treatments the unweeded control recorded the highest number of dicot weeds. Gramoxone + Fernoxone and Stam F-34 treatments were on par. The lowest number of dicot weeds was observed in Machete treated plots.

In the case of spacing, 30 cm flow line gave the highest dicot weed population. There was no significant difference between 45 cm flowline, 60 cm flowline and 20 x 15 cm dibbling. But 45 cm flowline gave the lowest number of dicot weeds.

C. Weed control efficiency.

Weed control efficiency was calculated on the basis of total weed population and presented in Table 14. The following formula was used for the calculation of weed control efficiency.

$$WCE = \frac{WPC - WPT}{WPC} \times 100$$

where

WCE = Weed control efficiency

WPC = Weed population in the control plot

WPT = Weed population in the weed control treatments.

From the results it was observed that Machete had the highest weed control efficiency (34.88%) followed by

Table 14

Weed control efficiency

Treatments	Total number of weeds per m^2 on 60th day	Weed control efficiency(%)
1. Stam P-34	152.52	26.33
2. Machete	134.52	34.88
3. Gramoxone + Fernoxone	151.00	26.91
4. Hand weeding	177.84	13.92
5. Unweeded control	206.60	

Gramoxone + Fernoxone (26.91%) and Stam F-34 (26.33%), while the hand weeded plot recorded the lowest weed control efficiency (13,92%).

D. Dry weight of weeds per square metre.

The observations on dry weight of total weeds taken on 30th, 40th, 50th and 60th day after sowing and at harvest were analysed separately and the analysis of variance tables are presented in Appendix XIII to XVII. The mean values corresponding to the different treatments at the various stages are given in Tables 15 to 19.

1. 30th day after sowing.

The effect due to weed control treatments alone was significant. The unweeded control plot recorded the maximum dry weight of weeds. Machete applied plots gave the lowest value of dry weight of weeds compared to other weedicides.

2. 40th day after sowing.

The effects due to weed control and spacing treatments were found to be significant. The control plot gave the maximum dry weight of weeds. Among the herbicides Machete treated plots gave the minimum dry weight of weeds.

The effect due to different spacing treatments was also significant. 20 x 15 cm dibbling gave thelowest value of dry weight of weeds.

3. 50th day after sowing.

The effect due to weed control treatments alone was found to be significant. The unweeded control plot recorded

Table 15

Dry weight of weeds on 30th day gm/m^2
(After Log. transformation)

	W1	W2	W3	W4	W5	Mean
S1	1.77	1.42	1.49	2008	2.18	1.790
S2	1.71	1.11	1.46	1.89	2.05	1.644
S3	1.73	1.02	1.44	1.97	2.07	1.646
S4	1.72	1.12	1.44	1.94	2.01	1.650
Mean	1.73	1.17	1.46	1.97	2.08	

C.D. (0.05) Weed control : 0.106

Table 16

Dry weight of weeds on 40th day gm/m^2

(After square root transformation)

	W1	W2	W3	W4	W5	Mean
S1	10.18	7.65	10.30	5.33	15.44	9.78
S2	9.71	5.93	8.37	4.49	12.26	8.15
S3	9.48	6.39	9.51	4.49	13.84	8.74
S4	8.32	5.48	7.88	3.95	13.14	7.75
Mean	9.42	6.36	9.02	4.57	13.67	

C.D. (0.05) Spacing : 0.986

C.D. (0.05) Weed control : 0.680

Table 17

Dry weight of weeds on 50th day gm/m^2

(After square root transformation)

	W1	W2	W3	W4	W5	Mean
S1	12.08	9.36	11.48	4.38	15.82	10.62
S2	11.60	9.18	10.80	4.85	16.36	10.56
S3	11.75	9.42	11.80	5.09	15.80	10.77
S4	10.31	7.79	10.03	4.20	14.85	9.44
Mean	11.44	8.94	11.03	4.63	15.71	

C.D. (0.05) Weed control : 0.702

Table 18

Dry weight of weeds on 60th day gm/m^2

(After square root transformation)

	W_1	W_2	W_3	W_4	W_5	Mean
S_1	14.71	11.60	15.04	6.02	17.79	13.03
S_2	13.40	10.05	12.39	5.85	18.88	12.11
S_3	13.09	11.27	13.70	6.62	19.76	12.89
S_4	12.95	10.13	12.84	7.02	19.57	12.50
Mean	13.54	10.76	13.49	6.38	19.0	

C.D. (0.05) Weed control : 0.88

Table 19

Dry weight of weeds at harvest kg/ha

	W_1	W_2	W_3	W_4	W_5	Mean
S_1	296.63	248.30	308.30	137.98	383.96	274.97
S_2	319.63	220.64	312.63	117.98	388.62	271.63
S_3	323.96	263.30	297.97	153.31	385.62	284.63
S_4	307.63	218.64	288.63	133.32	376.62	264.97
Mean	311.97	237.64	301.64	135.65	383.30	

C.D. (0.05) Weed control : 16.83

the maximum value of dry weight of weeds. Among the herbicides, Machete gave the lowest value of dry weight of weeds. Gramoxone + Fernoxone and Stam F-34 were on par.

4. 60th day after sowing.

The effect due to weed control treatments alone was significant. The maximum dry weight of weeds was observed in the unweeded control. Machete gave the lowest value of dry weight of weeds while Stam F-34 was onpar with Gramoxone + Fernoxone.

5. At harvest.

The effect due to weed controlttreatments alone was found to be significant. The unweeded control plot recorded the maximum dry weight of weeds at the time of harvest. Among the herbicides, Machete applied plots gave the least value of dry weight of weeds. There was no significant difference between the Stam F-34 and Gramoxone + Fernoxone treatments.

II. Crop growth characters.

a. Height of plants.

The observation on height of plants on 30th, 45th, 60th day after sowing and at harvest were taken and analysed separately and the analysis of variance tables are given in Appendix XVIII to XXI. The mean values are presented in Tables 20 to 23.

Table 20

Height of plants on 30th day (in cm)

	W1	W2	W3	W4	W5	Mean
S1	37.6	41.96	37.26	40.24	34.66	38.34
S2	36.96	40.46	34.74	40.40	31.96	36.90
S3	32.66	36.68	31.82	35.04	29.22	33.08
S4	37.28	42.12	39.08	43.10	35.02	39.32
Mean	36.12	40.30	35.72	39.69	32.71	

C.D. (0.05) Spacing : 2.2097

C.D. (0.05) Weed control: 4.0133

Table 21

Height of plants on 45th day (in cm)

	W1	W2	W3	W4	W5	Mean
S1	42.9	48.92	42.16	47.34	37.34	43.73
S2	41.22	48.62	38.74	48.98	34.10	42.33
S3	39.22	43.90	37.60	40.62	32.26	38.72
S4	46.20	52.42	44.04	51.10	40.06	46.76
Mean	42.38	48.46	40.635	47.01	35.94	

C.D. (0.05) Spacing : 3.8624

C.D. (0.05) Weed control : 1.8594

Table 22

Height of plants on 60th day (in cm)

	W_1	W_2	W_3	W_4	W_5	Mean
S_1	50.10	54.54	48.74	52.56	55.00	52.18
S_2	49.82	57.48	47.20	54.86	41.86	50.24
S_3	45.98	54.96	44.02	48.94	39.60	46.70
S_4	53.68	60.38	53.30	57.76	48.70	54.76
Mean	49.89	56.84	48.31	53.53	46.29	

C.D. (0.05) Spacing : 2.444

C.D. (0.05) Weed control : 1.2735

Table 23

Height of plants at harvest (in cm)

	W1	W2	W3	W4	W5	Mean
S1	69.40	76.76	69.08	75.80	62.88	70.78
S2	67.92	76.24	67.14	73.24	61.66	69.24
S3	64.98	76.98	62.34	71.14	57.36	66.56
S4	69.30	74.42	68.08	76.82	65.08	70.74
Mean	67.90	76.10	66.66	74.25	61.74	

C.D. (0.05) Weed control : 6.3476

1. 30th day after sowing.

From the result it was observed that the weed control and spacing effects were significant. The interaction effect did not show any significant difference. Machete treatment recorded the maximum height (40.3 cm) which was on par with hand weeding (39.6 cm) and superior to all other treatments. Among the spacing treatments, 20 x 15 cm dibbling gave the highest value (39.32 cm) which was on par with 30 cm flow line (38.34 cm). Next higher value was observed in 45 cm flow line which was found superior to 60 cm flow line.

2. 45th day after sowing.

The effect due to weed control and spacing treatments were found to be significant. The interaction effect was not significant. Machete applied plots recorded the maximum height (48.4 cm) which was on par with hand weeded treatment (47.01 cm). Both were superior to all the other treatments. Stam F-34 and Gramoxone + Fernoxone treatments were on par.

In the case of spacing treatments 20 x 15 cm dibbling gave the maximum height (46.7 cm) followed by 30 cm flow line, 45 cm flow line and 60 cm flow line respectively.

3. 60th day after sowing.

The weed control and spacing treatments were significant on the 60th day after sowing. The interaction effect was not significant. Maximum height (56.8 cm) was observed in Machete treated plots closely followed by hand weeding (53.5 cm). Both were superior to all the other treatments.

Unweeded control gave the least value of plant height (46.2 cm).

Among the spacing treatments 20 x 15 cm dibbling recorded the maximum height (54.7 cm) and was superior to all the other treatments. The lowest value was observed in 60 cm flow line.

4. At harvest.

The effect due to weed control treatments alone was significant. Spacing and interaction effect did not show any significant difference. Among the weed control treatments, the maximum height was observed in Machete treated plots (76.1 cm) which was superior to all the other treatments except hand weeding. Hand weeded treatment recorded a height of 74.2 cm and was on par with the Machete treatment.

b. Tiller number per square metre.

The observations on the total number of tillers per square metre on 30th, 45th and 60th day after sowing were taken and analysed separately and the analysis of variance tables are given in Appendix XXII to XXIV The mean values of the number of tillers at each observation are given in Tables 24 to 26.

1. 30th day after sowing.

The effects due to different methods of weed control and spacing were found to be significant. The maximum number of tillers was observed in Machete treated plot (278.96/m^2). The unweeded control plot recorded the least number of tillers (206.55/m^2). The interaction effect did not show any significant difference.

Table 24

Number of tillers/m^2 on 30th day

	W1	W2	W3	W4	W5	Mean
S1	240.19	296.16	250.85	296.16	235.53	265.38
S2	207.84	251.14	211.30	230.35	180.12	216.15
S3	180.80	221.56	195.20	214.4	164.80	195.35
S4	285.71	346.98	295.70	290.37	245.75	292.90
Mean	228.63	278.96	240.26	257.82	206.55	

C.D. (0.05) Spacing :35.32

C.D. (0.05) Weed control :11.14

Table 25

Number of tillers/m^2 on 45th day

	W1	W2	W3	W4	W5	Mean
S1	258.85	300.83	263.52	303.16	240.20	273.31
S2	213.04	251.14	211.30	232.09	183.59	218.63
S3	182.40	224.76	198.4	216.00	166.4	197.59
S4	269.40	312.35	241.76	284.38	210.46	263.47
Mean	230.67	272.27	228.74	258.91	200.16	

C.D. (0.05) Spacing : 39.05

C.D. (0.05) Weed control : 11.34

Table 26

Number of tillers/m^2 on 60th day

	W_1	W_2	W_3	W_4	W_5	Mean
S_1	258.85	298.49	268.13	303.16	244.86	274.71
S_2	209.57	249.40	211.30	222.12	181.86	214.85
S_3	182.63	223.16	198.4	218.36	161.6	196.83
S_4	280.38	348.98	271.72	376.29	225.77	300.63
Mean	232.85	280.01	237.40	279.98	203.52	

C.D. (0.05) Spacing : 35.71

C.D. (0.05) Weed control: 12.88

Among the various spacing treatments 20 x 15 cm dibbling recorded the highest number of tillers (292.90/m^2) and was on par with 30 cm flow line. The lowest number of tillers was observed in 60 cm flow line (195.35/m^2).

