TILLAGE REQUIREMENTS OF COWPEA

BY

RAVI KUMAR P. K.

THESIS

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DECLARATION

I hereby declare that this thesis entitled "Tillage requirements of cowpea" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

RAVIKUMAR. P.K.

Vellayani,

1982.

CERTIFICATE

Certified that this thesis entitled "Tillage requirements of cowpea" is a record of research work done independently by Sri. Ravikumar, P.K. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

(Dr. N. Sadanandan)
Chairman,
Advisory Committee,
Dean, Faculty of Agriculture.

College of Agriculture,
Vellayani, Dec, 1982.

Approved by:

Chairman:

Dr. N. Sadanandan

Members:

1. Dr. V.K. Sasidhar

2. Dr. R.S. Aiyer

21/2/83

21/2/83

3. Sri. K.P. Madhavan Nair

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Introduction

INTRODUCTION

Pulses occupy a very important position in Indian agriculture. They provide not only a cheap source of vegetable protein in human diet but also help in combating protein malnutrition. About 70 g of pulses should necessarily be included in the dietary schedule of a normal adult per day to supply the required protein (Gopalan and Narasinga Rao 1980). According to this standard the minimum pulse requirement of our country works out to be 23 million tonnes. However, the targetted output in the current year is far below the requirement being only about 13.5 million tonnes. While the population has increased tremendously during the past five years, there was no substantial increase in the pulse production which tended to remain around 12 million tonnes. As such the per capita availability has decreased from 68.5 g to 34.9 g calling for crash programmes in pulse production. The Government has rightly taken steps to increase pulse production in this "Productivity Year", and this has been given special consideration in the revised twenty point economic programme.

Pulse have the unique built-in mechanism for drawing the inexhaustible stock of nitrogen from the atmosphere.

Some of them serve as excellent forage and grain concentrate for the cattle. In addition to this, they protect the valuable soil from erosion to a greater extent. The crops that follow pulses as a component crop in the multiple cropping system are benefitted from the enriched soil. The above facts bring out the urgent need for increasing the production of pulses for supplying the people with protective foods, of high calorie value, to keep up the cattle population in good health and to maintain the soil in good condition.

The two possible avenues to achieve the above goals are the expansion of area under pulses especially in non-traditional areas and locations like summer rice fallows, coconut gardens etc., and breeding of high yielding varieties coupled with intensive management practices. The problems which are closely associated with the pulse production in the non-traditional areas are many, viz., problems in land-preparation, liming, pest and disease problems and need for 'tailor made' variety for these problem soils. In spite of these, the farmers will be ready to take up pulse cultivation in non-traditional areas if they are supplied with a low cost - production technology. Thus in Kerala, where cost of labour is relatively high a reduction in cost of land preparation which is the essence of low cost technology, will surely result in a multiple cropping sequence of Rice-Rice-Pulse.

From a cafeteria of pulse crops suitable for cultivation in rice fallows short duration cowpea varieties appear to be the most promising. Reduction in the cost of cultivation is the only alternative for popularising pulse cultivation as it is not possible to exploit the full genetic potential of the existing high yielding variety. In summer rice fallows we have to sow the crop in quick succession to utilise the residual moisture and as such the time available for preparatory cultivation is much less. The scarcity and high cost of labour in the peak season warrant suitable tillage practices to overcome such difficulties encountered by the cultivators.

Pulses often suffer from severe weed competition, on account of their slow initial growth rate. Generally the weeds out-grow the crop in early stages and if adequate control measures are not taken, yield will be reduced considerably. The optimum time for weeding is found to be seven and twenty eight days after planting (Anon., 1974). Land preparation often reduce the soil moisture considerably in the top five centimetres of soil (Delouche-1980). It may be remembered that after cultivation practices also have a deciding influence on the soil moisture conservation and weed control. The stage and frequency of weeding are very critical. Under conditions of intensive cropping, minimum tillage practices have great importance and applicability. This is especially true with a crop like pulse, grown in summer rice fallows where much time is lost by resorting to conventional tillage practices. Since, the conventional tillage practices are costly, it is worthwhile to find out alternate cheap methods of tillage and interculture to popularise its cultivation. Development of such agro-techniques are of much relevance to pulse cultivation especially in the summer rice fallows of Kerala. As the studies on the combined effect of tillage and interculture have not been undertaken so far in Kerala, the present investigation has been carried out with the following objectives.

1. To find out the minimum tillage requirements of cowpea.
2. To test the feasibility of growing cowpea without tillage.
3. To find out the effects of different levels of raking and weeding, on growth of cowpea and to find out the optimum time of inter cultivation.
4. To work out the economics of different tillage operations in summer rice fallows for cowpea.

Review of literature

REVIEW OF LITERATURE

Most of the world's cowpea, is grown by traditional agriculture - sown, cultivated, and harvested with hand tools. Recorded studies on cultural practices are relatively few. The review of literature pertaining to the present investigation is given below:

1. Tillage

Tillage is considered as the first step in crop production. Deep tillage operations have for centuries been a feature of the more advanced systems of farming. Conventional tillage, which is the most practised one has been described by Beaumer and Bakermans (1973) as the one which begins with a primary deep tillage, followed by some secondary tillage for seed bed preparation. Here, control of weeds, the most important objective of tillage is achieved by pre or post emergence recultivation or herbicide application.

The concept of tillage for crop production is changing rapidly. Garber (1927) successfully oversowed a legume into an unproductive grass sod without tillage. In the 1950's, as a consequence of the encouraging results obtained by mulch farming practices and by the discovery of new herbicides the minimum tillage received greater support. Eventhough the minimum tillage practices have been experimented on a number of crops, the published work on cowpea is few. Stanton *et al.* (1968) reported that the crop can be planted without any previous preparation of land. Studies at Pantnagar have shown that summer pulses can be planted after harvesting wheat without any preparatory tillage. (Saxena and Yadav, 1975). Ploughing the land two to three times and removing the weeds and stubbles has been considered as an important practice for raising cowpea (Anon., 1981).

1.1 Effect of tillage on soil moisture

Talati and Mehta (1963) reported that deep ploughing conserved more moisture than shallow ploughing and resulted in higher yields of bajra. Harold *et al.* (1967) observed a markedly increased amount of soil moisture coserved in the top 7" of soil in a no-tillage system compared to the tilled, in an experiment with corn. Jones *et al.* (1968) reported that the average available moisture in the effective root zone, 0.18 cm - 3.12 cm is higher in a no-tillage system than in other five systems involving increasing amounts of tillage. Dev *et al.* (1970) found a lower moisture content at the surface 5 cm layer in the ploughed soil as compared to the untilled. Moreover, he could observe an increase in moisture content in the deeper horizons. However, Goncharov *et al.* (1970) reported that the differences in ploughing depth did not affect the moisture regime at all. Michael *et al.* (1970)

reported that deep ploughing helps in conservation of rain water at the end of the rainy season. Blevins et al. (1971) observed a higher moisture content in no-tillage systems upto a depth of 60 cm with the largest difference in the top 8 cm in a silt loam soil. Beaumer and Bakermans (1973) could notice a higher moisture content at pF2 in the top 6 cm of the zero tilled soil than in the ploughed soil whereas the reverse was observed in the layer 11 - 16 cm. They observed the largest difference between tilled and untilled soil in the rewetting phase. Ali and Prasad (1974) found that moisture conservation was better under flat seed bed than under ridge and furrow beds. Oswal and Dakshinamoorthy (1975) reported that sub-soiling resulted in more yield and better water use efficiency as compared to chisel ploughing, mould board ploughing and surface cultivation. Minimum tillage has advantages over conventional system of soil and water conservation (Gurnah, 1975; Unger and Stewart, 1976). Bauer and Kucera (1978) could find an increased soil moisture content in the top 60 cm of untilled soil as compared to a tilled one. Guerrero et al. (1978) reported that soil moisture content was more stable when number of tillage operations was reduced in corn. Lal et al. (1978) found that water use efficiency of maize and cowpea was higher under no-tillage compared to tillage. Chopart et al. (1979) could not find any effect on water storage with minimum tillage during a dry season. Fenster and Peterson (1979) reported that chemical fallow stored more water annually compared to ploughed land. Rai and Yadav (1979) reported that deep ploughing resulted in more soil moisture in the upper 30 cm depth at the time of sowing. However, Delouche (1980) and Sasidharan (1981) reported that ploughing depleted soil moisture to a level marginal for germination of seeds. Khan *et al.* (1981) reported significant reduction of soil moisture content in rice fallows due to conventional tillage as compared to minimum tillage.

1.2 Effect of tillage on weed growth

Baeumer and Bakermans (1973) observed that zero tillage resulted in higher amounts of volunteer plants from previous crops especially where cereals are grown and value of crop is depreciated. Malik *et al.* (1973) observed more than double drymatter accumulation of weeds on non-tilled plots, compared to tilled ones. Gouthaman and Sankaran (1976) found no significant difference between tillage treatments on weed growth and weed drymatter in case of maize. Greenland (1975) reported that weed problem was greater in no-tillage system compared to tilled ones and recommended the exercise of suitable control measures to obtain higher yields. Experiments at Philippines revealed that for cowpea there was no significant difference in weed weight at harvest between tillage treatments (Anonymous, 1977). Estler (1978) reported that mechanical weed control in the course of regular basal tillage are superior to zero tillage as far as type of weeds are considered and the type of weed coverage. Bhushan et al. (1979) reported that under shallow tillage, weed growth was as high as 7.2 t/ha which could be brought down to 3.5 t/ha by the combined effect of deep tillage and simazine application. Castroverde and Mabbayad (1979) reported that tillage practices and pre-plant herbicide treatments have no significant difference in their effects on weed population. Mahto and Sinha (1980) reported that largest number of weeds and drymatter accumulation were seen in no-tillage plots compared to tilled one at 20 days after sowing of wheat. However, at 30 and 50 days after sowing there was no difference among the treatments.

1.3 Effect of tillage on growth characters

Kapoeed (1974) reported that deep tillage increased plant height of soyabean. But Sorur et al. (1976) could not find any significant effect on height of corn. Camper and Lutz Jr. (1977) also reported that tillage has no effect on height of soyabean. Simon and Skrdleta (1978) found that plant height was lower with no-tillage in case of field beans. Chaudhary et al. (1978) reported that tillage treatments as compared to no-tillage had higher plant height in case of wheat. Sasidharan (1981) reported that the height of groundnut plants at early stages was higher in the untilled treatment.

Simon (1973) observed a 22% decrease in drymatter production with zero tillage when compared to ploughing. However, Sorur et al. (1976) could not notice any significant difference in dry weight of corn due to tillage. Hakimi and Chakravarthy (1976) reported that ploughing and disking produced maximum plant growth and highest silage yield of corn. Elliot et al. (1977) noticed a better shoot growth of barley in early season due to ploughing and deep tine cultivation. Rowse and Stone (1977) also reported that deep cultivation increased drymatter production of broadbean by 12% over conventional ploughing. Chaudhary et al. (1978) reported that tillage treatments produced higher shoot weight and root weight in case of wheat compared to no-tillage. Simon and Skrdleta (1978) reported that the biomass production was lower with zero tillage. However, Lal et al. (1978) noticed higher drymatter production of corn and cowpea under no-tillage.

Taylor and Ratliff (1969) reported that root elongation rate in cotton and groundnut decreased with increase in soil strength. Barber (1971) observed that in annually ploughed soils, corn roots developed extensively to greater depths, than no tilled soils. Reddy and Dakshinamoorthy (1971) found that the root growth was higher with deep tillage in case of wheat. Reddy (1973) reported a decrease in root penetration with increased compaction of soil. Beaumer and Bakermans (1973) did not observe any difference between the effect of tillage treatments on length and frequency of adventitious roots of wheat. They also reported that the final root weight and pattern of root distribution at ripening stage is similar in both tilled and untilled soils. Linder et al. (1974) reported that deep loosening increased root penetration. EL Sherkawy and Sgaier (1975) observed increased penetration of roots of wheat from no-tillage to subsoiling. Varnell et al. (1975) reported a poor root growth of peanuts in the untilled treatment and attributed it, to the compact zone immediately below and to the sides of the row. Chopart et al (1976) reported that ploughing before sowing increased root growth rate, maximum root depth and radial root areas. Smittle and Threadgill (1977) reported that root production of cowpea followed an inverse pattern with soil strength. Ramos et al. (1979) reported that under minimum tillage system soybean plants had a higher root density in the upper most layer. Maurya and Lal (1980) reported that roots in the surface layer were more with no-tillage. But at lower depths of

10 - 40 cm roots were less in no-tillage plots. However, Sasidharan (1981) could not find any effect of tillage treatments on root growth of groundnut in the tracts of Onattukara, kerala.

Magesfield (1957) reported that excessive cultivation decreased nodulation of legumes. Simon and Skrdleta (1978) reported that the number and weight of nodules were lower with no-tillage compared to conventional ploughing. Klittich and Hughes (1980) reported that nodule weight of soybean plants were higher under sod than in conventional ploughing although no difference in yield of seen.

1.4 Effect of tillage on yield and yield attributes

Talati and Mehta (1963) reported that yield of bajra increased with increase in depth of ploughing. Harold *et al.* (1967) reported higher yields of maize with no-tillage than with conventional tillage. Triplett *et al.* (1968) noticed significant reduction in average grain yield of maize from no-tillage to conventional pre-sowing tillage. Bosse and Herzoz (1969) observed significantly higher yield of maize and lupin in the untilled treatment compared to tilled or disk harrowed ones. Ofori and Nandy (1969) found that on sandy loam soils ploughing to a depth of 9 cms increased the yield of maize compared to unploughed ones. Taylor and Ratliff (1969) observed a decrease in weight of tops of groundnut and cotton with increased soil strength at lowest moisture level. Neenau (1970) reported that yields of soybean were lower with direct drilling compared to conventional tillage. Singh (1970) reported that grain and bhusa yield of bengal-gram was not significantly affected by number of preparatory cultivations. However, he obtained the maximum yield under two ploughings, which was followed by three preparatory ploughings.

Balan *et al.* (1971) found that increasing the depth of ploughing from 15 to 25 cm increased the yield in case of soybean and maize. Blevins *et al.* (1971) observed higher yields of maize in no-tillage treatment. Underwood *et al.* (1971) found that groundnut grown in a compacted soil showed a decrease in yield with increase in soil strength. However, Vitosa *et al.* (1972) reported that maize yields were unaffected by ploughing depths. Kouwenhowen (1973) reported an increase in yield of cowpea under no-tillage compared to rotavation and disc-ploughing. Reddy (1973) reported that higher levels of compaction reduced the pod yield of groundnut significantly. Sanford *et al.* (1973) found that conventional tillage gave higher yields of soybean over reduced tillage. Singh and Gupta (1973) reported that preparatory and inter-tillage treatments did not affect the grain yield of wheat.

Foth (1974) reported higher yields with minimum tillage in case of maize. Tillage to a depth of 10 cm gave higher yields compared to 30 cm depth. Kaposei (1974) reported that yields of soybean was always increased by deep tillage. Rod and Pesek (1974) reported that cultivation methods had no significant effect on yield of barley. Rockwood and Lal (1974) reported that in periods of drought and stress, yield of cowpea is 28 per cent higher with zero tillage than that of ploughed treatment. Linder et al. (1974) observed that in sandy soils with loamy subsoils, deep loosening alone increased crop yields by 10 to 20 per cent.

Varnell et al. (1975) observed a significant reduction in yield of tops and pods of groundnut in zero tillage treatment. They noticed a reduction in seed size due to inadequate seed bed preparation.

Bertoni et al. (1976) observed higher yields of groundnut with ploughing compared to disking. Gouthaman and Sankaran (1976) found that there was no significant difference in yields of maize between different tillage treatments viz., conventional, minimum and zero. Smith and Lilard (1976) reported a higher grain yield in untilled treatment than the tilled one. Standifer and Ismail (1976) reported that yields obtained with minimum tillage was equal or more to those obtained with conventional tillage. Unger and Stewart (1976) observed that in multiple cropping systems, yields were higher under no-tillage. Vander (1976) found that conventional tillage gave higher yields than reduced tillage.

Vandoren *et al.* (1976) find that corn yields were remarkably insensitive to tillage.

Experiments at IRRI revealed that cowpea after a single rice crop could produce higher yield at zero tillage (Anonymous, 1977). Elliot *et al.* (1977) did not observe any difference between cultivation treatments on the yield of spring barley on sandy loam soil. However, Minhas (1977) obtained increased grain yield of maize by 700 - 800 kg with no-tillage system, combined with mulching or post-sowing tillage as compared to conventional tillage. Similar reports were also made by Kang and Yunusa (1977) in maize; Reddy *et al.* (1977) in Groundnut; Rai and Singh (1977) in wheat and Mock *et al.* (1977) in maize. Hakimi and Kachru (1977) observed a decrease in yield with respect to no-tillage in case of barley.

Bauer and Kucera (1978) reported the lowest grain yield with no-tillage system in spite of the increased moisture content in top 60 cm of soil. Kazanstev and Kolamkov (1978) reported that under local conditions yields of maize over a two year period was increased by 4 t/ha and that of wheat by 0.24 - 0.29 t/ha on plots with shallow cultivation. Lal *et al.* (1978) reported higher yields of maize and cowpea under no-tillage. Cancieno and Mabbayad (1979) reported that there was no significant difference in the yield of corn under different tillage practices viz., zero, minimum and conventional. Chopart et al. (1979) reported a higher yield in conventional tillage system as compared to minimum tillage system. Another study by Herzog et al. (1979) revealed that with increasing tillage intensity the yield increased proportionately. Kamprath et al. (1979) reported that yields of soybean was increased by ploughing and disking. Rai and Yadav (1979) observed higher yields of wheat under deep cultivation. However, Tompkins and Mullins (1979) observed that yield of cowpea was unaffected by tillage treatments.

Mahto and Sinha (1980) reported that deep cultivation gave higher yields of wheat. Ketcheson (1980) reported that corn yields were lower under no-tillage or reduced tillage than conventional tillage on medium textured soils. Similar results were obtained by Mullins et al. (1980) in case of lima beans. However, Patterson et al. (1980) reported that under favourable conditions all the cultivation techniques produced similar yields, cheapest being shallow ploughing with respect to cost of production.

Boquet and Walker (1981) reported that no-tillage gave higher yields of soybean compared to tilled one. Porter et al. (1981) found that in Calloway silt loam soils, yields of soybean was unaffected by tillage treatments. But in Portland clay soils, yields were higher under conventional tillage than zero tillage. Khan *et al.* (1981) reported that yields of maize stover number of grains per cob and 1000 grain weight were unaffected by tillage.

1.5 Effect of tillage on uptake of nutrients and quality of grain

Beaumer and Bakermans (1973) reported that P and K content of plants grown on untilled or mulched soil was higher or equal to the contents observed in conventionally tilled soil. Ali and Prasad (1974) reported that NPK uptake was higher under flat seed bed than ridge and furrow beds. Rowse and Stone (1977) reported that following deep dultivation, crops extracted more N, P and K, but there was little change in concentration of these elements in plant drymatter.

Singh (1970) reported that the quality of bengal gram was unaffected by tillage. He also found that protein content of bengal gram was stationary. Simenov and Vanchev (1978) reported that grain quality of wheat was unaffected by tillage.

1.6 Effect of tillage on soil properties

Talati and Mehta (1963) reported that nitrate content and exchangeable K content under deep ploughing were significantly higher than in shallow ploughed ones. However, depth of ploughing had no significant effect on available P content of soil. Arnott and Clements (1966) found more mineralised nitrogen on ploughed land than on sprayed grass land kept free of plant growth. Baeumer and Bakermens (1973) reported that zero tillage generally results in 9.7 per cent increase in available P and K, but available nitrogen was found to be lower. From a four year experiment on lysimetric moniliths, Pak and Tsyapura (1974) reported that tillage increased the availability of Potassium in a dark chestnut meadow solonetz. Fleige and Baeumer (1974) reported that zero tillage increased the organic carbon content of 0 - 30 cm soil layer. Azevedo and Fernandes (1975) found that under minimum tillage the total N content of soil was increased. Dowdell and Carnel (1975) reported that the concentration of nitrate nitrogen at 30 cm depth in clay soil was 2.8 times greater after ploughing than after direct drilling during the winter and spring. Blevins et al. (1977) reported that organic carbon was higher under no tillage than conventional tillage. Zuo and Lal (1979) reported that no-tillage with crop residue mulching resulted in higher concentration of organic carbon, total N, available P and exchangeable K than the ploughed treatment.

2. Raking and weeding

Weeds are wasteful competitors of all crops. Weeding is an important cultural operation for better growth of crops. Weeding is essential for pulses because they being dry land crops, competition for moisture is acute. Besides, growth rate of pulses being slow in the early stages, weeds tend to outgrow the crop. Critical periods for weed control appears to be first four weeks according to Jeswani and Saini (1981). Weed control and productivity relationship showed that there was considerable increase in productivity of pulse crops by weed control(Ahlawat et al. 1981).