2. 45th day after sowing.

The effect due to weed control and spacing treatments were significant on the 45th day after sowing. Machete treatment was found to be superior to all the other weed control treatments. Maximum number of tillers (272.27/m^2) was observed in Machete applied plots. Hand weeded plots recorded the next higher number (258.91/m^2) of tillers. The least value of the number of tillers was seen in the unweeded control plot.

Among the various spacing effects 30 cm flow line gave the maximum number of tillers (273.31/m^2) and was on par with 20 x 15 cm dibbling (263.47/m^2). The lowest number of tillers was observed in 60 cm flow line.

The interaction effect was not significant.

3. 60th day after sowing.

The spacing and weed control treatments were significant on the 60th day after sowing. The highest number of tillers was recorded in Machete treatment (280.01/m^2) and was on par with hand weeded treatment (279.98/m^2). The unweeded control plot gave the lowest value of tiller count (203.52/m^2) while Stam F-34 and Gramoxone + Fernoxone were on par.

Among the different spacing treatments 20 x 15 cm dibbling gave the maximum number of tillers (300.63/m^2). The next higher number of tillers was observed in 30 cm flow line (274.71/m^2). 45 cm flow line and 60 cm flow line were on par.

The interaction effect was not found to be significant.

III. Yield characters.

a. Productive tillers per square metre.

The analysis of variance table is presented in Appendix XXV The mean values of the number of productive tillers is given in Table 27.

From the analysis of variance table (Appendix XXV), it was found that the effect due to various methods of weed control and spacing were significant. The maximum number of productive tillers was observed in Machete treated plots (250.23/m^2) closely followed by hand weeded treatments (249.62/m^2). Gramoxone + Fernoxone was on par with Stam F-34 treatment. The unweeded control recorded the least value of productive tillers (193.7/m^2).

Among the different spacing treatments 30 cm flow line was found to be superior to all the other treatments. The highest number of productive tillers (266.40/m^2) was recorded in 30 cm flow line. The next higher number of productive tillers was observed in 20 x 15 cm dibbling. 60 cm flow line gave the lowest value of the number of productive tillers per square metre.

Table 27

Number of productive tillers/m^2 at harvest

	W_1	W_2	W_3	W_4	W_5	Mean
S_1	253.36	289.66	256.44	294.32	236.72	266.10
S_2	203.48	242.06	204.04	216.78	176.98	208.66
S_3	173.26	215.74	195.6	216.02	157.3	191.58
S_4	227.16	253.44	227.54	271.36	205.81	236.66
Mean	214.01	250.23	220.90	249.62	193.7	

C.D. (0.05) Spacing : 18.24

C.D. (0.05) Weed control : 10.88

b. Percentage of productive tillers.

The analysis of variance table corresponding to the percentage of productive tillers is presented in Appendix XXVI and mean values in Table 28.

The effect due to different methods of weed control alone was found to be significant. The highest percentage of productive tillers was observed in the hand weeded plots (61.54) and was on par with Machete treated plots (60.55). Stam F-34 treatment was on par with Gramoxone + Fernoxone treatment. The unweeded control plot recorded the lowest percentage of productive tillers (48.56). The effect due to spacing and interaction were not significant.

c. Length of paniole.

Analysis of variance table is presented in Appendix XXVII and the mean values in Table 29.

The effects due to spacing and weed control treatments were significant while the interaction effect was not significant. Among the weed control treatments Machete treated plots recorded the maximum length (20.3 cm) and was on par with hand weeded treatments. Both were superior to all the other treatments. The unweeded control plot recorded the lowest value (16.12 cm). Stam F-34 and Gramoxone + Fernoxone treatments were on par.

In the case of spacing treatments, 20 x 15 cm dibbling gave the maximum length (18.94cm). 30 cm flow line and 45 cm flow line were on par while 60 cm flow line was inferior to

Table 28

Percentage of productive tillers

(After angular transformation)

	W_1	W_2	W_3	W_4	W_5	Mean
S_1	54.78	61.81	54.49	61.42	48.10	56.12
S_2	54.48	61.47	54.98	63.28	48.03	56.44
S_3	55.3	57.28	55.54	58.35	48.73	55.04
S_4	54.10	61.65	54.17	63.11	49.38	56.48
Mean	54.66	60.55	54.79	61.54	48.56	

C.D. (0.05) Weed control : 1.03

Table 29

Length of paniole.

	W1	W2	W3	W4	W5	Mean
S1	18.68	20.54	18.36	20.42	16.34	18.86
S2	18.10	20.74	17.94	19.82	15.94	18.50
S3	16.90	19.98	16.64	19.54	14.96	17.60
S4	18.34	19.96	18.10	21.10	17.24	18.94
Mean	18.00	20.30	17.76	20.22	16.12	

C.D. (0.05) Spacing : 0.3139

C.D.(0.05) Weed control : 0.8416

all the other treatments.

d. Number of filled grains per panicle.

The analysis of variance table on the number of filled grains per panicle is presented in Appendix XXVand the mean values in Table 30.

The effect due to weed control treatments alone was significant. The spacing and interaction effects did not show any significant difference. Hand weeded treatment recorded the maximum value (71.19) and was on par with Machete treatment (68.29). Both were superior to all the other treatments. The unweeded control gave the least number of filled grains per panicle (29.33).

e. 1000 grain weight.

The analysis of variance table for 1000 grain weight is presented in Appendix XXIXand mean values in Table 31.

The effect due to various methods of weed control alone was significant. The interaction and spacing effect did not show any significant difference. Maximum weight was observed in Machete treatment (23.75 gms) which was on par with hand weeding (23.70 gms). The least value of 1000 grain weight was observed in the unweeded control (22.5 gms).

f. Grain yield.

Analysis of variance table for the grain yield is presented in Appendix XXXand the mean values in Table 32.

Table 30

Number of filled grains per panicle.

	W1	W2	W3	W4	W5	Mean
S1	54.76	69.76	53.94	74.40	28.46	56.26
S2	54.24	68.24	45.70	65.68	29.48	52.66
S3	46.14	65.58	37.24	66.12	25.26	48.06
S4	56.14	69.60	51.60	78.56	34.12	58.00
Mean	52.82	68.29	47.12	71.19	29.33	

C.D. (0.05) Weed control : 5.8226.

Table 31

Thousand grain weight (gms)

	W_1	W_2	W_3	W_4	W_5	Mean
S_1	22.8	23.70	22.90	23.62	22.56	23.11
S_2	23.02	23.78	22.94	23.68	22.46	23.17
S_3	22.82	23.74	22.96	23.68	22.52	23.14
S_4	23.12	23.78	23.24	23.82	22.46	23.28
Mean	22.94	23.75	23.01	23.70	22.50	

C.D. (0.05) Weed control : 0.1694

Table 32

Grain yield kg/ha

	W1	W2	W3	W4	W5	Mean
S1	870 (29.03)	2110 (45.13)	1010 (31.44)	3200 (55.81)	380 (18.99)	1514 (36.08)
S2	750 (27.24)	2250 (46.16)	980 (31.09)	2870 (53.23)	270 (15.71)	1424 (34.69)
S3	730 (26.78)	1800 (42.14)	750 (26.71)	2030 (44.75)	430 (19.89)	1144 (32.05)
S4	1340 (35.32)	1640 (39.53)	1330 (35.92)	3100 (55.57)	360 (18.08)	1554 (36.88)
Mean	922.5 (29.59)	1950 (43.24)	1012.5 (31.29)	2800 (52.34)	360 (18.17)	

C.D. (0.05) Weed control : 2.98
(for transformed data)

Note : Transformed data in brackets

The effect due to various weed control treatments alone was significant. Maximum grain yield was recorded in hand weeded plots (2800 kg/ha). The next higher value of grain yield was observed in Machete treatment (1950 kg/ha). Gramoxone + Fernoxone was found to be superior to stam F-34.

g. Straw yield.

The analysis of variance table for the yield of straw is presented in Appendix XXXI and the mean values in Table 33.

The effects due to various methods of weed control and spacing were found to be significant. The maximum straw yield was recorded in hand weeded plots (3103.5 kg/ha). The next higher value of straw yield was observed in Machete treated plots (1971 kg/ha). Stam F-34 was superior to Gramoxone + Fernoxone treatment. The least value of straw yield was found in the unweeded control plot (1028.25 kg/ha).

Among the spacing treatments 20 x 15 cm dibbling gave the maximum yield of straw. The next higher value of straw yield was observed in 30 cm flow line while the lowest yield of straw was recorded in 60 cm flow line. The interaction effect did not show any significant difference.

IV. Chemical analysis.

a. Nitrogen uptake by weeds.

The analysis of variance table corresponding to the uptake of nitrogen at the 40th day after sowing is presented in Appendix XXXII and mean values inTTable 34.

Table 33

Straw yield kg/ha

	W1	W2	W3	W4	W5	Mean
S1	1086 (3.43)	2022 (3.77)	921 (3.31)	3786 (4.10)	1071 (3.52)	1777.2 (3.63)
S2	1062 (3.49)	1902 (3.77)	1035 (3.49)	2955 (3.97)	918 (3.45)	1574.4 (3.63)
S3	1062 (3.46)	1629 (3.70)	699 (3.34)	1554 (3.70)	624 (3.23)	1113.6 (3.49)
S4	2044.8 (3.64)	2331 (3.78)	1851 (3.69)	4119 (4.13)	1500 (3.46)	2369.16 (3.74)
Mean	1313.7 (3.51)	1971 (3.76)	1126.5 (3.46)	3103.5 (3.98)	1028.25 (3.42)	

+ C.D. (0.05) Spacing : 0.160

+ C.D. (0.05) Weed control : 0.194

+ For transformed data

Note : Transformed data in brackets

Table 34

Nitrogen uptake by weeds kg/ha

	W_1	W_2	W_3	W_4	W_5	Mean
S_1	13.02	6.30	13.86	3.70	36.50	14.68
S_2	11.36	3.56	8.84	2.18	27.44	10.68
S_3	10.62	4.62	11.32	2.54	37.24	13.27
S_4	8.80	4.42	8.04	1.90	32.62	11.16
Mean	10.95	4.73	10.52	2.58	33.45	

C.D. (0.05) Weed control : 3.32

The effect due to different weed control treatments alone was found to be significant. Control plot recorded the maximum uptake of nitrogen (33.45 kg/ha). Hand weeded plot recorded the lowest value for uptake of nitrogen (2.58 kg/ha). The next lower value for the uptake of nitrogen was observed in Machete treated plots (4.73 kg/ha). Gramoxone + Fernoxone was on par with Stam F-34 treatment.

b. Phosphorus uptake of weeds.

The analysis of variance table corresponding to the uptake of phosphorus on the 40th day after sowing is given in Appendix XXX and mean values in Table 35.

The effect due to various weed control methods and spacing were significant. The interaction effect did not show any significant difference. The unweeded control plot recorded the maximum uptake of phosphorus (5.13 kg/ha). The lowest value for the phosphorus uptake was observed in hand weed plot (0.19 kg/ha) and was on par with Machete treatment (0.42 kg/ha).

Among the spacing treatments the lowest value for the uptake of phosphorus was observed in 20 x 15 cm flow line (1.92 kg/ha) and was on par with 45 cm flow line. 60 cm flow line and 30 cm flow line were on par with regard to the uptake of phosphorus.

c. Potassium uptake of weeds.

The analysis of variance table corresponding to the uptake of potassium on 40th day after sowing is presented in Appendix XXXV and mean values in Table 36.

Table 35

Phosphorus uptake by weeds kg/ha

	W_1	W_2	W_3	W_4	W_5	Mean
S_1	2.26	0.70	2.58	0.32	7.42	2.66
S_2	2.16	0.44	1.66	0.22	5.36	1.97
S_3	2.22	0.58	1.98	0.22	6.96	2.39
S_4	1.54	0.38	1.56	0.18	5.92	1.92
Mean	2.05	0.42	1.56	0.19	5.13	

C.D. (0.05) Spacing : 0.52

C.D. (0.05) Weed control : 0.58

Table 36

Potassium uptake by weeds kg/ha

	W_1	W_2	W_3	W_4	W_5	Mean
S_1	3.0	1.42	3.12	0.28	9.99	3.38
S_2	2.7	0.80	2.00	0.34	6.76	2.52
S_3	2.6	1.06	0.40	0.26	10.16	2.90
S_4	2.08	0.78	0.31	0.28	7.9	2.27
Mean	2.60	0.81	1.46	0.29	8.48	

C.D. (0.05) Weed control : 1.04

From the analysis of variance table (Appendix XXXIV), it was found that the maximum uptake of potassium is in the unweeded control plot (8.48 kg/ha). Hand weeded treatment recorded the least value for the uptake of potassium (0.29 kg/ha) and onwas on par with Machete treatment (0.81 kg/ha). The next lower value for the phosphorus uptake was given by Gramoxone + Pernoxone, followed by Stam F-34.

d. Nitrogen content of crop plants.

The nitrogen content of plants on 40th day after sowing was analysed and the analysis of variance table is presented in Appendix XXXV and mean values in Table 37.

The effect due to weed control and spacing were found to be significant while the interaction effect did not show any significant difference. Machete treatment gave the maximum nitrogen content in plants on 40th day (0.92%) and was closely followed by hand weeded treatment (0.89%). The lowest value of nitrogen content was observed in the unweeded control.

Among the spacing treatments 20 x 15 cm dibbling gave the highest value of nitrogen content (0.82%). 60 cm flow line reported the minimum nitrogen content (0.79%) in plants on 40th day after sowing.

e. Phosphorus content of crop plants.

The phosphorus content of plants on 40th day after sowing was analysed and the analysis of variance table is given in Appendix XXXVI and the mean values in Table 38.

Table 37

Nitrogen content of plants on 40th day

	W1	W2	W3	W4	W5	Mean
S1	0.8284	0.913	0.7596	0.8786	0.6136	0.7986
S2	0.7946	0.9448	0.7912	0.891	0.6170	0.8077
S3	0.7912	0.9146	0.7748	0.8782	0.5978	0.7913
S4	0.8494	0.9122	0.7854	0.9230	0.6406	0.8221
Mean	0.8159	0.9211	0.7777	0.8927	0.6172	

C.D. (0.05) Spacing : 0.02142

C.D. (0.05) Weed control: 0.02438

Table 38

Phosphorus content of plants on 40th day after sowing.

	W1	W2	W3	W4	W5	Mean
S1	0.3828	0.4350	0.3572	0.4274	0.3152	0.3835
S_2	0.3868	0.4454	0.3758	0.4089	0.2900	0.3814
S_3	0.3630	0.4326	0.3659	0.4292	0.3161	0.3814
S_4	0.3659	0.4593	0.3803	0.4274	0.2804	0.3827
Mean	0.3746	0.4431	0.3698	0.4232	0.3004	

C.D. (0.05) Weed control : 0.0224

The effect due to various weed control treatments alone was significant. Machete treated plots recorded the maximum phosphorus content (0.44%). Next higher value was given by the hand weeded treatment (0.42%). The unweeded control plot recorded the lowest phosphorus content (0.30%) in plants on 40th day after sowing.

f. Potassium content of crop plants.

The potassium content of plants on 40th day after sowing was analysed and the analysis of variance table is given in Appendix XXVII and the mean values in Table 39.

The analysis of variance table (Appendix XXVII) shows that the effect due to weed control treatments alone was significant. The unweeded control recorded the lowest potassium content (0.189%) Machete treated plots gave the maximum value of potassium content (0.235%) and was on par with hand weeded treatment. Gramoxone + Fernoxone was on par with Stam F34.

g. Protein content of grains.

The analysis of variance table is presented in Appendix XXVIII and the mean values in Table 40.

The effect due to weed control treatments alone was significant. Machete applied plots recorded the highest value of protein content (8.89%) and was on with hand weeded treatment (8.85%). Stam F-34 and Gramoxone + Fernoxone treatments were

Table 39

Potassium content of plants on 40th day.

	W_1	W_2	W_3	W_4	W_5	Mean
S_1	0.208	0.228	0.208	0.232	0.188	0.212
S_2	0.208	0.248	0.208	0.228	0.192	0.216
S_3	0.204	0.232	0.208	0.228	0.192	0.212
S_4	0.204	0.232	0.208	0.232	0.184	0.212
Mean	0.206	0.235	0.208	0.230	0.189	

C.D. (0.05) Weed control: 0.0076

Table 40

Protein content of grains(%)

	W_1	W_2	W_3	W_4	W_5	Mean
S_1	8.42	8.85	8.39	8.78	7.69	8.42
S_2	8.36	8.99	8.36	8.92	7.25	8.37
S_3	8.32	8.94	8.32	8.96	7.52	8.41
S_4	8.29	8.79	8.36	8.74	7.45	8.32
Mean	8.35	8.89	8.36	8.65	7.47	

C.D. (0.05) Spacing: 0.1394

on par. The unweeded control recorded the minimum protein content in grains.

V. Economics.

The economics of weed control treatments calculated at the prevailing market rates are shown in Table 41.

The net returns from the additional produce over unweeded control was estimated and it was found that Machete recorded the highest net profit/ha of Rs 1757.50

Table 41

Grain yield and economics of weed control

Sl. No.	Treatments	Grain yield (kg/ha)	Increase in yield over unweeded control (kg/ha)	Cost of herbicides plus application charges (₹/ha)	Price of increased yield (₹/ha)	Net profit (₹/ha)
1.	Stam F-34	924	564	225.00	705.00	480.00
2.	Machete	1950	1590	230.00	1987.50	1757.50
3.	Gramoxone + Fernoxone	1015	655	275.00	818.75	543.75
4.	Hand weeding	2800	2440	1500.00	3050.00	1550.00
5.	Control	360				

DISCUSSION

DISCUSSION

An experiment was conducted in the Rice Research Station and Instructional Farm, Mannuthy during the first crop season of 1978 to study the performance of a rice variety 'Aswathy' under different methods of sowing and weed control. The results of the observations made in the investigations are discussed below.

I. Observation on weed.

A. Weed species.

Observation on weed species revealed that grasses, sedges and broad leaved weeds competed with crop plants. The most serious weeds of rice in Mannuthy were species of Echinochloa and Cyperus. Apart from these some grasses such as Cynodon dactylon, Eragrostis sp., Eleucine indica, Panicum sp., Setaria sp. etc. were found to be important. Among the broad leaved weeds, some of the dry and garden land weeds such as Phyllanthus debilis, Cleome viscosa, Oldenlandia sp., Sida sp. were also present. This is probably due to the dry conditions prevailing in the field for more than a month; which might have encouraged the emergence and growth of these weeds. Sahadevan (1966) reported the presence of dicot weeds in uplands paddy fields of Kerala.

B. Weed count.

a. Total weed population per square metre.

The total weed count data recorded on 30th, 40th, 50th and 60th day after sowing showed significant variation due

to different methods of weed control and spacing. Total weed population at all the stages revealed that unweeded control plot had significantly higher number of weeds than the weed control treatments. As weeding operations were not conducted in the control plots, total weed population in them recorded the maximum at all stages.

All the herbicidal weed control treatments recorded the lowest values for total weed population and it followed the same trend till harvest. This reveals that all the herbicides are efficient in controlling the weed growth upto the time of harvest. Similar results have been reported by many workers. Mohammed Ali and Sankaran (1975) revealed that control plot had higher number of weeds (156-231/m^2) than the weed control treatments. Mandal (1977) revealed that pre-emergence application of Butachlor at 3.6 kg/ha controlled all annual grasses, sedges and broad leaved weeds throughout the crop period in dry land rice. Singh and Chauhan (1977) showed that the weeds in upland paddy could be effectively controlled with the application of propanil at 1.4 kg/ha + one hand weeding as compared to control. According to Singh and Rao (1977) a combined spray of Gramoxone + Fernoxone was very efficient in controlling aquatic weeds.

Among the herbicidal treatments, Machete gave the lowest weed population. This shows that Machete is more efficient in controlling weeds in direct sown paddy under semi dry condition than the other herbicides. Effectiveness of Machete in giving

good control of weeds have also been reported by Balu and Sankaran (1977), Durey and Rao (1977), Kakat and Mani (1977) and Balu et al. (1978).

There was no significant difference between Stam F-34 and Gramoxone + Fernoxone treatment. The effectiveness of Stam F-34 in controlling rice land weeds was observed by Nair et al. (1964), Sajo (1965) and Sahu and Jena (1968). The efficiency of controlling weeds by a combined spray of Gramoxone + Fernoxone was also reported by Singh Chandra and Rao (1977), Singh et al. (1977) and Singh and Gupta (1978).

Though the weed population in herbicidal treatments was low, the weed control efficiency was not high. This was due to the lack of sufficient water for flooding after the application of herbicides to prevent new sprouts of weeds. However, the herbicide treated plots recorded less number of total weeds than the hand weeded and unweeded control plots. At all stages the hand weeded plots recorded the next lower number of total weeds than the control plots. Hand weeding being a mechanical method, could not prevent the sprouting of new weed seeds.

From the observations, there was significant difference between spacing treatments as well. At all stages highest value for weed population was obtained in 60 cm flow line. This was because of the increased space in between crops, which facilitated better growth of weeds with little competition for light and nutrients.

b. Monocot weed population

Monocot weed population recorded the maximum in the unweeded control plots at all the stages of observations. Next

higher value was obtained in the hand weeded plots and the least value for Machete treated plots. This shows that the pre-emergence application of Machete is best in controlling weeds in direct sown rice. This was because of the adequate showers received immediately after the pre-emergent application of Machete which enabled the good spread of the chemical in the soil and thereby control the weeds at the seed stage itself. The presowing and post emergent treatments did not show any significant difference. But both suppressed the weeds better compared to plots which received hand weeded and unweeded treatments.

Of the different spacing treatments 60 cm flow line gave the highest value.

c. Dicot weed population.

At all stages of observations control plot recorded the maximum value for dicot weed population. The next higher number was observed in hand weeded plots. The herbicidal treatments gave lower values for dicot weed population. Although Machete treated plots recorded the least value for dicot weed population the numbers were significantly higher than the corresponding values of monocot weed population. This shows that it is more efficient in controlling monocot weeds than dicot weeds. This was in agreement with the findings of Gill et al. (1977).

Regarding the control of monocot weeds Stam F-34 was on par with Gramoxone + Fernoxone treatment. Gramoxone + Fernoxone is more effective in controlling broad leaved weeds. Similar

results have been reported by Chandra Singh and Rao (1977), and Singh and Gupta (1978).

Among the spacing effects, 45 cm was the best spacing in flow line method of sowing under semi dry conditions. This may probably be due to lack of adequate space for the weeds for their survival. Space is one of the important factors for which weeds compete with crop plants. Hidayathullah et al. (1942) observed that weeds take up space that should have been occupied by crop plants and thus reduce the yield of the latter, by depriving them of nutrients, moisture and light. If more space is available more will be the weed growth.

d. Weed control efficiency.

From the observations the weed control efficiency was not appreciable in all the weed control treatments. This was due to the inadequate water supply at the time of requirement. However, Machete recorded the highest weed control efficiency followed by Gramoxone + Fernoxone and Stam F-34. This reveals the efficiency of herbicides in suppressing the weeds. Hand weeded plot recorded the lowest weed control efficiency which showed the presence of higher weed population next to control plot. Even after hand weeding there were quick establishment of weeds and they continued to be present upto harvest. Hand weeding could not prevent the germination of weed seeds remaining in the soil and moreover, during weeding operations, the soil was disturbed which helped the buried seeds to come up to the surface and germinate.

c. Dry weight of weeds.