2.1 Effect of raking and weeding on soil moisture

Sreenivasan (1953) observed that, favourable influence of intercultivation is only due to its efficiency in removing weeds and not to its capacity to produce a mulch. Sachan et al. (1977) reported an increased soil moisture content with dust mulch produced by two hoeings over control. Sasidharan (1981) reported that hoeing had no effect on conserving soil moisture at the early stages. But hoeing at 60th day after sowing, conserved more soil moisture.

2.2 Effect of raking and weeding on weed growth

Ogle (1967) reported that Trifluralin at 0.56 to 1.12 kg/ha applied presowing and immediately harrowed and rotovated in has given good control of weeds. Gautam and Singh (1971) reported that weed density was lower in weeded plots over unweeded control. Jainet al (1972) reported that drymatter production of weeds was found to be lower with two weeding. Rachie and Robert (1974) reported that mechanical cultivation or hoeing may be the most practical means of weed control under tropical conditions. Pahuja *et al.* (1975) reported that drymatter production of weeds was minimum under weed free condition followed by two hoeings and TokE-25 treatment when compared to weedy check. Gautam *et al.* (1975) reported that drymatter accumulation of weeds was significantly lowered under repeated hand weeding and herbicide treatment to that of weedy check. Gouthaman and Sankaran (1976) observed lesser number of weeds in hand weeding and atrazine band application followed by inter-cultivation. Significant reduction in dry weight of weeds, in hand weeding was reported by Soundararajan *et al.* (1976, 1977). Panwar and Malik (1977) reported that very poor growth of weeds took place under crop canopy after hand-weeding. Experiments by Soundararajan *et al.* (1980) revealed that hand weeding is the best for control of weeds.

2.3 Effect of raking and weeding on growth characters

Chaugle and Khuspe (1962) observed an increase in height of groundnut plants in treatments receiving no intercultivation. Singh (1975) reported that hoeing after four weeks of sowing resulted in highest shoot height of moong Retinam *et al.* (1976) reported that hand weeding twice resulted in maximum height of gram compared to other herbicidal treatment and unweeded control. Sasidharan (1981) reported that hoeing on 45th day after sowing increased the height of plants.

2.4 Effect of raking and weeding on yield and yield attributes

Kulkarni *et al.* (1963) reported that weeding increased the yield of groundnut. Kaul *et al.* (1970) reported that hoeing increased the yield of maize under one ploughing when compared to no-tillage or ploughing plus four cultivations. Gautam and Singh (1971) reported that hand weeding at six week stage gave slightly higher yield of peas over chemical weeding. Prem Singh *et al.* (1971) reported that hand weeding increased the yields of moong. However, Hanser *et al.* (1972) reported no significant yield difference among weed control system, viz., cultivation, and cultivation plus herbicide. Jain *et al.* (1972) reported that pod number and seed test weight of soybean were closely related with intensity of weeding. Among the cultural methods used in this experiment, maximum yield was recorded with two weedings. Ali *et al.* (1974) reported that hoeing and hand weeding gave higher yields of cowpea. Experiments at IITA revealed that hand weeding cowpeas at 7 seven and twenty eight days after emergence gave seed yields as high as that in control plots kept weed free by hand weeding. (Anon.,1974) Pahuja *et al.* (1975) noticed maximum yield of gram and pea under weed free conditions followed by two hoeings at 30 and 45 days. Singh *et al.* (1975) reported that higher yields of cowpea was obtained by weeding twice at 25 and 45 days after sowing. Gautam *et al.* (1975) observed higher yields of soybean with repeated hand weeding and herbicides.

Deskova (1975) observed a decrease in yield of groundnut pods by 38.3 per cent with the reduction of inter row cultivation from five to two. Singh (1975) reported that hoeing after four weeks of sowing increased grain yield of moong. Gouthaman and Sankaran (1976) reported that Atrazine followed by intercultivation recorded the maximum yield of maize. Soundararajan *et al.* (1976) could not find any positive correlations between the number of weedings and the number of pods and yields of groundnut. Panwar and Malik (1977) reported that hand weeding increased the yield of Black gram. Soundarajan *et al.* (1977) reported that pod yield of groundnut was significantly increased when weeds were either controlled by hand weeding or by herbicides. However, Versteeg and Maldona (1978) reported a slightly decreased yield of cowpea due to hand weeding alone when compared to herbicide and hand weeding. Burnside (1979) reported that weeding at 2 to 4 weeks after planting increased the yield of soybean.

Eweida *et al.* (1980) reported that seed yields of soybean were increased by hoeing. But the number of weedings had no significant effect. Moursi *et al.* (1980) reported that seed and total yields of fied beans were significantly increased by weed control. Hoeing twice gave the highest yield. Results from a two year experiment by Soundrarajan *et al.* (1980) revealed that pod yield of groundnut was maximum in one hand weeding and hoeing at 25 days in one year. In the second year nitrofen 1 kg a.i/ha and hand weeding and hoeing at 45 days gave the maximum yield. Ahlawat et al. (1981) reported that weeding only once gave about 40 per cent increase in yield of cowpea. Sasidharan (1981) reported that hoeing on 15th day after sowing gave maximum yield of groundnut.

Materials and methods

MATERIALS AND METHODS

The response of cowpea to different tillage practices and intercultural operations was investigated in a field experiment conducted in the summer rice fallows of Pattambi. The materials used and methods adopted are detailed below.

1. Materials

1.1 Location.

The experiment was conducted in the rice fallows of Central Rice Research Station, Pattambi. The station is located at 18°N latitude and the altitude of the place is 25 metres above mean sea level.

1.2 Cropping history of the field

The experimental site was cultivated with bulk crop of rice during the first and second crop seasons of 1980-81.

1.3 Season.

The experiment was carried out during the summer season of 1980-81. The crop was sown on 28-2-1981 and harvested on 18-5-1981.

1.4 Soil

Soil of the experimental site is sandy loam with the following physico-chemical properties.

Clay	-	27.41%
Silt	-	12.80%
Fine Sand	-	16.50%
Coarse Sand	-	43.20%

Total nitrogen	-	0.0856% (Microkjeldhal method)
Available P_2O_5	-	0.0016% (Bray's method)
Available K_2O	-	0.0028% (Neutral normal ammonium acetate)
Organic carbon	-	0.84% (Black and Walkely's method)
pH	-	5.3 (1:2 soil solution ratio using glass electrode pH meter)

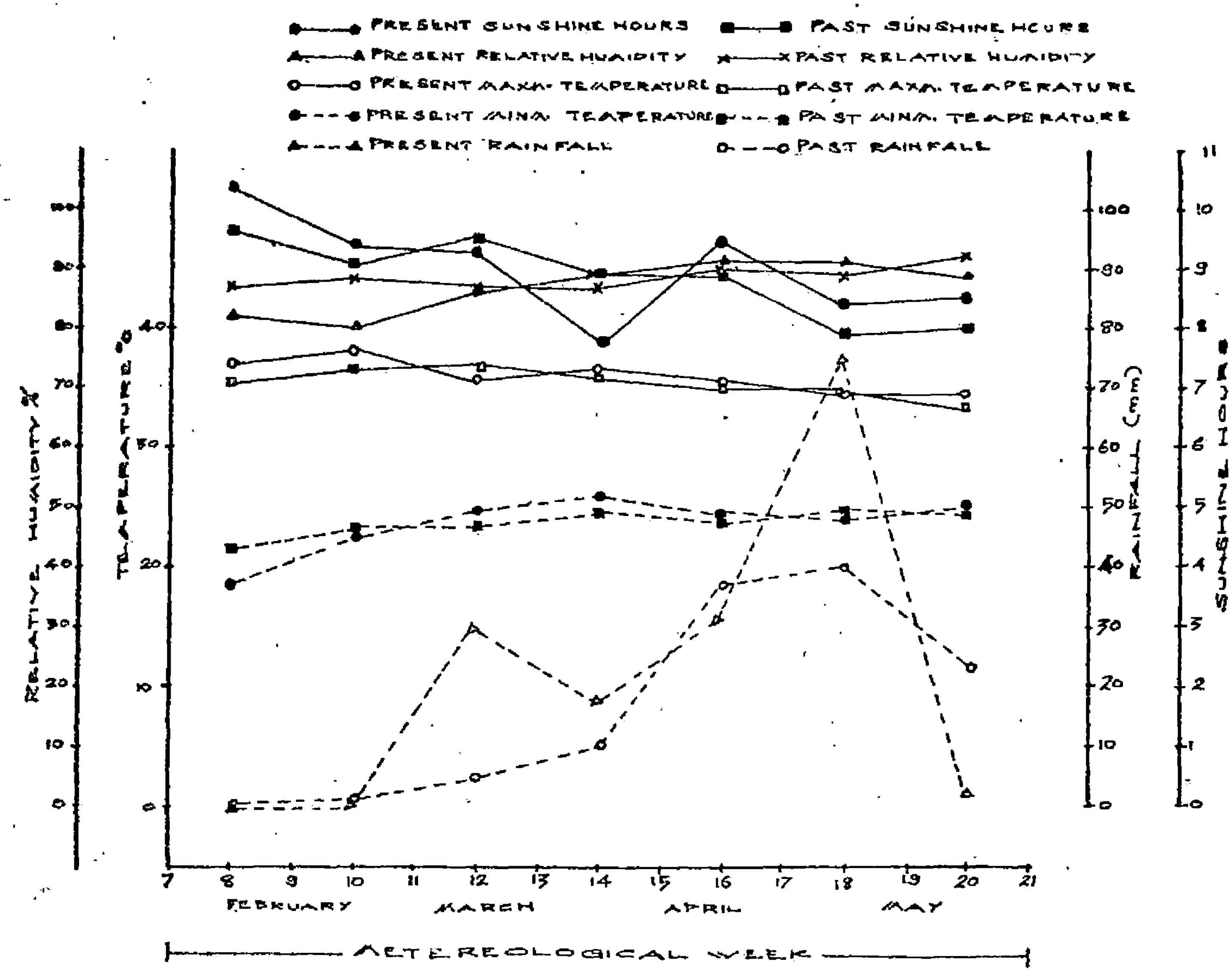
1.5 Weather conditions

The meterological parameters recorded are rainfall, maximum and minimum temperature, relative humidity and sunshine hours. The average weekly values and their variation from the average of the past five years from sowing to harvest were worked out and presented in Appendix I and illustration given in Fig.1.

1.6 Variety

Cowpea cultivar Kanakamani was selected for the trial. It is a short duration, bushy and moderate high yielding dual purpose variety. It is photosensitive and moderately drought tolerant. It is excellent both as a green pulse and green vegetable and has got a protein content of

WEATHER CONDITIONS DURING THE CROPPING PERIOD (1980-81) AND CORRESPONDING AVERAGES FOR THE PAST FIVE YEARS (1976-77 TO 1980-81) FIG. 1



22.4 per cent. It yields upto 1100 kg grain/ha or 2500 to 3500 kg pods/ha (Viswanathan 1978).

1.7 Seed material

The seed materials for the experiment was obtained from the station. Rhizobium culture for treating the seeds was obtained from Microbiological Laboratory of the Department of Agriculture, Pattambi.

1.8 Fertilizers

Fertilizers with following analysis were used.

Urea	-	46% N
Super phosphate	-	16% P_2O_5
Muriate of potash	-	60% K_2O

2. Methods

2.1 Design and layout

The experiment was laid out in a split plot design with tillage treatments in the main plot and levels of raking and weeding in sub-plots. The lay out plan of the experiment is as given in Fig.2.

2.2 Treatments

The treatment details are furnished below:

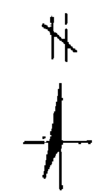
Main plot treatments (levels of tillage)

1. M_1 Dibbling on stubbles
2. M_2 Chemical tillage with "Lasso" @ 1.5 kg a.i/ha and dibbling

LAYOUT PLAN SPLIT-PILOT EXPERIMENT IN RANDOMISED BLOCK DESIGN

FIG-2

REPLICATION I			REPLICATION-II			REPLICATION III			REPLICATION-IV		
M_4S_1	M_4S_3	M_4S_2	M_6S_3	M_6S_1	M_6S_2	M_3S_1	M_3S_3	M_3S_2	M_1S_3	M_1S_2	M_1S_1
M_6S_1	M_6S_2	M_6S_3	M_3S_2	M_2S_3	M_3S_1	M_1S_3	M_1S_2	M_1S_1	M_5S_2	M_5S_1	M_5S_3
M_6S_1	M_6S_3	M_5S_2	M_1S_1	M_1S_3	M_1S_2	M_2S_1	M_2S_3	M_2S_2	M_6S_3	M_6S_1	M_6S_2
M_2S_2	M_2S_1	M_2S_3	M_5S_2	M_5S_1	M_5S_3	M_6S_2	M_6S_1	M_6S_3	M_4S_1	M_4S_2	M_4S_3
M_3S_3	M_3S_2	M_3S_1	M_2S_1	M_2S_2	M_2S_3	M_4S_3	M_4S_2	M_4S_1	M_3S_1	M_3S_3	M_3S_2
M_1S_2	M_1S_3	M_1S_1	M_4S_3	M_4S_2	M_4S_1	M_5S_1	M_5S_3	M_5S_2	M_2S_2	M_2S_3	M_2S_1



MAJOR TREATMENTS

M_1- DIBBLING ON STUBBLES

M_2- CHEMICAL TILLAGE WITH LASSO @ 1.5 kg a.i/ha

M_3- PREPARATION WITH ONE PLOUGHING AND SOWING

M_4- PREPARATION WITH TWO PLOUGHING AND SOWING

M_5- PREPARATION WITH THREE PLOUGHING AND SOWING

M_6- SOWING AND THEN PLOUGHING

MINOR TREATMENTS

S1- RAKING AND WEEDING ON 15th AND 30th DAY

S_2- RAKING AND WEEDING ON 15th DAY ONLY

S_3- RAKING AND WEEDING ON 30th DAY ONLY

3. M_3 Preparation with one ploughing and sowing.
4. M_4 Preparation with two ploughings and sowing.
5. M_5 Preparation with three ploughings and sowing.
6. M_6 Sowing and then ploughing. once

Sub-plot treatments (levels of raking and weeding)

1. S_1 Raking and weeding on 15th and 30th day.
2. S_2 Raking and weeding on 15th day only.
3. S_3 Raking and weeding on 30th day only.

Number of replications - 4

Total number of plots - 72

2.3 Spacing and plot size

Spacing - 30 x 15 cm.

Gross plot size - 4.5 m x 4.2 m.

Net plot size - 2.1 m x 3.9 m.

Border rows: One row of plants was left as border row all around the plot. Two rows of plants along the length of the plot on either side were left, so as to facilitate periodical removal of sample plants from the field. One more row was left after the destructive row as guard row.

2.4 Field culture

After the harvest of second crop of rice the field was initially divided into main plots as per the design.

The plots receiving no-tillage were kept unploughed. Other plots receiving different levels of tillage were ploughed accordingly. In M_6 plots, one ploughing was done after sowing. Plots receiving treatment M_2 ie. chemical tillage, were sprayed with "Lasso" at the rate of 1.5 kg a.i/ha.

2.5 Fertilizer application

Lime at the rate of 250 kg/ha was broadcast on the plots before ploughing. Then plots receiving tillage were ploughed while others were kept undisturbed. A uniform dose of N, P and K at the rate of 20:30:10 kg per hectare respectively was given to all plots. Half the amount of nitrogen and entire quantity of phosphorus and potash were applied basally. The fertilizers were applied by taking a furrow in between the rows of plants in all the treatments. The remaining amount of nitrogen was applied as 2 per cent foliar spray of urea on the 21st day and 31st day after sowing.

2.6 Seeds and sowing

The seeds were inoculated with Rhizobium culture obtained from the Microbiological Laboratory of the Department of Agriculture, Pattambi, and dibbled at the rate of two seeds per hole. The M_6 (sowing and ploughing treatment) plots were sown broadcast as per treatment.

2.7 After cultivation

The sub-plots S_1 and S_2 were raked on 15th day after sowing and weeds were removed. Second raking of S_1 and first raking of S_3 was done on 30th day after sowing and weeds were removed.

2.8 Irrigation

Life saving irrigations were given as and when required.

2.9 Plant protection

Two prophylatic sprays of Ekalux-25 wase given.

2.10 Harvesting and threshing

The crop was harvested in 2 stages, first on 3-5-1981 and second on 18-5-1981. Pods were hand picked and threshed to separate the grain from husk. Along with the final picking the vines were also pulled out.

3. Observations recorded

The characters studied and observations recorded are detailed below.

3.1 Soil moisture observations

Soil moisture content of all plots at a depth of 0-30 cm was recorded at different growth stages of the crop viz., at germination, branching, flowering and pod formation. Two sampling areas from each plot was selected at random and soil samples were collected using a soil auger. The moisture content was estimated gravimetrically and recorded.

3.2 Dry matter content of weeds

The dry matter content of weeds were found out at four stages, viz., 15th day, 30th day, 45th day and 60th day after sowing. A wooden frame of 1 square metre area was placed randomly in the net plot of each treatment and weeds were removed. The weeds so collected were sundried and then oven dried and the weight was recorded.

3.3 Biometric observations

3.3.1 Height of plants

Ten plants from each plot were selected at random and tagged. The height of the plants from the scar of the first cotyledonous leaves to the tip of the growing point was measured in centimetres at four stages of growth, viz., 20th day, 40th day, 60th day after sowing and at harvest. The mean height of plants was worked out and recorded.

3.3.2 Number of leaves per plant

The total number of compound leaves in the selected observation plants were recorded at 20th day, 40th day, and 60th day after sowing and at harvest. The mean number of leaves per plant was worked out and recorded.

3.3.3 Weight of root nodules per plant

This was worked out at the time of flowering. Four plants were dug out carefully at uniform depth from the rows left exclusively for the purpose. Roots of the plants were washed free of soil particles. The nodules were removed from the roots, oven dried and weight of nodule per plant was worked out.

3.3.4 Dry matter production per plant

Four plants were cut at ground level from the rows left exclusively for the purpose and were air-dried and then oven dried at 80° $\pm$ 5°C till a constant weight was recorded. The dry matter production in grams per plant was then calculated. This observation was recorded at 20th day, 40th day and 60th day after sowing.

3.3.5 Depth of penetration, diametral spread and weight of roots per plant

This was recorded at the time of harvest. Four plants selected at random were dug out without breaking their root. The length of the tap root from the hypocotyle region was measured to determine the depth of penetration of tap root. The horizontal length to both sides, of the longest primary branches was measured to assess the diametral spread of the root system. The roots were then oven dried and dry weight of roots per plant was recorded.

3.4 Yield and yield attributes

3.4.1 Number of pods per plant

Pods collected from the observation plants were counted separately and the average was worked out.

3.4.2 Length of pod

Length of ten pods selected randomly from the net plot of each treatment were measured in cm and the average was worked out.

3.4.3 Number of seeds per pod

Pods used for measuring the length were threshed separately and the number of seeds in each pod was counted and the average was worked out.

3.4.4 100 seed weight

Hundred seeds were selected randomly from the bulk in each net plot, weighed and recorded in grams.

3.4.5 Grain yield

Yield of grain obtained from each net plot was recorded separately and expressed in kg/ha adjusted to 12 per cent moisture.

3.4.6 Bhusa yield

After the pods were picked from each net plot, the plants were uprooted, sundried uniformly and weighed. The weight was expressed in kg/ha.

3.4.7 Total dry matter production

The sample plants were sun dried and then dried to a constant weight in an air oven kept at 80 $\pm$ 5°C for 48 hours. Dry matter production was worked out for each treatment and expressed in kg/ha.

3.4.8 Harvest index

The harvest index was worked out based on the grain, husk and bhusa yield obtained from the net plot using the following formula and expressed in percentage as suggested by Nichiporovich and Stronova (1960).

$$H\ I\ \% = \frac{\text{Economic yield} \times 100}{\text{Biological yield}}$$

3.5 Chemical studies

3.5.1 Plant analysis

The samples were oven dried at 80°C and powdered in a wiley mill and used for chemical analysis. The plant, grain and husk samples were separately analysed for N, P_2O_5 and K_2O.

3.5.1.1 Nitrogen content

Total nitrogen content of the plant, husk and grain samples were determined by modified Micro Kjeldahl method (Jackson 1967).

3.5.1.2 Phosphorus content

Phosphorus contents of the samples were determined by using triple acid extraction method (Jackson, 1967). The Klett-Summerson photo-electric colorimeter was used for reading the colour intensity developed by vanado-molybdo-phosphoric acid.

3.5.1.3 Potassium content

The potassium contents of plant samples were determined by triple acid extraction method and then reading in an EEL flame photometer.

3.5.1.4 Uptake studies

The total uptake of nitrogen, phosphorus and potassium at harvest was calculated and expressed in kg/ha.

3.5.2 Soil analysis

The composite soil sample collected prior to the experiment and soil samples collected from individual plots after the experiment were analysed for total nitrogen, available P_2O_5, available K_2O and organic carbon content.

Total nitrogen was determined by modified Microkjeldhal method (Jackson 1967).