Dry weight of weeds was highest in unweeded control plots at all stages of observations and was significantly superior to all other weed control treatments. Unchecked weed growth during the crop period was responsible for the increased dry weight of weeds in the control plots. The weed exploited all the benefits provided for the crop plants resulting in more dry matter production. The least value for mean dry weight was recorded in the hand weeded plots closely followed by Machete treated plots. This was because at the observation time, the weeds in the hand weeded plots though in large numbers, were at very young or seedling stage. At the same time the weeds in the herbicidal treatments (even in less numbers) were at a more mature stage and in the mean time they have added much dry weight. The dry weight of weeds in Stam F-34 treatment did not show any significant difference with the Gramoxone + Fernoxone treatment. (See figure. 3)

In the case of spacing effects 60 cm flow line showed higher value for the dry weight of weeds. This was definitely due to the availability of larger space between the crop rows.

II. Crop growth characters.

a. Height of plants.

At all stages of observations Machete treatment gave the maximum height. This was due to the controlled weed growth resulting in reduced competition for food and other benefits meant for crop plant. There was no significant difference between Machete treatment and hand weeding. The two hand weedings

carried out in the hand weeded treatment gave a good check of the weeds and thereby the competition for nutrients and other factors were minimised. The height of plants in Stam F-34 and Gramoxone + Fernoxone treatments were on par.

At harvest, the hand weeded treatment was on par with Machete treatment. The results also show that weed competition leads to the reduction in height of rice in the unweeded control. This is in agreement with the findings of Smith and Shaw (1966). It can therefore be inferred that, efficient weed control can result in increased plant height in rice crop irrespective of the method of control adopted. Similar results were reported by Mukhopadhyay (1967) in rice and George et al. (1967) in sorghum.

Regarding the spacing effects 20 x 15 cm dibbling gave the maximum height. In them the competition for nutrient absorption per plant being low, nutrient absorption per plant might have been in excess of the quantity required for the development of earheads. This might have been utilised for the vegetative growth of plants resulting in the height increase in the later stages. In the case of flow line methods, the plants in the same line were not adequately spaced. According to Tanaka (1964) increase in height is related to the receipt of radient energy. Since the plants are grown closely in the flow lines, sun light can not reach the base of the plants, which leads to acceleration of internodal elongation in the early stages.

b. Tiller number.

Irrespective of the stage of observation tiller number was maximum in the hand weeded plots. This was due to the reduced crop-weed competition for nutrients and other factors. Because of two hand weedings given, the weeds were prevented from adding weight. As the first hand weeding was carried on the 30th day the rice plants were freed from competition. First 45 days are considered as the weed free days for rice crop and afterwards even if weed growth is more, it will not affect the crop to a great extent. The next higher number was observed in Machete treated plots. This was because of the effective control of weeds during the weed free period. There was no significant difference between Stam F-34 and Gramoxone + Fernoxone treatment.

The observations on tiller count show that weed competition reduces tillering of the crop in the unweeded control plots. Similar results of reduction in tillering due to weed competition were recorded by Smith and Shaw (1968) in rice and Santalemen (1963) in wheat.

Among the different spacing treatments 20 x 15 cm dibbling was found to be superior to all the flow line methods. This is because in flow lines the crop plants were over crowded and the competition for nutrients and other factors was more.

III. Yield characters.

a. Productive tillers/square metre.

Productive tillers per square metre were significantly influenced by the various weed control and spacing treatments. Machete treated plots recorded the maximum number of productive

tillers (250.23/m^2) and was on par with hand weeded treatments (249.62/m^2) showing the effectiveness of these treatments in controlling weeds. The unweeded control recorded the lowest number. It may probably be due to the crop-weed competition for space and nutrients. Similar observations in the reduction of productive tillers in crop plants have been reported by Santalmen (1963). Of the various spacing effects 30 cm flow line and 20 x 15 cm dibbling were on par with regard to the number of productive tillers.

b. Percentage of productive tillers.

Percentage of productive tillers was also influenced by weed control treatments. Highest percentage of productive tillers was recorded in hand weeded (twice) plots (61.54) which was on par with Machete treatment (60.55). Higher nutrient uptake as a result of reduced weed growth might have contributed to higher percentage of productive tillers. The unweeded control plot gave the lowest percentage of productive tillers of 45.56 where weed infestation was maximum. Higher consumption of nutrients by weed and keen competition for other factors deprived the plants of their nutrients resulting in the lowest percentage of productive tillers in the control plot. Santaleman (1963) had reported similar observations of reduction in the percentage of productive tillers in crop plants under heavy weed infestation.

c. Length of paniole.

The Machete treatment gave the maximum length for paniole. This was due to the reduced weed growth and competition in the

plots. Regarding the spacing treatments 20 x 15 cm dibbling was found to be superior to all the other treatments. It can be seen that the above two treatments had least weed population. Weed infestation significantly reduces the length of panicle. The reduction in length of panicle can be attributed to the crop weed competition as reported by Blackman et al. (1938).

d. Number of filled grains per panicle.

The number of filled grains per panicle was significantly influenced by weed control treatments. Hand weeded plot gave the maximum number of filled grains per panicle (71.19) and was on par with Machete treatment (68.29). This may be due to the increased availability of nutrients because of less total competition due to the lower number of weeds. The highest weed population in the unweeded control plot reduced the nutrient uptake resulting in the lesser number of filled grains per panicle.

e. Thousand grain weight.

The different weed control treatments influenced the thousand grain weight. The maximum thousand grain weight was observed in Machete applied plots and was on par with the hand weeded treatment. The increased uptake of nutrients due to the less degree of weed competition may be the reason for the increase in thousand grain weight. There was no significant difference between all the other treatments.

f. Grain yield.

The grain yield was significantly influenced by various

weed control treatments. The maximum grain yield was obtained in hand weeded plots compared to all the other treatments. This increase in yield has resulted from better conditions for the production of maximum percentage of productive tillers, longer panicles and increased number of filled grains per panicle, obtained under this treatment. This is in agreement with the findings recorded at International Rice Research Institute (Anon, 1967).

Machete gave the next higher value for grain yield and was significantly superior to all the other treatments. The effectiveness of Machete in controlling weeds and giving good yields was reported earlier by Durey and Rao (1977).

Gramoxone + Fernoxone was found to be equally efficient as Stam F-34 in controlling weeds and giving good yields and were superior to control. The effectiveness of both the herbicides was reported earlier by several investigators.

The control plot recorded the lowest grain yield. It is evident that weed competition led to reduction in growth and yield attributes of the crop. The low grain yield in the unweeded control plots is the resultant of the sum total of reduction in plant vigour, tillering, percentage of productive tillers, length of panicle, and number of filled grains per panicle, due to crop weed competition for moisture, nutrients, light and space. [Figure - 7]

g. Straw yield.

The effect due to herbicides was significant in increasing straw yield also. Hand weeded (twice) plot recorded the highest straw yield as in the case of grain yield. Machete gave the

next highest straw yield while Gramoxone + Fernoxone was inferior with Stam F-34. But all these were found to be significantly superior to the unweeded control. The increased straw yield in the weed control treatments may be due to higher plant height and more nutrient absorption by plants as a result of the weed control effects of these treatments and consequent reduction in competition for space, nutrients and particularly moisture, especially in a dry sown crop like this. [See Fig. 8]

Among the spacing treatments highest straw yield was obtained in 20 x 15 cm dibbling, while the lowest straw yield was recorded in 60 cm flow line. This may be due to the largest weed population and competition in 60 cm flow line treatment.

IV. Chemical analysis.

a. Nitrogen uptake by weeds.

The results showed that the nitrogen uptake of weeds on 40th day after sowing was significantly influenced by the different weed control treatments. The nitrogen uptake in the unweeded control plot was the maximum compared to all the other treatments. This showed that the nutrient requirement for the crop had been continously reduced by weeds in the control plot which adversely affected the yield. The nitrogen uptake by weeds in the weed control treatments were low compared to the control. Weed control treatments provided opportunity for higher nitrogen uptake by crop, when compared to control plot by reducing the population and dry weight of weeds. This resulted in the enhancement of grain yield. This is in agreement with the findings of Boerema (1963)and Mani (1975). The lowest value of nitrogen

uptake was observed in hand weeded plots which was due to the lowest dry weight of weeds. [See Figure - 4]

b. Phosphorus uptake by weeds.

Phosphorus uptake was also influenced significantly by the weed control and spacing treatments. Maximum uptake of phosphorus was recorded in the control plots and the minimum uptake in the hand weeded plots. This was due to the fact that the control plots gave the maximum dry weight of weeds while the hand weeded plots gave the minimum dry weight. The next lower value was observed in Machete treatment as it had recorded the next lower value of dry weight of weeds, to the hand weeded treatment. Among the spacing treatments the minimum phosphorus uptake was observed in 20 x 15 cm dibbling. [See Fig 5]

c. Potassium uptake by weeds.

Potassium uptake by weeds was also influenced by weed control treatments. As in the case of nitrogen and phosphorus, the highest value of potassium uptake was also registered in the unweeded control where as the minimum value was in the hand weeded plots. Of the different herbicides tested, Machete recorded the lowest value for the potassium uptake on 40th day. [See Fig. 6]

d. Nitrogen content of crop.

Nitrogen content of plants was significantly influenced by weed control and spacing treatments. Highest nitrogen content was observed in Machete treated plots and was followed by hand weeded treatment. The efficiency of Machete in controlling weeds and thus reducing the competition for nutrients may be the reason for the increased nitrogen content of plants in

Machete treatment. The unweeded control plots recorded the minimum nitrogen content in plants compared to all the weed control treatments. Weed control treatments provided opportunity for higher nitrogen uptake by crop when compared to the control by reducing the population and dry weight of weeds. This resulted in the enhancement of grain yield. This is in agreement with the findings of Boerema (1963) and Mani (1975).

e. Phosphorus content of crop.

Weed control treatments significantly influenced the phosphorus content of plants. The highest value of phosphorus content was seen in Machete treatments followed by the hand weeded treatments. The lower weed population in them resulting in the reduction of the extent of crop weed competition may be the reason for this. The plants in the unweeded control plots recorded the lowest phosphorus content probably because of their large sharing of nutrients with the weeds.

f. Potassium content of crop.

Potassium content of crop was also significantly influenced by the various weed control treatments. As in the case of nitrogen and phosphorus, potassium content was maximum in the Machete treated plots and the minimum in the unweeded control plots.

g. Protein content of grains.

The weed control treatments influenced the protein content of grains significantly. The highest value was observed in Machete treatment and it was on par with the hand weeded treatment. The higher value of protein content observed in them was

due to the increased uptake of nitrogen by crop, especially in the later stages of plant growth. The lowest value of protein content of grains was seen in control. Datta (1972) revealed that weed control was one of the major sources of variation in protein content. According to Paul et al. (1976) igran at a concentration of 250 g/ha raised the protein content to 8.21 per cent whereas the control plot contained only 6.82 per cent.

V. Economics of weed control.

From the Table 41, it was found that Machete gave the highest net profit compared to the unweeded control. Higher grain yield over control is the reason for higher net profit. In hand weeding even though the grain yield was maximum, the cost of labour was very high due to severe weed infestation which consequently brought down the net profit to Rs.1550.00

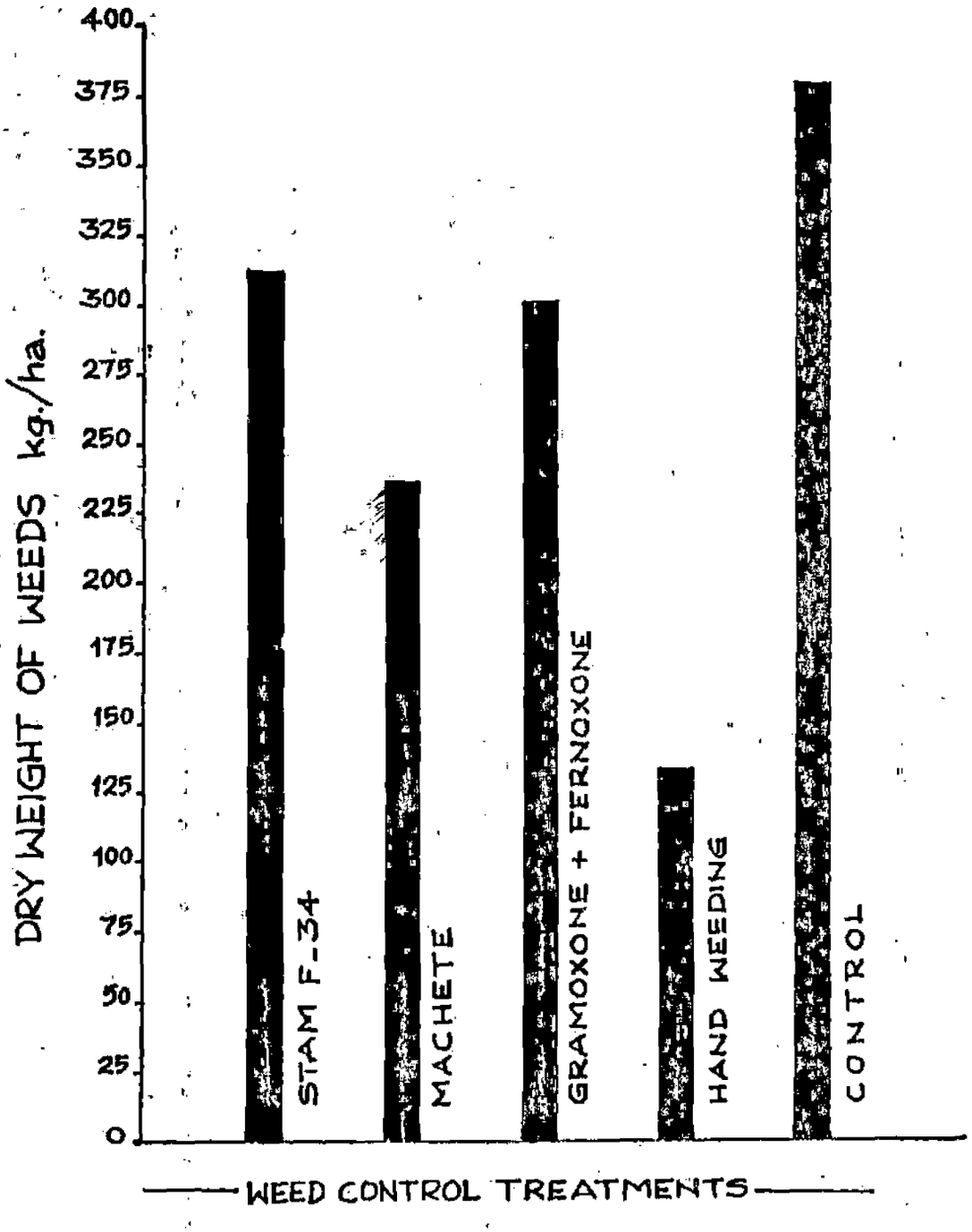


Fig-3. EFFECT OF WEED CONTROL TREATMENTS ON DRYWEIGHT OF WEEDS AT HARVEST

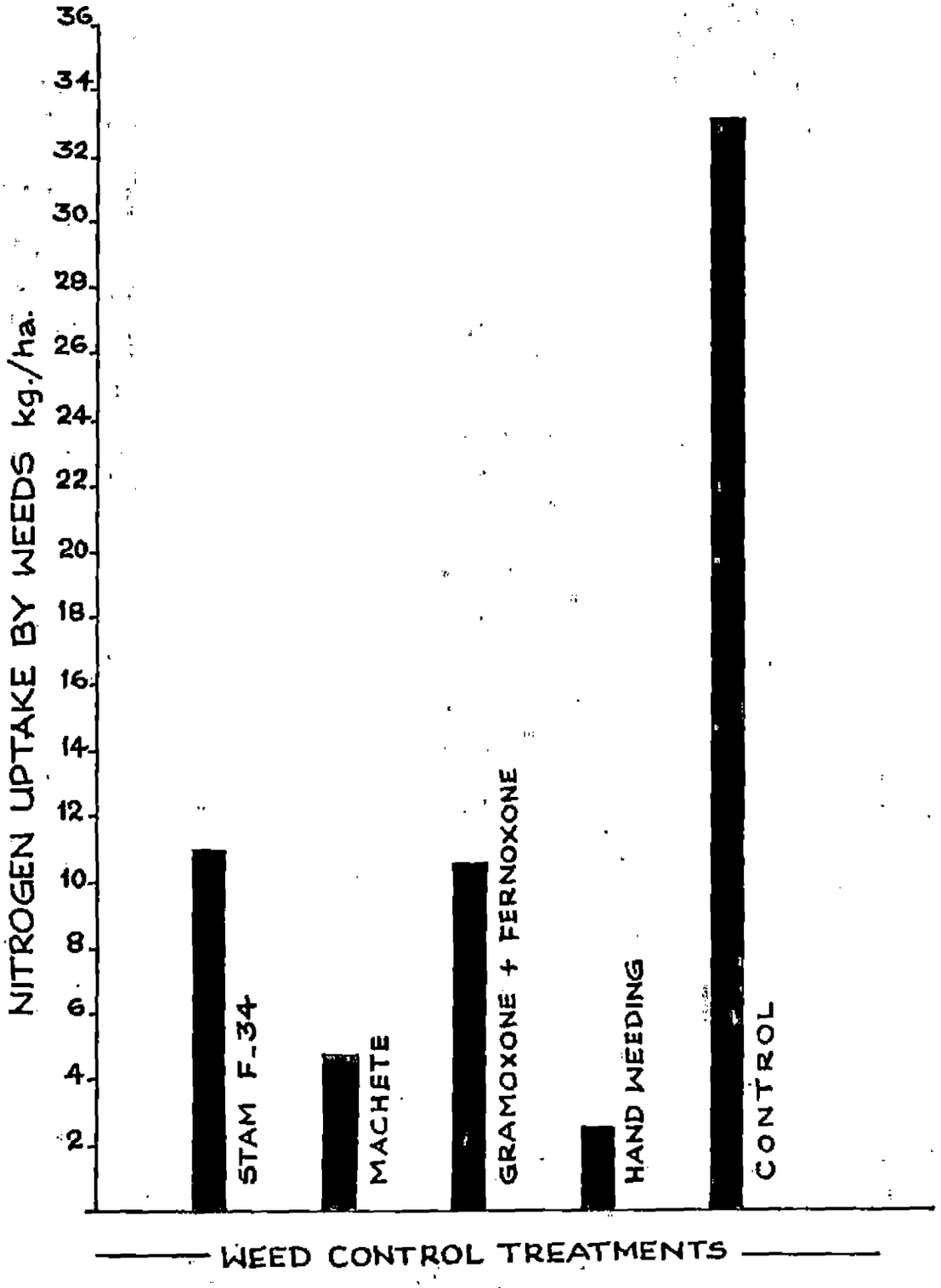


Fig-4. EFFECT OF WEED CONTROL TREATMENTS ON NITROGEN UPTAKE BY WEEDS

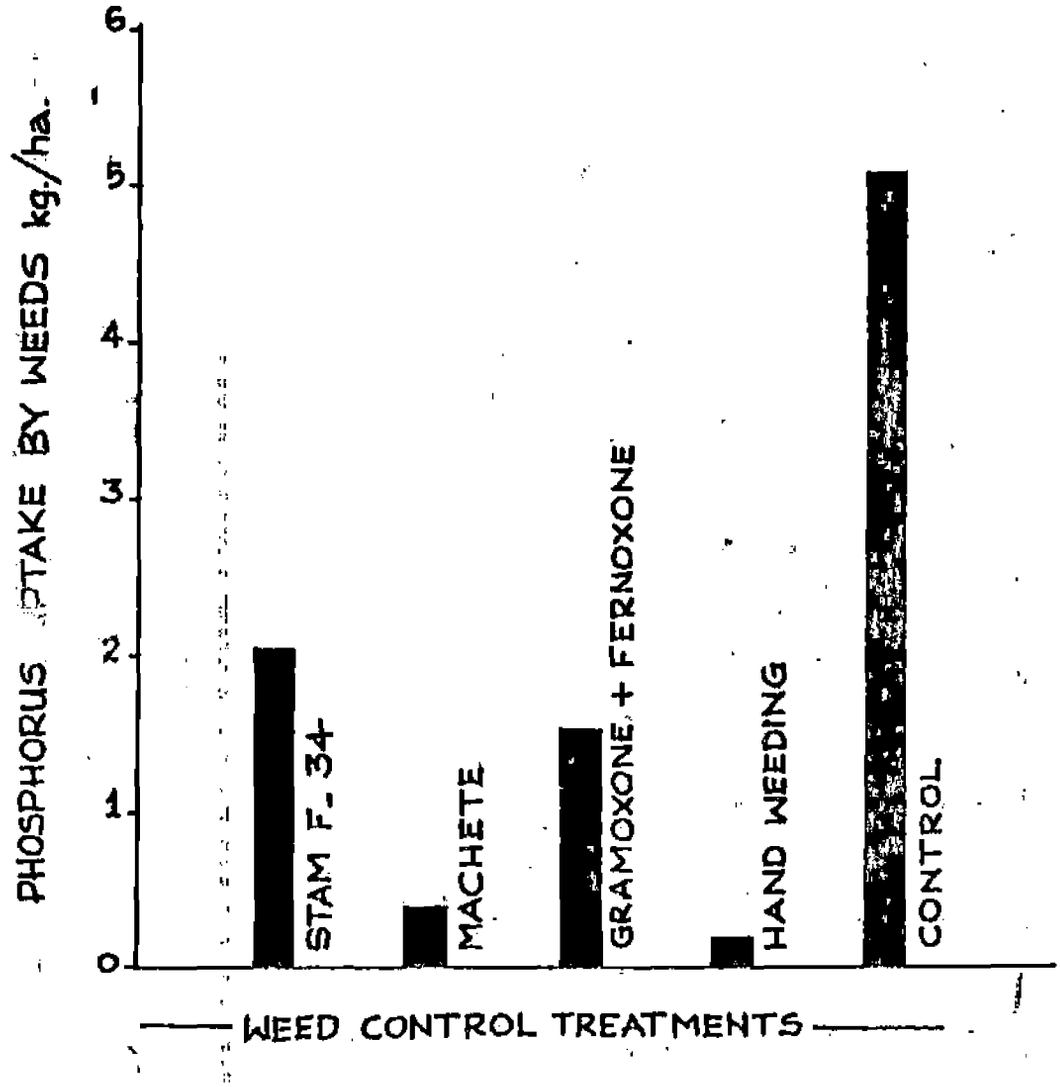


Fig-5. EFFECT OF WEED CONTROL TREATMENTS ON PHOSPHORUS UPTAKE BY WEEDS

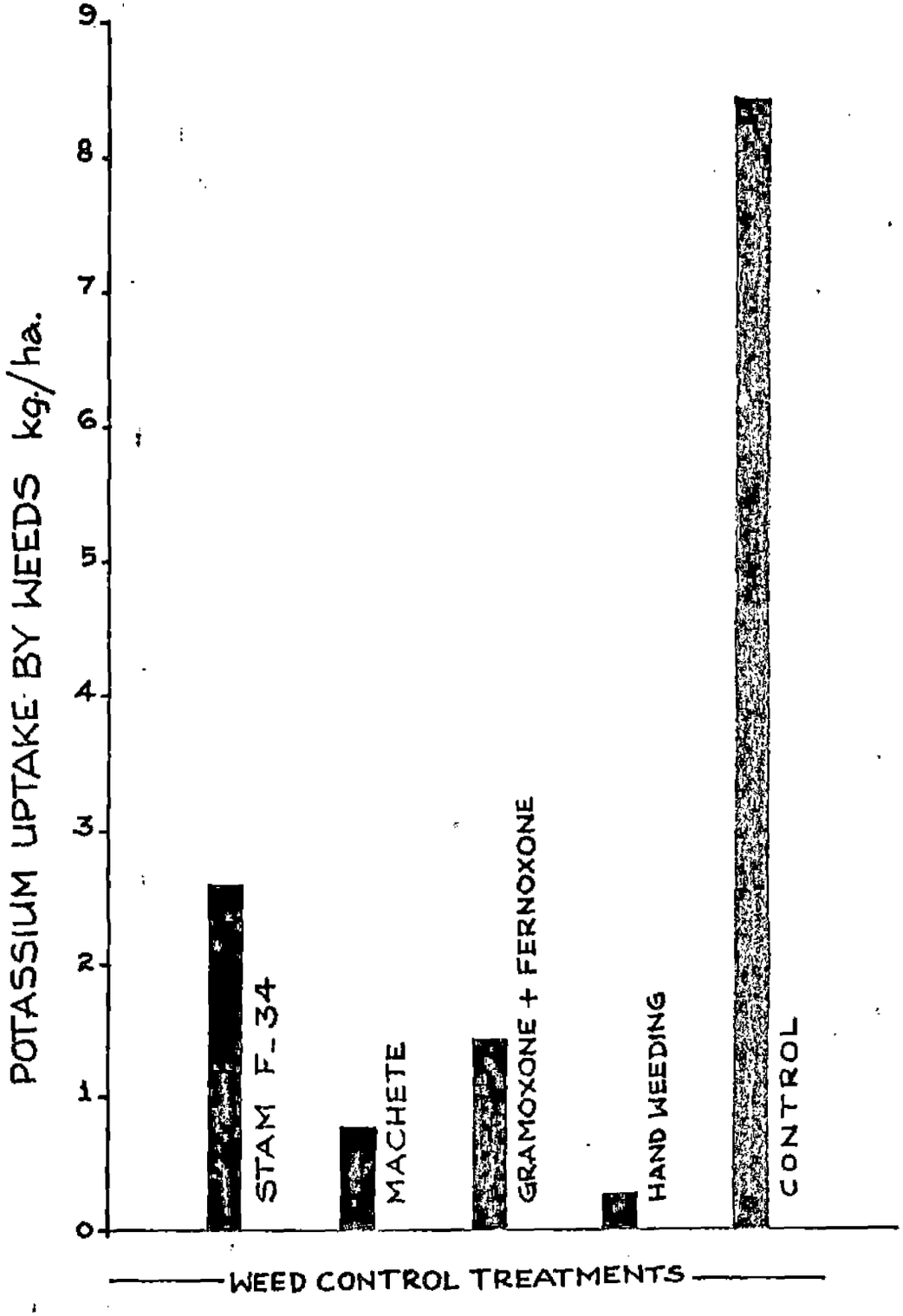


Fig-6. EFFECT OF WEED CONTROL TREATMENTS ON POTASSIUM UPTAKE BY WEEDS

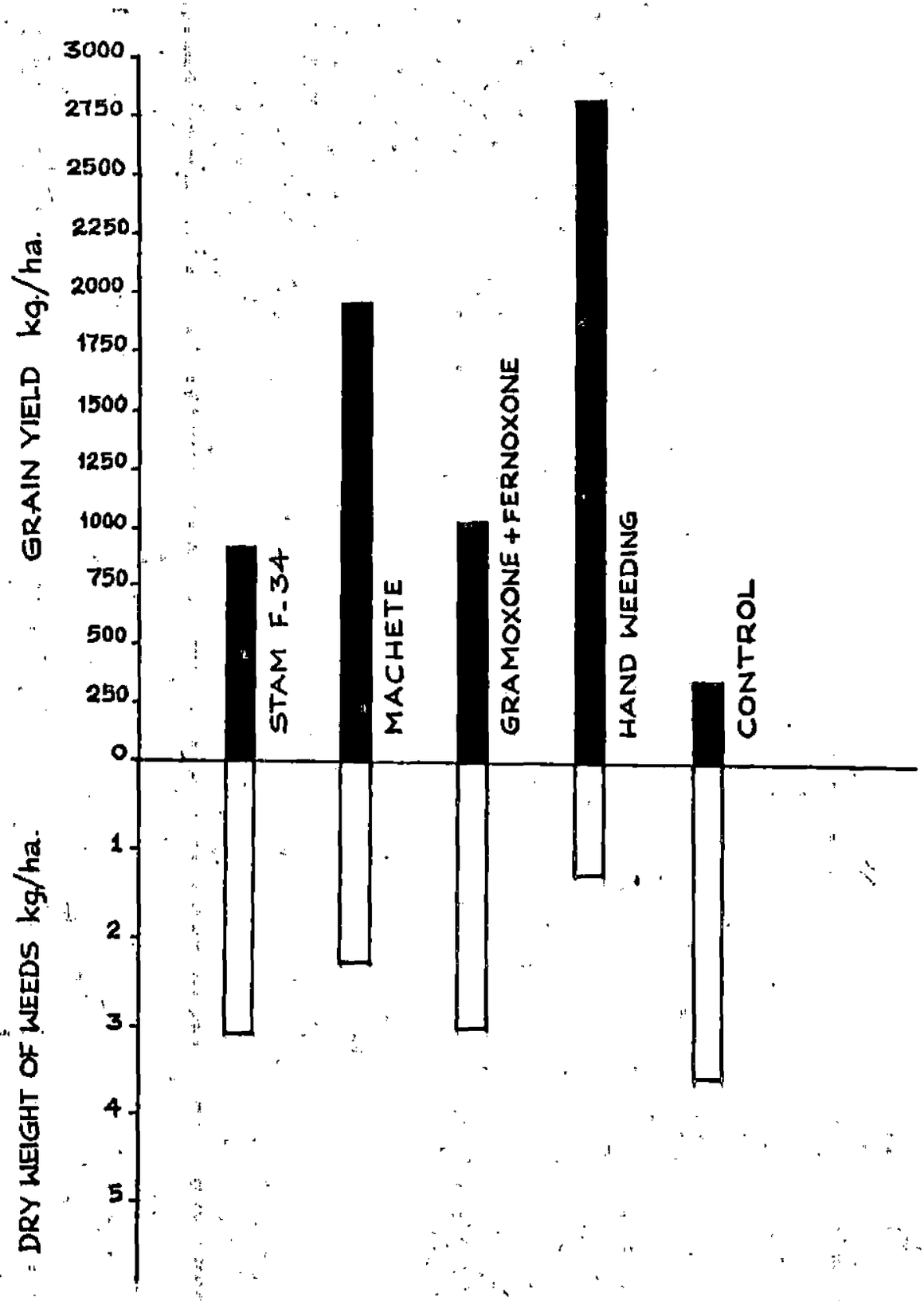


Fig-7. GRAIN YIELD OF RICE AND DRY WEIGHT OF WEEDS AS AFFECTED BY WEED CONTROL TREATMENTS

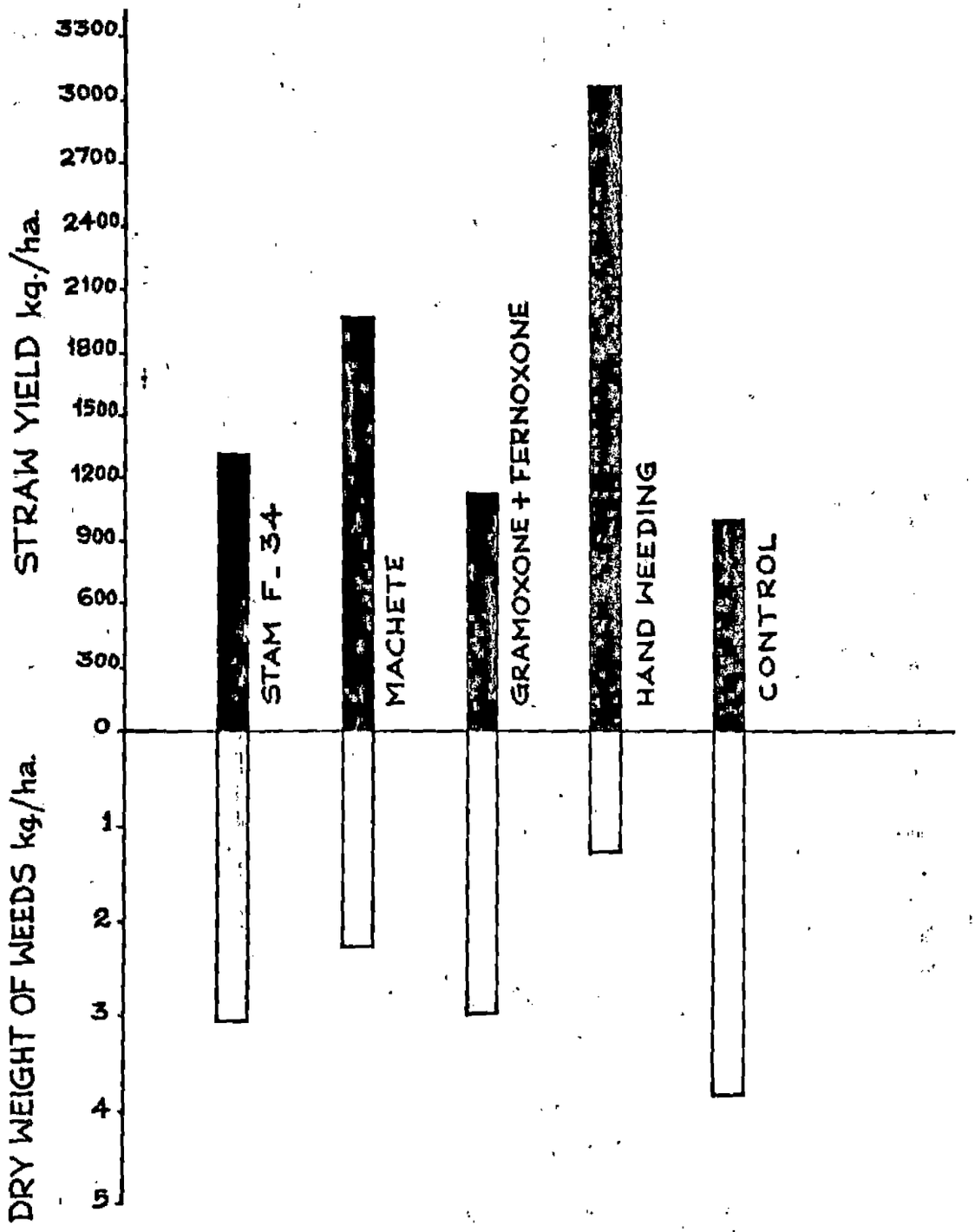


Fig-8. STRAW YIELD OF RICE AND DRY WEIGHT OF WEEDS AS AFFECTED BY WEED CONTROL TREATMENTS

SUMMARY

SUMMARY

An experiment was conducted in the Rice Research Station and Instructional Farm, Mannuthy, Kerala Agricultural University, during the first crop season of 1978 to evaluate the performance of a rice variety 'Aswathy' under different methods of direct seeding and weed control.