Available phosphorus was determined by Brays method (Jackson 1967).

Available potassium was determined by Neutral normal ammonium acetate method (Jackson, 1967).

Organic carbon content was estimated by Black and Walkely's method (Jackson, 1967).

3.6 Quality characteristics - Protein content of the grain

The percentage of protein in the grain was calculated by multiplying the percentage of nitrogen in the grain by a factor 6.25 (Simpson et al. 1965).

4. Statistical analysis

Data relating to each character of the crop was analysed statistically by applying the technique of analysis of variance (Panse and Sukhatme, 1978).

Results

RESULTS

The results of the experiment conducted to study the influence of cultural practices on the growth and development of cowpea in rice fallows of Pattambi are presented below.

1. Soil moisture content

The mean soil moisture content in the 0 - 30 cm layer of soil at the time of sowing to pod development stage ie. about 50 days after sowing is given in Tables 1.1 to 1.4 and the analysis of variance in Appendix II.

Table 1.1 presents the moisture content of soil at the time of sowing. Results indicated that tillage treatment, interculture and their interactions had no influence on soil moisture content. However, there was slightly higher moisture content in the treatment in which sowing was done on stubbles (M_1).

Tables 1.2, 1.3 and 1.4 present the moisture content of soil at branching, flowering and pod formation stages. Here also tillage treatments, interculture and their interactions had no effect, although there was slightly higher moisture contents, at zero tillage treatments (M_1 and M_2).

Table 1.1 Effect of tillage and interculture on soil moisture content in percentage at the time of sowing (0-30 cm).

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	24.06	24.84	25.92	23.68	18.63	24.68	23.63
	S_2	25.44	23.20	24.54	23.18	21.47	23.48	23.58
	S_3	24.43	25.95	20.06	21.01	23.63	22.78	22.98
	Mean	24.64	24.66	23.50	22.62	21.24	23.65	

SE_m for tillage 1.847

SE_m for interculture 9.818

SE_m for interculture at the same level of tillage 2.405

SE_m for tillage at the same level of interculture 2.695

Table 1.2 Effect of tillage and interculture on soil moisture content in percentage at branching (0-30 cm).

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	17.30	19.38	17.28	16.00	17.53	19.33	17.80
	S_2	18.49	21.35	20.60	17.28	18.20	18.13	19.01
	S_3	21.07	21.33	18.48	20.35	17.65	18.13	19.50
Mean		18.95	20.68	18.78	17.88	17.79	18.53	

SE_m for tillage	1.097
SE_m for interculture	7.405
SE_m for interculture at the same level of tillage	1.814
SE_m for tillage at the same level of interculture	1.843

Table 1.3 Effect of tillage and interculture on soil moisture content in percentage at flowering (0-30 cm).

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter culture	S_1	17.63	16.00	15.90	15.43	11.83	18.13	15.82
	S_2	17.83	15.90	18.83	14.03	15.43	16.20	16.37
	S_3	18.10	19.43	15.95	14.85	14.45	15.95	16.45
Mean		17.85	17.11	16.89	14.77	13.90	16.76	

SE_m for tillage	1.833
SE_m for interculture	7.601
SE_m for interculture at the same level of tillage	1.862
SE_m for tillage at the same level of interculture	2.381

Table 1.4 Effect of tillage and interculture on soil moisture content in percentage at pod formation stage (0-30 cm).

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	20.95	24.05	20.03	18.93	17.80	19.6	20.95
	S_2	22.33	20.23	22.53	18.73	19.03	24.88	22.33
	S_3	22.88	20.95	22.40	20.90	17.95	20.03	22.88
Mean		22.05	21.74	21.65	19.52	18.26	21.50	

SE_m for tillage	1.643
SE_m for interculture	8.355
SE_m for interculture at the same level of tillage	2.047
SE_m for tillage at the same level of interculture	2.344

2. Drymatter content of weeds

Weed dry weight/m^2 at 15 days interval, between 15 days and 60 days after sowing is given in Tables 2.1 to 2.4 and the analysis of variance in Appendix III. Weed dry weight after 60 days was not taken because, after about 45 days the crop smothered the weeds.

Table 2.1 presents the weed dry weight/m^2 at 15 days after sowing. The results revealed that tillage had significant influence on weed drymatter. No-tillage treatments had higher weed dry weight as compared to tillage treatments. All the tillage treatments were on par. Raking also did not have any effect. The interaction effect was also not significant.

Table 2.2 presents the weed dry weight at 30 days after sowing. All the tillage treatments are having lesser weed weight compared to no-tillage treatments. All the tillage treatments were on par. No-tillage treatments ie. sowing on stubbles and chemical tillage with'Lasso'@ 1.5 kg ai/ha were also on par.

The minor treatments of raking and weeding had significant influence on weed dry weight. Raking and weeding on 30th day (S_3) recorded significantly higher values for weed dry weight as compared to raking and

Table 2.1 Effect of tillage and interculture on drymatter content of weeds at 15 days after sowing (g/m^2).

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	157.35	143.73	55.10	64.93	103.40	69.33	98.97
	S_2	238.60	125.95	43.15	94.00	55.30	55.33	102.05
	S_3	111.38	115.03	75.70	62.30	83.43	67.15	85.83
	Mean	169.11	128.23	57.98	73.74	80.71	63.93	

C.D (0.05) for tillage	28.73
SE_m for interculture	9.87
SE_m for interculture at the same level of tillage	24.18
SE_m for tillage at the same level of interculture	23.98

Table 2.2 Effect of tillage and interculture on drymatter content of weeds at 30 days after sowing (g/m^2).

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	95.83	51.72	27.55	27.18	43.60	37.58	48.90
	S_2	92.28	61.58	22.90	44.10	30.28	34.15	47.55
	S_3	150.73	177.03	66.85	74.4	87.28	84.20	106.75
Mean		112.94	100.11	39.10	48.56	53.12	51.98	

C.D (0.05) for tillage	50.01
C.D (0.05) for interculture	19.94
SE_m for interculture at the same level of tillage	24.07
SE_m for tillage at the same level of interculture	30.62

weeding on 15th and 30th day (S_1) and raking and weeding on 15th day (S_2). However, the interaction between tillage and interculture had no significant effect.

Table 2.3 presents the drymatter content of weeds at 45 days after sowing. Tillage treatments had significantly lower weed weight compared to no-tillage treatments, although they were on par among themselves. Treatment, M_3 (one ploughing) recorded the lowest weed weight of 48.8 g/m^2 while treatment, M_1 (sowing on stubbles) recorded the highest weed weight of 166.27 g/m^2. Interculture had significant effect on weed dry weight. Raking and weeding on 15th day (S_2) recorded significantly higher values for weed dry weight when compared to raking and weeding twice (S_1) and raking and weeding on 30th day (S_3). However, the interaction between tillage and interculture had no effect.

Table 2.4 brings out the weed drymatter at 60 days after sowing. Tillage treatments recorded significantly lower drymatter content of weeds compared to no-tillage treatments. While tillage treatments were on par, no-tillage treatments differed significantly between themselves. Herbicide application recorded lower weed density as compared to zero tillage alone.

Table 2.3 Effect of tillage and interculture on drymatter content of weeds at 45 days after sowing (g/m^2).

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Interculture	S_1	131.75	73.10	21.58	37.80	24.63	28.65	52.92
	S_2	187.68	142.68	84.95	99.50	131.13	104.65	125.10
	S_3	179.38	106.45	39.88	52.93	85.93	32.00	82.76
	Mean	166.27	107.41	48.80	63.41	80.56	55.10	

C.D (0.05) for tillage	60.03
C.D (0.05) for interculture	20.54
SE_m for interculture at the same level of tillage	24.79
SE_m for tillage at the same level of interculture	34.70

Table 2.4 Effect of tillage and interculture on drymatter content of weeds at 60 days after sowing (g/m^2).

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	79.38	52.43	35.90	35.60	35.38	30.28	44.83
	S_2	154.90	117.83	61.88	78.15	101.28	75.90	98.32
	S_3	130.30	72.38	62.73	48.60	53.23	48.95	60.36
Mean		121.53	80.88	53.50	54.12	63.29	51.71	

C.D (0.05) for tillage	31.82
C.D (0.05) for interculture	14.60
SE_m for interculture at the same level of tillage	17.61
SE_m for tillage at the same level of interculture	20.74

Interculture had significant effect on weed dry weight. Raking and weeding twice (S_1) recorded significantly lower values compared to other treatments. Raking and weeding on 15th day (S_2) recorded the highest weed dry weight of 98.32 g/m^2 and raking and weeding twice (S_1) recorded the lowest value of 44.83 g/m^2. The interaction between tillage and interculture had no effect.

3. Growth and growth attributes

3.1 Height of plants

The data on mean height of plants recorded at 20th, 40th and 60th days after sowing and at harvest are presented in Tables 3.1 to 3.4 and the analysis of variance in Appendix IV.

It is seen that tillage, interculture and their interactions had no influence on plant height at 20 days after sowing.

Table 3.2 presents the data on plant height at 40 days after sowing. Tillage had significant effect on plant height and recorded higher plant height as compared to no-tillage treatments. Among the tillage treatments, M_3 (one ploughing) recorded significantly higher value of 44.15 cm, all others being on par except M_6 (sowing and then ploughing) which was on par with M_3. No-tillage treatments were also on par.

Table 3.1 Effect of tillage and interculture on plant height at 20 days after sowing (cm).

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	15.80	15.98	17.53	17.38	16.53	17.85	16.84
	S_2	15.83	15.45	16.50	15.85	16.38	16.70	16.12
	S_3	16.15	17.13	17.98	16.98	15.88	15.70	16.63
	Mean	15.93	16.18	17.33	16.73	16.26	16.75	

SE_m for tillage	0.90
SE_m for interculture	0.35
SE_m for interculture at the same level of tillage	0.87
SE_m for tillage at the same level of interculture	1.14

Table 3.2 Effect of tillage and interculture on plant height at 40 days after sowing (cm).

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	31.65	35.78	44.58	37.28	39.03	41.48	38.30
	S_2	28.05	33.53	44.05	38.80	37.13	40.10	36.94
	S_3	29.08	31.20	43.83	37.10	35.73	37.55	35.75
	Mean	29.59	33.50	44.15	37.73	37.20	39.71	

C.D (0.05) for tillage	6.21
SE_m for interculture	1.51
SE_m for interculture at the same level of tillage	3.70
SE_m for tillage at the same level of interculture	4.20

Interculture and interaction between tillage and interculture had no effect on plant height.