Weed characters such as weed species, number of total, monocot and dicot weeds, dry weight of weeds and nutrient uptake by weeds were studied. Crop growth characters such as height and tillering, yield attributing characters such as number of productive tillers, percentage of productive tillers, length of panicle, number of filled grains per panicle, thousand grain weight and yield of grain and straw were also observed and recorded. Protein content of grains and nitrogen, phosphorus and potassium content of plants were determined.

1. Grasses like Echinochloa colonum, Brachiaria ramosa, Panicum species sedges like Cyperus species, Fimbristylis miliacea and broad leaved weeds such as Cleome viscosa Phyllanthus debilis, Ludwigia parviflora were the important weeds found in rice fields in the Rice Research Station and Instructional Farm, Mannuthy.

2. Machete treatment effectively controlled the total weed population including both monocot and dicot weeds. Among the spacing treatments, 45 cm flow line gave the lowest value of total weed population both monocot and dicot.

3. Highest weed control efficiency was recorded in Machete treated plots.

4. Among the herbicides, lowest dry matter production was observed in Machete treatment. The spacing and interaction effects were not significant.

5. Tiller production was maximum in hand weeded plots and in 20 x 15 cm dibbling.

6. Weed control treatments were effective in influencing the number of productive tillers per square metre. Hand weeding gave the maximum number of productive tillers closely followed by Machete treatment. Among the spacing treatments, 30 cm flow line was superior to all the other treatments.