The data on mean plant height at 60 days after sowing presented in Table 3.3, revealed that tillage treatments had significantly higher plant height over no-tillage treatments. Among tillage treatments, Treatment M_5 (ploughing thrice) recorded significantly lower values of 98.35 cm as compared to other levels. Treatment M_3 (one ploughing) recorded the highest height of 121.62 cm. No-tillage treatments were on par.

Raking and weeding on 15th and 30th day (S_1) recorded significantly higher plant height compared to other levels which were on par. Interaction had no effect.

Table 3.4 presents the mean plant height at harvest. Here also tillage treatments had significant effect on plant height as compared to no-tillage treatments. Among tillage treatments, M_3 (one ploughing) was found to be superior, all other being on par. No-tillage treatments did not differ significantly between themselves.

Raking and weeding twice (S_1) recorded the highest plant height. Raking and weeding on 15th day (S_2) and raking and weeding on 30th day (S_3) were on par. Interaction between tillage and interculture had no effect.

Table 3.3 Effect of tillage and interculture on plant height at 60 days after sowing (cm).

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	69.05	82.13	137.48	104.88	103.28	108.16	100.83
	S_2	55.75	68.93	121.18	101.28	95.95	110.83	92.32
	S_3	68.05	64.28	106.20	101.63	95.83	105.25	90.20
Mean		64.28	71.78	121.62	102.59	98.35	108.08	

C.D (0.05) for tillage	18.95
C.D (0.05) for interculture	8.11
SE_m for interculture at the same level of tillage	9.79
SE_m for tillage at the same level of interculture	11.96

Table 3.4 Effect of tillage and interculture on plant height at harvest (cm).

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	88.90	103.83	152.70	115.53	121.88	118.80	116.95
	S_2	75.53	89.05	130.23	112.45	111.18	126.25	107.45
	S_3	79.95	89.28	123.23	121.50	107.38	125.90	107.87
	Mean	81.48	94.05	135.38	116.49	113.48	123.65	

C.D (0.05) for tillage	16.86
C.D (0.05) for interculture	8.32
SE_m for interculture at the same level of tillage	10.03
SE_m for tillage at the same level of interculture	11.39

3.2 Number of leaves per plant

The data on mean number of leaves per plant recorded at 20th, 40th and 60th days after sowing and at harvest are presented in Tables 4.1 to 4.4 and the analysis of variance in Appendix IV.

It is seen that neither tillage and interculture nor their interactions could influence the leaf number at 20 days after sowing.

Tillage treatments had significantly higher leaf number at 40 days after sowing compared to no-tillage treatments and they were on par among themselves. The treatment M_3 recorded the highest leaf number of 12.2 leaves per plant while the treatment M_1, recorded the lowest leaf number of 8.40 leaves per plant. Raking and weeding on 15th and 30th day (S_1) had higher leaf number compared to S_2 (Raking and weeding on 15th day) and S_3 (Raking and weeding on 30th day). But S_2 and S_3 were on par. Raking and weeding on 30th day recorded the lowest leaf number. The interaction between tillage and interculture had no effect on the number of leaves.

Tillage treatments had significantly higher leaf number at 60 days after sowing when compared to no-tillage treatments. But, there were no significant differences between the two no-tillage treatments and the different tillage treatments. Treatment M_3 recorded the highest leaf number

Table 4.1 Effect of tillage and interculture on number of leaves per plant at 20 days after sowing

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	3.90	4.30	4.73	4.38	4.28	4.50	4.35
	S_2	3.73	3.90	4.68	4.48	4.28	4.68	4.29
	S_3	4.05	3.88	4.83	4.35	4.20	4.18	4.25
	Mean	3.89	4.04	4.74	4.40	4.25	4.45	

SE_m for tillage	0.257
SE_m for interculture	0.096
SE_m for interculture at the same level of tillage	0.236
SE_m for tillage at the same level of interculture	0.321

Table 4.2 Effect of tillage and interculture on number of leaves per plant at 40 days after sowing.

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	8.65	8.87	12.80	12.25	11.33	12.33	11.04
	S_2	8.08	8.58	12.30	11.33	11.03	11.88	10.45
	S_3	8.48	8.25	11.50	10.25	10.48	11.55	10.08
	Mean	8.40	8.56	12.20	11.28	10.94	11.75	

C.D (0.05) for tillage	1.413
C.D (0.05) for interculture	0.601
SE_m for interculture at the same level of tillage	0.725
SE_m for tillage at the same level of interculture	0.889

Table 4.3 Effect of tillage and interculture on number of leaves per plant at 60 days after sowing.

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	10.60	10.43	14.90	15.23	13.23	13.45	12.97
	S_2	9.60	10.08	14.70	12.35	11.68	13.52	11.99
	S_3	10.20	9.25	13.35	11.93	11.28	13.03	11.50
Mean		10.13	9.92	14.32	13.17	12.06	13.33	

C.D (0.05) for tillage	2.303
C.D (0.05) for interculture	0.686
SE_m for interculture at the same level of tillage	0.828
SE_m for tillage at the same level of interculture	1.270

Table 4.4 Effect of tillage and interculture on number of leaves per plant at harvest.

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	5.80	6.20	4.20	4.14	5.03	5.04	5.06
	S_2	4.33	4.63	4.91	5.02	4.32	4.66	4.64
	S_3	5.05	5.31	5.18	4.99	4.05	4.58	4.86
	Mean	5.06	5.36	4.76	4.71	4.46	4.76	

SE_m for tillage	0.800
SE_m for interculture	0.400
SE_m for interculture at the same level of tillage	0.980
SE_m for tillage at the same level of interculture	1.131

of 14.32 leaves per plant while the treatment M_2 recorded the lowest leaf number of 9.92 leaves per plant. Raking and weeding twice (S_1) had higher leaf number compared to S_2 (Raking and weeding on 15th day) and S_3 (Raking and weeding on 30th day) which were on par. Raking and weeding on 30th day (S_3) recorded the lowest leaf number. Interaction had no effect.

Tillage treatments, interculture and their interactions had no effect on number of leaves per plant at harvest.

3.3 Drymatter production

Tables 5.1, 5.2 and 5.3 present the drymatter production per plant at 20th, 40th and 60th days after sowing respectively. The analysis of variances is given in Appendix IV.

Tillage, interculture and interaction between tillage and interculture could exert any influence on drymatter production at 20th and 40th days after sowing. But the interculture treatments showed significant effect at 40th days after sowing. Raking and weeding twice (S_1) recorded significantly higher value (4.57 g/plant) compared to raking and weeding on 15th day (S_2) and raking and weeding on 30th day (S_3) which were on par. Raking and weeding on 30th day recorded the lowest value of 3.77 g/plant.

Table 5.1 Effect of tillage and interculture on drymatter production at 20 days after sowing (g/plant).

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	0.90	0.83	1.30	0.97	1.00	1.10	1.01
	S_2	0.93	0.69	0.95	0.93	1.06	1.10	0.94
	S_3	0.92	0.87	1.14	1.04	0.90	0.98	0.98
	Mean	0.92	0.79	1.13	0.98	1.01	1.06	

SE_m for tillage	0.119
SE_m for interculture	0.066
SE_m for interculture at the same level of tillage	0.162
SE_m for tillage at the same level of interculture	0.178

Table 5.2 Effect of tillage and interculture on drymatter production at 40 days after sowing (g/plant).

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	3.22	5.14	4.63	3.88	5.92	4.61	4.57
	S_2	3.31	3.29	4.32	4.65	4.36	4.55	4.12
	S_3	2.49	3.59	4.98	3.93	3.84	3.81	3.77
	Mean	3.00	4.00	4.65	4.15	4.77	4.32	

SE_m for tillage 0.619

C.D (0.05) for interculture 0.638

SE_m for interculture at the same level of tillage 0.771

SE_m for tillage at the same level of interculture 0.882

Table 5.3 Effect of tillage and interculture on drymatter production at 60 days after sowing (g/plant).

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Interculture	S_1	5.17	7.99	9.35	7.73	7.35	9.39	7.83
	S_2	5.89	7.14	7.88	8.65	9.55	9.76	8.15
	S_3	5.81	6.64	8.42	8.44	7.09	6.99	7.21
	Mean	5.62	7.26	8.55	8.27	7.99	8.71	

C.D (0.05) for tillage	1.863
SE_m for interculture	0.333
C.D (0.05) for interculture at the same level of tillage	1.684
C.D (0.05) for tillage at the same level of interculture	2.274

Tillage treatments had significant effect on dry-matter production at 60 days after sowing. Treatment M_1 (Sowing on stubbles) recorded the lowest value, all others being on par. Sowing and then ploughing treatment (M_6) recorded the highest value of 8.71 g/plant. While interculture had no significant effect at 60 days after sowing, interaction had significant effect. Among M_1, M_2, M_3 and M_4 interculture had no significant effect on drymatter production. However, treatment M_5 (Ploughing thrice) raking and weeding on 15th day (S_2) had significantly higher dry-matter production compared to other interculture levels. In M_6 treatment, raking and weeding on 30th day (S_3) recorded significantly lower value compared to raking and weeding on 15th day (S_2) and raking and weeding twice on 15th and 30th day (S_1) which were on par among themselves.

Under raking and weeding twice (S_1) and raking and weeding on 30th day, treatment S_3 (Sowing on stubbles) recorded significantly lower values when compared to other tillage levels which were on par. Under raking and weeding on 15th day (S_2) tillage treatments had significantly higher drymatter production over no-tillage treatments although they were on par among themselves.

3.4 <u>Dry weight of root nodules per plant at flowering</u>

The mean dry weight of root nodules per plant at flowering is given in Table 6 and the analysis of variance in Appendix IV.

Table 6 Effect of tillage and interculture on dry weight of root nodules at flowering (g/plant).

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Interculture	S_1	0.032	0.022	0.034	0.053	0.028	0.051	0.037
	S_2	0.051	0.040	0.016	0.046	0.028	0.029	0.035
	S_3	0.046	0.032	0.027	0.044	0.024	0.019	0.035
Mean		0.043	0.038	0.026	0.048	0.027	0.033	

SE_m for tillage	0.0078
SE_m for interculture	0.0063
SE_m for interculture at the same level of tillage	0.0154
SE_m for tillage at the same level of interculture	0.0149

The weight of root nodules per plant was not influenced by the different levels of tillage, interculture and their interactions.

3.5 Spread of roots

The mean maximum spread of roots is presented in Table 7.1 and the analysis of variance in Appendix IV.

While the levels of tillage, and the interaction between tillage and interculture had no influence on the spread of roots, interculture had significant effect on root spread. Raking and weeding on 15th and 30th day (S_1) had higher root spread compared to raking and weeding on 15th day (S_2) and raking and weeding on 30th day (S_3) which were on par.

3.6 Length of root

The mean values of length of root at harvest are presented in Table 7.2 and the analysis of variance in Appendix IV.

The levels of tillage and interaction between tillage and interculture had no influence on the length of root. However, interculture had significant effect on root length. Raking and weeding twice (S_1) had higher root length compared to raking and weeding on 15th day (S_2) and raking and weeding on 30th day (S_3) which were on par.

Table 7.1 Effect of tillage and interculture on spread of roots at harvest (cm).

	Tillage						Mean
	M_1	M_2	M_3	M_4	M_5	M_6	
S_1	25.63	23.88	24.63	24.50	24.63	25.90	24.86
Inter-culture S_2	21.38	21.25	23.88	21.25	21.50	22.23	21.91
S_3	21.75	21.00	22.00	21.88	22.05	23.65	22.05
Mean	22.02	22.04	23.50	22.54	22.73	23.93	

SE_m for tillage	1.153
C.D. (0.05) for interculture	1.360
SE_m for interculture at the same level of tillage	1.643
SE_m for tillage at the same level of interculture	1.769

Table 7.2 Effect of tillage and interculture on length of root at harvest (cm).

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_5	
Inter-culture	S_1	18.38	21.19	21.38	20.00	19.31	21.75	20.33
	S_2	17.25	17.56	19.88	19.44	19.13	20.03	18.88
	S_3	19.19	16.44	20.13	16.88	16.94	18.88	18.07
	Mean	18.27	18.39	20.45	18.77	18.45	20.22	

SE_m for tillage	1.051
C.D (0.05) for interculture	1.314
SE_m for interculture at the same level of tillage	1.827
SE_m for tillage at the same level of interculture	1.825

3.7 Root weight per plant

The mean root weight at harvest is presented in Table 7.3 and respective analysis of variance in Appendix IV.

The data revealed no significant influence of levels of tillage, interculture and their interactions on root weight.

4. Yield and yield attributes

4.1 Number of pods per plant

The date on mean number of pods per plant are presented in Table 8.1 and the analysis of variance in Appendix V.

Tillage treatments had significantly higher number of pods than no-tillage treatments. However, there were no significant differences between the different tillage and no-tillage treatments. Treatment M_3 (one ploughing) and M_6 (sowing and then ploughing) recorded the highest number of pods of 3.93 while treatment M_2 (zero tillage with herbicide) recorded the lowest pod number of 2.99. Interculture had significant effect. Raking and weeding twice (S_1) recorded significantly higher values compared to raking and weeding on 15th day (S_2) and raking and weeding on 30th day (S_3) which were on par. However, interaction had no effect.

Table 7.3 Effect of tillage and interculture on root weight at harvest (g/plant).

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	1.64	1.49	1.79	1.58	1.70	1.00	1.66
	S_2	1.23	1.65	1.49	1.64	1.25	1.51	1.46
	S_3	1.43	1.35	1.76	1.71	1.41	1.61	1.55
Mean		1.43	1.50	1.67	1.64	1.45	1.64	

SE_m for tillage	0.151
SE_m for interculture	0.098
SE_m for interculture at the same level of tillage	0.241
SE_m for tillage at the same level of interculture	0.248

Table 8.1 Effect of tillage and interculture on number of pods per plant.

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	3.45	3.43	4.50	4.25	4.15	4.33	4.02
	S_2	2.98	2.70	3.75	3.40	3.55	3.83	3.37
	S_3	2.90	2.85	3.55	3.15	3.33	3.63	3.23
	Mean	3.10	2.99	3.93	3.60	3.68	3.93	

C.D (0.05) for tillage 0.69

C.D (0.05) for interculture 0.32

SE_m for interculture at the same level of tillage 0.39

SE_m for tillage at the same level of interculture 0.45

4.2 Length of pod

The mean values on length of pod are presented in Table 8.2 and the analysis of variance in Appendix V.

The tillage treatments failed to produce any significant effect on the length of pods.

Raking and weeding on 15th and 30th day (S_1) recorded significantly higher values of pod length compared to raking and weeding on 15th day (S_2) and raking and weeding on 30th day (S_3) which were on par.

Interaction between tillage and interculture had significant effect on the length of pod. Among tillage treatments M_1, M_3, M_4 and M_6 interculture had no significant effect on pod length. In M_2 and M_5 treatments, raking and weeding twice (S_1) gave significantly higher values for pod length when compared to raking and weeding on 30th day (S_3). Raking and weeding on 15th day (S_2) and raking and weeding twice (S_1) and raking and weeding on 30th day (S_3) were on par in treatment M_2. But in M_5 (ploughing thrice) only raking and weeding twice (S_1) and raking and weeding on 15th day (S_2) were on par.

In raking and weeding on 15th day and 30th day (S_1), tillage treatments did not differ between themselves in the case of pod length. However, in raking and weeding on 15th day (S_2) tillage treatment had significantly higher

Table 8.2 Effect of tillage and interculture on length of pod (cm).

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	15.01	15.30	16.13	15.11	15.63	15.90	15.53
	S_2	14.46	14.45	15.70	14.73	15.28	15.58	15.03
	S_3	14.29	14.24	15.38	15.56	13.60	15.24	14.71
Mean		14.38	14.66	15.73	15.13	14.83	15.60	

SE_m for tillage	0.178
C.D (0.05) for interculture	0.360
C.D (0.05) for interculture at the same level of tillage	0.900
C.D (0.05) for tillage at the same level of interculture	1.130

values compared to no-tillage treatments. In S_3 (Raking and weeding on 30th day), treatment M_5 (Ploughing thrice) recorded the lowest value for pod length compared to other tillage levels.

4.3 Number of seeds per pod

The mean values on number of seeds per pod are presented in Table 8.3 and the analysis of variance in Appendix V.

Data revealed that there was no significant effect due to tillage and interaction between tillage and interculture on the number of seeds per pod. However, interculture had significant effect on number of seeds per pod. Raking and weeding twice (S_1) recorded the highest number of seeds per pod which was on par with raking and weeding on 15th day only (S_2). However, raking and weeding on 15th day (S_2) and raking and weeding on 30th day (S_3) were also on par.

4.4 Seed-test weight

The mean values for 100 seed weight are presented in Table 8.4 and the analysis of variance in Appendix V.

It can be seen from the Table that neither the levels of tillage and interculture nor their interactions could produce any significant influence on the 100 seed weight.

Table 8.3 Effect of tillage and interculture on number of seeds per pod.

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	13.58	14.18	13.78	13.35	13.65	13.00	13.65
	S_2	12.90	12.75	14.15	13.63	13.25	13.08	13.29
	S_3	13.13	12.95	13.38	13.28	13.00	13.48	13.20
	Mean	13.20	13.20	13.77	13.42	13.30	13.38	

SE_m for tillage	0.256
C.D (0.05) for interculture	0.390
SE_m for interculture at the same level of tillage	0.476
SE_m for tillage at the same level of interculture	0.465

Table 8.4 Effect of tillage and interculture on 100 seed weight (g).

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	12.10	12.08	12.50	12.48	12.78	13.13	12.51
	S_2	11.55	12.63	13.03	12.55	12.45	12.68	12.48
	S_3	11.98	12.58	12.88	12.90	12.13	12.48	12.48
	Mean	11.87	12.43	12.79	12.64	12.45	12.76	

SE_m for tillage 0.305

SE_m for interculture 0.202

SE_m for interculture at the same level of tillage 0.495

SE_m for tillage at the same level of interculture 0.506

4.5 Grain yield

The data regarding the grain yield as influenced by levels of tillage and interculture are presented in Table 8.5 and the analysis of variance in Appendix V.

Tillage treatments produced significantly higher yields over no-tillage treatments. But there were no significant differences between the two no-tillage treatments and the different tillage treatments. Treatment M_3 (One ploughing) recorded highest grain yield of 1043.34 kg/ha while treatment M_1 (Sowing on stubbles) recorded the lowest grain yield of 629.73 kg/ha. Raking and weeding on 15th day and 30th day (S_1) gave significantly higher yields compared to raking and weeding on 15th day (S_2) and raking and weeding on 30th day (S_3) which were on par. Interaction between tillage and interculture had no effect.

4.6 Bhusa yield

The mean bhusa yield as influenced by levels of tillage, interculture and their interaction are presented in Table 8.6 and the analysis of variance in Appendix V.

Levels of tillage failed to produce any significant effect on bhusa yield. Raking and weeding on 15th day and 30th day (S_1) recorded significantly higher values compared to raking and weeding on 15th day (S_2) and raking and weeding on 30th day (S_3). But S_2 and S_3 were on par.

Table 8.5 Effect of tillage and interculture on grain yield (kg/ha).

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	720.39	712.19	1233.21	1104.09	937.12	1072.72	963.29
	S_2	628.81	702.69	919.39	942.31	958.49	984.43	856.02
	S_3	539.99	521.98	977.41	823.51	914.83	894.38	778.69
	Mean	629.73	645.62	1043.34	956.65	936.81	983.85	

C.D (0.05) for tillage	160.54
C.D (0.05) for interculture	85.42
SE_m for interculture at the same level of tillage	103.10
SE_m for tillage at the same level of interculture	112.99

Table 8.6 Effect of tillage and interculture on bhusa yield (kg/ha).

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	1312.58	1709.40	1907.81	1709.40	1724.66	1785.71	1691.59
	S_2	824.18	1388.89	1480.46	1862.03	1221.00	1831.50	1434.68
	S_3	1068.38	1358.36	1465.20	1434.68	1578.08	1510.99	1402.61
Mean		1068.38	1485.55	1617.83	1668.70	1507.91	1709.40	

SE_m for tillage	215.21
C.D (0.05) for interculture	134.79
C.D (0.05) for interculture at the same level of tillage	338.29
C.D (0.05) for tillage at the same level of interculture	526.01

Interaction between tillage and interculture had significant effect. In M_1 and M_3 raking and weeding twice (S_1) recorded significantly higher values of bhusa yield when compared to other levels of interculture. In M_2 and M_5 treatments, raking and weeding twice (S_1) recorded significantly higher values compared to S_3 (Raking and weeding on 30th day only). Raking and weeding on 15th day (S_2) was on par with the other two levels of interculture. In M_4 treatment, raking and weeding on 15th day (S_2) recorded significantly higher values for bhusa yield compared to raking and weeding on 30th day (S_3). Raking and weeding twice (S_1) was on par with raking and weeding on 15th day (S_2) and raking and weeding on 30th day (S_3). However, no significant difference between raking and weeding treatments were observed in sowing and then ploughing treatment (M_6). Among raking and weeding twice (S_1), treatment M_1 recorded the lowest value compared to other tillage levels. In raking and weeding on 15th day (S_2), treatments M_1 and M_5 recorded significantly lower values when compared to other tillage treatments. However, no significant difference between tillage treatments were observed under raking and weeding on 30th day (S_3).