7. Machete and hand weeding gave the highestpercentage of productive tillers. The spacing and interaction effects did not show any significant difference.

8. Weed control treatments significantly influenced the length of panicle. Hand weeded plot recorded the maximum length of paniclo and was on par with Machete treatment. Among the spacing effects, 20 x 15 cm dibbling gave maximum length. Flow line 30 xcm and 45 cm were found to be on par.

9. The maximum number of filled grains was observed in hand weeded plots. The spacing and interaction effects did not show any significant difference.

10. There was significant increase in 1000 grain weight with weed control treatments. Hand weeding and Machete were significantly superior to all the other treatments in

1000 grain weight. Spacing and interaction effects showed no significant difference.

11. Grain yield was significantly influenced by weed control treatments. Highest grain yield was recorded in hand weeded plots followed by Machete treatment. Different levels of spacing did not have any significant effect on grain yield.

12. Yield of straw was also significantly influenced by weed control treatments. Hand weeded treatment gave the highest straw yield which was on par with Machete treatment. Among the spacing treatments 20 x 15 cm dibbling gave the maximum yield of straw. The next higher value was observed in 30 cm flow line.

13. Weed control treatments significantly influenced the nitrogen, phosphorus and potassium uptake by weeds. Among the herbicides, Machete gave the lowest uptake of nutrients by weeds with regard to the uptake of phosphorus alone, 20 x 15 cm dibbling and 45 cm flow line were on par. Hand weeding and Machete treatment recorded significantly higher percentage of grain protein. The spacing and interaction effects did not show any significant difference.

14. Application of Machete at the rate of 2 kg a.i/ha on 6th day after sowing rice was able to control weed growth efficiently resulting in higher yield of grain and straw and higher net profits.

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* Originals not seen.

Appendix I

Total weed population on 30th day after sowing/m^2

(Analysis of variance table)

Source	S.S.	df	M.S.	F.
Total	39547.39	99	--	--
Block	5067.44	4	1266.86	20.46
Spacing	1829.63	4	609.88	9.85**
Error (1)	743.12	12	61.93	--
Weed control	29222.54	4	7305.64	184.73**
Interaction	153.62	12	12.80	0.32
Error (2)	2531.04	64	39.55	--

** Significant at 0.01 level.

Appendix II

Total weed population of 40th day after sowing/m^2

(Analysis of variance table)

Source	S.S.	df	M.S.	F.
Total	40062.04	99	--	--
Block	4464.54	4	1116.14	13.58
Spacing	1236.20	3	412.07	5.01*
Error (1)	986.50	12	82.21	-
Weed control	31203.14	4	7800.79	291.05**
Interaction	456.30	12	38.03	1.42
Error (2)	1715.36	64	26.80	-

* Significant at 0.05 level.

** Significant at 0.01 level.

Appendix III

Total weed population on 50th day after sowing/m^2

(Analysis of variance table)

Source	S.S	df	M.S.	F.
Total	40679.4	99	--	--
Block	4689.1	4	1172.28	10.88
Spacing	1902.8	3	634.27	5.89*
Error (1)	1292.7	12	107.73	-
Weed control	30384.5	4	7596.13	239.51**
Interaction	380.5	12	31.71	0.99
Error (2)	2029.8	64	31.72	-

* Significant at 0.05 level.

** Significant at 0.01 level.

Appendix IV

Total weed population on 60th day after sowing/m^2

(Analysis of variance table)

Source	S.S	df	M.S	F
Total	54955.8	99	--	--
Block	5899.8	4	1474.95	6.16
Spacing	3331.8	3	1110.6	4.64*
Error (1)	2869.8	12	239.15	--
Weed control	35776.6	4	8944.15	95.53**
Interaction	1085.8	12	90.48	0.96
Error (2)	5992.0	64	93.63	

* Significant at 0.05 level.

** Significant at 0.01 level.

Appendix V

Monocot weed population on 30th day after sowing/m^2

(Analysis of variance table)

Source	S.S	df	M.S	F
Total	14858.44	99	--	--
Block	2591.44	4	647.86	22.64
Spacing	285.32	3	95.10	3.32
Error (1)	343.28	12	28.60	--
Weed control	10358.54	4	2589.63	144.06**
Interaction	129.38	12	10.78	0.59
Error (2)	1150.48	64	17.97	--

** Significant at 0.01 level.

Appendix VI

Monocot weed population on 40th day after sowing/m^2

(Analysis of variance table)

Source	S.S	df	M.S	F
Total	16546.24	99	-	-
Block	1498.54	4	374.63	16.80
Spacing	552.64	3	184.21	8.26**
Error (1)	267.46	12	22.28	-
Weed control	11925.34	4	2981.33	89.44**
Interaction	168.66	12	14.05	0.421
Error (2)	2133.60	64	33.33	-

** Significant at 0.01 level.

Appendix VII

Monocot weed population on 50th day after sowing/m^2

(Analysis of variance table)

Source	S.S	df	M.S	F
Total	17289.24	99	--	--
Block	1242.14	4	310.535	6.60
Spacing	1022.44	3	340.813	7.25**
Error (1)	563.86	12	46.988	--
Weed control	13110.74	4	3277.685	186.04**
Interaction	222.46	12	18.538	1.05
Error (2)	1127.60	64	17.618	--

** Significant at 0.01 level.

Appendix VIII

Monocot weed population on 60th day after sowing/m^2

(Analysis of variance table)

Source	S.S	df	M.S	F
Total	19056.75	99	--	--
Block	1859.90	4	464.97	4.67
Spacing	917.39	3	305.79	3.07
Error (1)	1193.46	12	99.45	--
Weed control	13066.00	4	3266.5	118.60**
Interaction	256.96	12	21.41	0.77
Error (2)	1763.04	64	27.54	--

** Significant at 0.01 level.

Appendix IX

Dicot weed population on 30th day after sowing/m^2

(Analysis of variance table)

Source	S.S	df	M.S	F
Total	9962.76	99	--	--
Block	732.56	4	183.14	14.65
Spacing	659.88	3	219.96	17.60**
Error (1)	149.92	12	12.49	--
Weed control	7718.06	4	1929.51	224.10**
Interaction	151.22	12	12.60	1.46
Error (2)	551.12	64	8.61	--

** Significant at 0.01 level.

Appendix X

Dicot weed population on 40th day after sowing/m^2

(Analysis of variance table)

Source	S.S	df	M.S	F
Total	8461.04	99	--	--
Block	728.34	4	182.085	3.56
Spacing	139.76	3	46.580	0.913
Error (1)	612.14	12	51.010	--
Weed control	6273.74	4	1568.435	159.15**
Interaction	76.34	12	6.3616	0.64
Error (2)	630.72	64	9.855	--

** Significant at 0.01 level.

Appendix XI

Dicot weed population on 50th day after sowing/m^2

(Analysis of variance table)

Source	S.S	df	M.S	F
Total	9219.39	99	--	--
Block	1663.44	4	415.860	11.19
Spacing	245.15	3	81.716	2.20
Error (1)	445.60	12	37.133	--
Weed control	6213.54	4	1553.385	182.3**
Interaction	106.30	12	8.858	1.039
Error (2)	545.36	64	8.521	--

** Significant at 0.01 level.

Appendix XII

Dicot weed population on 60th day after sowing/m^2

(Analysis of variance table)

Source	S.S	df	M.S	F
Total	11360.64	99	--	--
Block	2710.14	4	677.535	13.93
Spacing	709.52	3	236.506	4.86*
Error (1)	583.38	12	48.615	--
Weed control	6717.54	4	1679.38	206.82**
Interaction	119.98	12	9.99	1.23
Error (2)	520.08	64	8.12	--

* Significant at 0.05 level.

** Significant at 0.01 level.

Appendix XIII

Dry weight of weeds on 30th day after sowing(g/m^2)

(Analysis of variance table)

Source	S.S	df	M.S	F
Total	17.71	99	--	--
Block	3.04	4	0.76	8.4
Spacing	0.39	3	0.13	1.4
Error (1)	1.04	12	0.09	--
Weed control	11.15	4	2.79	93.0**
Interaction	0.28	12	0.02	0.6
Error (2)	1.81	64	0.03	--

** Significant at 0.01 level.

Note: Data analysed after log. transformation

Appendix XIV

Dry weight of weeds on 40th day after sowing (g/m^2)

(Analysis of variance table)

Source	S.S	df	M.S	F
Total	1241.89	99	--	--
Block	103.15	4	25.79	10.07
Spacing	58.14	3	19.38	7.57**
Error (1)	30.77	12	2.56	--
Weed control	956.79	4	239.20	194.47**
Interaction	14.27	12	1.19	0.97
Error (2)	78.77	64	1.23	--

** Significant at 0.01 level.

Note: Data analysed after square root transformation.

Appendix XV

Dry weight of weeds on 50th day after sowing (g/m^2)

(Analysis of variance table)

Source	S.S	df	M.S	F
Total	1548.8	99	--	--
Block	93.82	4	23.46	8.41
Spacing	28.29	4	9.43	3.38
Error (1)	33.47	12	2.79	--
Weed control	1301.77	4	325.44	248.43**
Interaction	7.38	12	0.62	0.47
Error (2)	84.07	64	1.31	--

** Significant at 0.01 level.

Note: Data analysed after square root transformation.

Appendix XVI

Dry weight of weeds on 60th day after sowing (g/m^2)

(Analysis of variance table)

Source	S.S	df	M.S	F
Total	2079.19	99	--	--
Block	620.95	4	155.24	20.67
Spacing	12.75	3	4.25	0.57
Error (1)	90.17	12	7.51	--
Weed control	1184.52	4	296.13	148.07**
Interaction	43.0	12	3.58	1.79
Error (2)	127.8	64	2.00	--

** Significant at 0.01 level.

Note: Data analysed after square root transformation.

Appendix XVII

Total dry weight of weeds per plot at harvest (kg)

(Analysis of variance table)

Source	S.S	df	M.S	F
Total	7.6549	99	--	--
Block	0.7008	4	0.1752	15.83
Spacing	0.0458	3	0.0152	1.38
Error (1)	0.1327	12	0.0110	--
Weed control	6.2519	4	1.5629	228.81**
Interaction	0.0863	12	0.0071	1.05
Error (2)	0.4371	64	0.0068	--

** Significant at 0.01 level.

Appendix XVIII

Height of plants on 30th day after sowing (cm)

(Analysis of variance table)

Source	S.S	df	M.S	F
Total	4624.10	99	--	--
Block	346.98	4	86.745	6.74
Spacing	562.57	3	187.523	14.58**
Error (1)	154.26	12	12.855	--
Weed control	778.01	4	194.502	4.54**
Interaction	43.34	12	3.611	0.08
Error (2)	2738.94	64	42.795	--

** Significant at 0.01 level.

Appendix XIX

Height of plants on 45th day after sowing(cm)

(Analysis of variance table)

Source	S.S	df	M.S	F
Total	4234.87	99	—	—
Block	240.72	4	60.18	1.53
Spacing	801.11	3	267.036	6.79**
Error (1)	471.31	12	39.275	—
Weed control	1999.63	4	499.907	54.41**
Interaction	134.11	12	11.175	1.21
Error (2)	587.99	64	9.187	—

** Significant at 0.01 level.

Appendix XX

Height of plants on 60th day after sowing (cm)

(Analysis of variance table)

Source	S.S	df	M.S	F
Total	4046.42	99	--	--
Block	539.07	4	134.767	8.56
Spacing	828.26	3	276.086	17.55**
Error (1)	188.77	12	15.730	--
Weed control	2128.42	4	532.105	123.46**
Interaction	86.08	12	7.173	1.66*
Error (2)	275.82	64	4.309	--

* Significant at 0.05 level.

** Significant at 0.01 level.

Appendix XXI

Height of plants at harvest(cm)

(Analysis of variance table)

Source	S.S	df	M.S	F
Total	14206.49	99	--	--
Block	3565.66	4	891.415	18.44
Spacing	294.57	3	98.19	2.03
Error (1)	579.88	12	48.32	--
Weed control	2734.91	4	683.72	6.38**
Interaction	179.79	12	14.98	0.13
Error (2)	6851.68	64	107.05	--

** Significant at 0.01 level.

Appendix XXII

Tiller number on 30th day after sowing/m^2

(Analysis of variance table)

Source	S.S.	df	M.S	F
Total	303764.155	99	--	--
Block	26461.915	4	6615.48	2.01
Spacing	149536.735	3	49845.58	15.17**
Error (1)	39420.150	12	3285.01	--
Weed control	61072.807	4	15268.20	49.09**
Interaction	7367.692	12	613.97	1.97*
Error (2)	19904.855	64	311.01	--

* Significant at 0.05 level.

** significant at 0.01 level.

Appendix XXIII

Tiller number on 45th day after sowing/m^2

(Analysis of variance table)

Source	S.S	df	M.S	F
Total	258172.95	99	--	--
Block	21281.74	4	5320.44	1.32
Spacing	97975.35	3	32658.45	8.13**
Error (1)	48194.21	12	4016.18	--
Weed control	63652.76	4	15913.19	49.32**
Interaction	6417.69	12	534.81	1.66
Error (2)	20651.20	64	322.68	--

** Significant at 0.01 level.

Appendix XXIV

Tiller number on 60th day after sowing/m^2

(Analysis of variance table)

Source	S.S.	df	M.S	F
Total	381766.959	99	--	--
Block	22773.50	4	5693.38	1.70
Spacing	179859.97	3	59953.32	17.85**
Error (1)	40303.06	12	3358.54	--
Weed control	87192.82	4	21798.21	52.48**
Interaction	25054.06	12	2087.84	5.03*
Error (2)	26583.54	64	415.37	--

* Significant at 0.05 level.

** Significant at 0.01 level.

Appendix XXV

Productive tillers/m^2

(Analysis of variance table)

Source	S.S	df	M.S	F
Total	186164.6	99	--	--
Block	26077.0	4	6519.25	7.44
Spacing	79674.09	3	26558.03	30.32**
Error (1)	10512.56	12	876.05	--
Weed control	47144.93	4	11786.23	39.72**
Interaction	3766.35	12	313.86	1.06
Error (2)	18989.69	64	296.71	--

** Significant at 0.01 level.

Appendix XXVI

Percentage of productive tillers

(Analysis of variance table)

Source	S.S.	df	M.S	F
Total	2748.85	99	--	--
Block	165.97	4	41.49	3.80
Spacing	34.29	3	11.43	1.05
Error (1)	130.88	12	10.91	--
Weed control	2199.9	4	549.98	195.03**
Interaction	37.25	12	3.10	1.1
Error (2)	180.56	64	2.82	--

** Significant at 0.01 level.

Note: Data analysed after angular transformation.

Appendix XXVII

Length of panicle (cm)

(Analysis of variance table)

Source	S.S	df	M.S.	F.
Total	564.828	99	--	--
Block	128.580	4	32.145	17.84
Spacing	28.443	3	9.481	5.26*
Error (1)	21.613	12	1.801	--
Weed control	253.437	4	63.359	33.66**
Interaction	12.292	12	1.024	0.54
Error (2)	120.463	64	1.882	--

* Significant at 0.05 level.

** Significant at 0.01 level.

Appendix XXVIII

Number of filled grains per paniole

(Analysis of variance table)

Source	S.S	df	M.S	F
Total	39916.59	99	--	--
Block	7086.95	4	1771.373	11.02
Spacing	1446.80	3	482.266	3.00
Error (1)	1927.89	12	160.657	--
Weed Control	23137.36	4	5784.34	64.21**
Interaction	552.30	12	46.025	0.51
Error (2)	5765.29	64	90.082	--

** Significant at 0.01 level.

Appendix XXIX

1000 grain weight(g)

(Analysis of variance table)

Source	S.S	df	M.S	F
Total	51.12	99	—	—
Block	1.105	4	0.2762	2.45
Spacing	0.404	3	0.1346	1.19
Error (1)	1.351	12	0.1125	—
Weed control	22.68	4	5.72	74.69**
Interaction	0.492	12	0.041	0.53
Error (2)	4.888	64	0.0763	—

** Significant at 0.01 level.

Appendix XXX

Grain yield (kg/ha)

(Analysis of variance table)

Source	S.S	df	M.S	F.
Total	17661.69	99	--	--
Block	633.38	4	158.35	3.23
Spacing	337.06	3	112.35	2.29
Error (1)	589.04	12	49.09	--
Weed control	13897.39	4	3474.35	147.34**
Interaction	695.82	12	57.99	2.46
Error (2)	1509.00	64	23.58	--

** Significant at 0.01 level.

Note: Data analysed after square root transformation

Appendix XXXI

Straw yield (kg/ha)

(Analysis of variance table)

Source	S.S	df	M.S.	F.
Total	28.60	99	--	--
Block	15.30	4	3.82	54.57
Spacing	0.83	3	0.28	4.0*
Error (1)	0.84	12	0.07	--
Weed control	4.50	4	1.13	11.3**
Interaction	0.62	12	0.05	0.5
Error (2)	6.51	64	0.10	--

* Significant at 0.05 level.

** Significant at 0.01 level.

Note: Data analysed after Log. transformation.

Appendix XXXII

Nitrogen uptake by weeds on 40th day after sowing (kg/ha)

(Analysis of variance table)

Source	S.S	df	M.S.	F.
Total	15898.55	99	--	--
Block	1004.67	4	251.17	6.82
Spacing	261.14	3	87.05	2.36
Error (1)	442.20	12	36.85	--
Weed control	12081.73	4	3020.43	102.9**
Interaction	220.11	12	18.34	0.62
Error (2)	1878.70	64	29.35	--

** Significant at 0.01 level.

Appendix XXXIII

Phosphorus uptake by weeds on 40th day after sowing (kg/ha)

(Analysis of variance table)

Source	S.S	df	M.S	F.
Total	601.40	99	--	--
Block	27.80	4	6.95	9.79
Spacing	9.89	3	3.30	4.65*
Error (1)	8.52	12	0.71	--
Weed control	489.59	4	122.40	139.09**
Interaction	9.1	12	0.76	0.86
Error (2)	56.50	64	0.88	--

* Significant at 0.05 level.

** Significant at 0.01 level.

Appendix XXXIV

Potassium uptake by weeds on 40th day after sowing (kg/ha)

(Analysis of variance table)

Source	S.S	df	M.S	F.
Total	1153.09	99	--	--
Block	72.73	4	18.18	9.00
Spacing	16.41	3	5.47	2.71
Error (1)	24.18	12	2.02	--
Weed control	835.43	4	208.86	72.27**
Interaction	24.68	12	2.06	0.72
Error (2)	184.66	64	2.89	--

** Significant at 0.01 level.

Appendix XXXV

Nitrogen content of crop on 40th day after sowing (%)

(Analysis of variance table)

Source	S.	df	M.S	F.
Total	8.353	99	--	--
Block	0.119	4	0.029	7.829
Spacing	0.168	3	0.056	14.686**
Error (1)	0.045	12	0.0038	--
Weed control	6.583	4	1.647	83.839**
Interaction	0.172	12	0.014	0.729
Error (2)	1.257	64	0.019	--

** Significant at 0.01 level.

Appendix XXXVII

Potassium content of crop on 40th day after sowing(%)

(Analysis of variance table)

Source	S.S	df	M.S	F.
Total	439.04	99	--	--
Block	3.44	4	0.86	0.292
Spacing	3.52	3	1.173	0.399
Error(1)	35.28	12	2.94	--
Weed control	284.24	4	71.06	45.261**
Interaction	12.08	12	1.006	0.641
Error (2)	100.48	64	1.57	--

** Significant at 0.01 level.

Appendix XXXVI

Phosphorus content of crop on 40th day after sowing(%)

(Analysis of variance table)

Source	S.S	df	M.S	F
Total	0.3792	99	--	--
Block	0.0175	4	0.0043	2.960
Spacing	0.00008	3	0.000027	0.018
Error (1)	0.0177	12	0.00147	--
Weed control	0.2458	4	0.0614	45.778**
Interaction	0.0121	12	0.0010	0.7517
Error (2)	0.0359	64	0.0013	--

** Significant at 0.01 level.

Appendix XXXVII

Potassium content of crop on 40th day after sowing(%)

(Analysis of variance table)

Source	S.S	df	M.S	F.
Total	439.04	99	--	--
Block	3.44	4	0.86	0.292
Spacing	3.52	3	1.173	0.399
Error(1)	35.28	12	2.94	--
Weed control	284.24	4	71.06	45.261**
Interaction	12.08	12	1.006	0.641
Error (2)	100.88	64	1.57	--

** Significant at 0.01 level.

Appendix XXXVIII

Protein content of grain (%)

(Analysis of variance table)

Source	S.S.	df	M.S.	F.
Total	30.755	99	--	--
Block	0.166	4	0.0417	1.111
Spacing	0.160	3	0.0533	1.421
Error (1)	0.450	12	0.0375	--
Weed control	25.931	4	6.495	125.63**
Interaction	0.689	12	0.0574	1.110
Error (2)	3.308	64	0.0516	--

** Significant at 0.01 level.

STUDIES ON THE PERFORMANCE OF RICE VARIETY 'ASWATHY' UNDER DIFFERENT METHODS OF DIRECT SEEDING AND WEED CONTROL

BY

P. SREEDEVI

ABSTRACT OF A THESIS

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ABSTRACT

Studies on the performance of a rice variety 'Aswathy' under different methods of direct seeding and weed control.

An experiment was conducted in the Rice Research Station and Instructional Farm, Mannuthy, Kerala Agricultural University during the first crop season of 1978 to study the performance of a rice variety 'Aswathy' under different methods of direct seeding and weed control.

Split plot experiment in randomised block design with spacing as major treatments and weed control methods as minor treatments was adopted and the treatments were replicated five times. Presowing treatment with Gramoxone + Fernoxone, pre-emergent treatment with Machete and post-emergent treatment with Stam F-34 were applied. Hand weedings were done on 30th and 40th day after sowing.

Machete efficiently controlled total weed population and was found superior to all the other herbicides tested.

Total dry weight of weeds was least in hand weeded plots. Machete gave values comparable with hand weeding. The different spacing and interaction effect did not show any significant difference on total dry weight of weeds.

Weed control treatments influenced productive tillers per square metre, percentage of productive tillers, length of panicle, thousand grain weight and protein content of grains. Machete and hand weeding were on par with regard to the effect

on all these characters. Number of productive tillers per square metre and length of panicle were influenced by spacing treatments. Flow line 30 cm gave maximum number of productive tillers which 20 x 15 cm dibbling gave the maximum length of panicle.

Hand weeded treatment recorded the highest grain yield of 2,800 kg/ha and straw yield of 3103 kg/ha. Among the herbicides Machete recorded the highest value of grain and straw yields. The spacing and interaction did not show any significant influence on grain yield.

Unchecked weed growth depleted soil nitrogen, phosphorus and potassium to the extent of 33.45, 5.13, 8.48 kg/ha respectively while Machete (2 kg a.i/ha) brought down the uptake of nitrogen, phosphorus and potassium to 4.73, 0.42, 0.81 kg/ha respectively. Spacing effect was found significant only on phosphorus uptake. 20 x 15 cm dibbling was on par with flow line 45 cm.

The nitrogen, phosphorus and potassium content of crop was maximum (0.92%, 0.44%, 0.235% respectively) in the Machete treatment. The unweeded control recorded the lowest nitrogen (0.61%), phosphorus (0.30%) and potassium (0.189%) content of crop. Regarding the nitrogen content, 20 x 15 cm dibbling gave the maximum value. The phosphorus and potassium content of plants were not affected by neither spacing nor interaction.

Machete treatment and hand weeding gave the highest protein content of grains (8.84). The spacing and interaction effect did not show any significant difference on the protein content of grains.