4.7 Total drymatter production

The data on mean total drymatter production are presented in Table 8.7 and the analysis of variance in Appendix V.

Table 8.7 Effect of tillage and interculture on total drymatter production (kg/ha).

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Interculture	S_1	2376.37	2873.02	3556.77	3349.21	3184.68	3183.76	3087.30
	S_2	1694.14	2308.28	2788.46	3130.34	3194.44	2844.32	2659.99
	S_3	1996.34	2089.44	3032.64	2649.57	2762.51	2784.80	2552.55
Mean		2022.28	2423.57	3125.95	3043.03	3047.21	2937.63	

C.D (0.05) for tillage	567.60
C.D (0.05) for interculture	179.01
SE_m for interculture at the same level of tillage	216.00
SE_m for tillage at the same level of interculture	319.56

Tillage treatments had significantly higher values over no-tillage treatments. But there were no significant differences between the two no-tillage treatments and the different tillage treatments. Treatment M_1 (Sowing on stubbles) recorded the lowest value of 2022.28 kg/ha while treatment M_3 (One ploughing) recorded the highest value of 3125.95 kg/ha.

Raking and weeding on 15th and 30th day (S_1) gave significantly higher values compared to other levels of interculture. Raking and weeding on 15th day (S_2) and raking and weeding on 30th day (S_3) were on par. Interaction between tillage and interculture had no effect.

4.8 Harvest index

The data on harvest index are presented in Table 8.8 and the analysis of variance in Appendix V.

Data revealed that tillage, interculture and their interactions were ineffective in the case of harvest index.

5. Quality factors - chemical composition and nutrient uptake

5.1 Protein content of grain

The mean protein percentages of grain are presented in Table 9 and the analysis of variance in Appendix VI.

Table 8.8 Effect of tillage and interculture on harvest index

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	30.08	24.91	34.52	34.60	31.00	35.23	31.73
	S_2	36.03	30.77	34.14	30.35	30.37	35.98	32.94
	S_3	25.54	28.42	32.69	33.02	34.43	33.61	31.29
Mean		30.55	28.03	33.78	32.66	31.94	34.94	

SE_m for tillage	0.56
SE_m for interculture	1.42
SE_m for interculture at the same level of tillage	3.49
SE_m for tillage at the same level of interculture	4.56

Table 9. Effect of tillage and interculture on protein content of grain (percentage)

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	22.96	26.95	27.57	24.34	24.75	16.17	25.46
	S_2	23.94	24.98	25.29	25.25	27.81	25.94	25.53
	S_3	25.75	25.95	26.69	24.80	25.90	26.48	25.93
	Mean	24.22	25.96	26.51	24.80	26.15	26.20	

SE_m for tillage	0.905
SE_m for interculture	0.679
SE_m for interculture at the same level of tillage	1.664
SE_m for tillage at the same level of interculture	1.632

It can be seen from the Table that neither the levels of tillage and interculture nor their interaction exerted any influence on the protein content of grain .

5.2 Nitrogen content of plant parts

The data on total nitrogen content expressed as percentages in grain, bhusa and husk at harvest are presented in Tables 10.1, 10.2 and 10.3 and the analysis of variance in Appendix VI.

The data revealed that there was no significant effect due to tillage, interculture and their interactions.

5.3 Phosphorus content of plant parts

5.3.1 Phosphorus content of grain

Data on phosphorus content of grain are presented in Table 11.1 and the analysis of variance in Appendix VI.

The data revealed that there was no significant effect due to tillage treatments, interculture and their interactions on phosphorus content of grain.

5.3.2 Phosphorus content of bhusa at harvest

Data on phosphorus content of bhusa harvest are presented in Table 11.2 and the analysis of variance in Appendix VI.

Table 10.1 Effect of tillage and interculture on nitrogen content of grain (percentage)

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Interculture	S_1	3.67	4.31	4.41	3.90	3.80	4.19	4.05
	S_2	3.83	4.00	4.05	4.04	4.45	4.15	4.09
	S_3	4.12	4.15	4.27	3.97	4.14	4.24	4.15
Mean		3.87	4.15	4.24	3.97	4.13	4.19	

SE_m for tillage	0.145
SE_m for interculture	0.102
SE_m for interculture at the same level of tillage	0.251
SE_m for tillage at the same level of interculture	0.251

Table 10.2 Effect of tillage and interculture on nitrogen content of bhusa (percentage)

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	1.84	1.47	1.94	1.22	1.82	1.82	1.68
	S_2	2.01	1.94	1.67	1.80	1.22	1.86	1.74
	S_3	1.97	2.16	1.22	1.94	2.18	1.63	1.84
	Mean	1.94	2.85	1.61	1.64	1.74	1.77	

SE_m for tillage 0.248

SE_m for interculture 0.162

SE_m for interculture at the same level of tillage 0.397

SE_m for tillage at the same level of interculture 0.408

Table 10.3 Effect of tillage and interculture on nitrogen content of husk (percentage)

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	0.95	0.96	1.03	1.00	1.04	0.94	0.99
	S_2	0.80	1.06	0.98	0.98	1.05	0.81	0.95
	S_3	0.96	1.05	0.95	1.02	0.76	0.80	0.92
	Mean	0.90	1.02	0.99	0.99	0.95	0.85	

SE_m for tillage	0.074
SE_m for interculture	0.048
SE_m for interculture at the same level of tillage	0.120
SE_m for tillage at the same level of interculture	0.120

Table 11.1 Effect of tillage and interculture on phosphorus content of grain (percentage)

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	1.14	1.25	1.31	1.10	1.12	1.18	1.18
	S_2	1.62	1.37	1.11	1.13	1.18	1.22	1.20
	S_3	1.10	1.17	1.17	1.15	1.08	1.14	1.14
	Mean	1.13	1.26	1.20	1.13	1.25	1.18	

SE_m for tillage	0.052
SE_m for interculture	0.034
SE_m for interculture at the same level of tillage	0.082
SE_m for tillage at the same level of interculture	0.085

Table 11.2 Effect of tillage and interculture on phosphorus content of bhusa (percentage)

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	0.602	0.716	0.392	0.458	0.566	0.653	0.564
	S_2	0.510	0.412	0.777	0.512	0.459	0.547	0.536
	S_3	0.516	0.453	0.519	0.681	0.608	0.491	0.544
	Mean	0.543	0.527	0.563	0.550	0.544	0.564	

SE_m for tillage	0.061
SE_m for interculture	0.036
C.D (0.05) for interculture at the same level of tillage	0.178
C.D.(0.05) for tillage at the same level of interculture	0.192

The data revealed that there was no effect due to tillage and interculture on phosphorus content of bhusa at harvest. But interaction was found to be significant.

In no-tillage treatments M_1 and M_2, raking and weeding twice resulted in higher values of phosphorus content compared to raking and weeding once either on 15th day or 30th day.

In M_3 raking and weeding on 15th day (S_2) resulted in higher values of phosphorus content compared to raking and weeding on 15th and 30th day (S_1) and raking and weeding on 30th day (S_3) which were on par. In M_4, raking and weeding on 30th day (S_3) resulted in significantly higher values compared to raking and weeding twice (S_1) and raking and weeding on 15th day (S_2). But S_1 and S_2 are on par. In M_5 and M_6 no significant difference between raking and weeding treatments were observed.

In raking and weeding twice, tillage treatments M_3 and M_4 (One ploughing and two ploughing respectively) recorded lower values of phosphorus content. No-tillage treatments M_1 and M_2 were on par. Chemical tillage with 'Lasso' @ 1.5 kg ai/ha (M_2) recorded the highest value of 0.716 while M_3 recorded the lowest value of 0.392. In raking and weeding on 15th day (S_2) treatment M_3

recorded significantly higher values, all others being on par. In raking and weeding on 30th day (S_3), M_2 recorded significantly lower values compared to other treatments which were on par.

5.3.3 Phosphorus content of husk

The data on phosphorus content of husk are presented in Table 11.3 and the analysis of variance in Appendix VI.

The data revealed no significant influence of tillage, interculture and their interactions, on phosphorus content of husk.

5.4 Potassium content of plant parts

The data on potassium content expressed as percentage in grain, bhusa and husk at harvest are presented in Tables 12.1 to 12.3 and the analysis of variance in Appendix VI.

The data revealed that there was no significant effect due to tillage, interculture and their interaction on potassium content of plant parts.

5.5 Uptake of nitrogen, phosphorus and potassium at harvest

5.5.1 Uptake of nitrogen at harvest

The data on uptake of nitrogen at harvest are presented in Table 13 and the analysis of variance in Appendix VI.

Table 11.3 Effect of tillage and interculture on phosphorus content of husk (percentage)

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	0.22	0.27	0.28	0.20	0.25	0.18	0.23
	S_2	0.20	0.24	0.27	0.20	0.24	0.15	0.22
	S_3	0.22	0.24	0.22	0.22	0.18	0.17	0.21
	Mean	0.21	0.25	0.26	0.20	0.23	0.17	

SE_m for tillage	0.028
SE_m for interculture	0.014
SE_m for interculture at the same level of tillage	0.033
SE_m for tillage at the same level of interculture	0.039

Table 12.1 Effect of tillage and interculture on potassium content of grain (percentage)

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	1.54	1.58	1.66	1.52	1.52	1.56	1.56
	S_2	1.47	1.60	1.50	1.53	1.58	1.66	1.56
	S_3	1.45	1.53	1.53	1.57	1.54	1.57	1.53
Mean		1.48	1.57	1.56	1.54	1.55	1.59	

SE_m for tillage	0.054
SE_m for interculture	0.023
SE_m for interculture at the same level of tillage	0.057
SE_m for tillage at the same level of interculture	0.071

Table 12.2 Effect of tillage and interculture on potassium content of bhusa (percentage)

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	0.98	1.00	1.06	0.96	0.97	0.99	0.99
	S_2	0.98	1.01	0.95	0.98	1.01	1.01	0.99
	S_3	0.92	0.98	0.91	1.00	0.98	1.00	0.97
Mean		0.94	0.99	0.99	0.98	0.98	1.01	

SE_m for tillage	0.034
SE_m for interculture	0.015
SE_m for interculture at the same level of tillage	0.036
SE_m for tillage at the same level of interculture	0.045

Table 12.3 Effect of tillage and interculture on potassium content of husk (percentage)

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Interculture	S_1	0.66	0.68	0.71	0.65	0.65	0.67	0.67
	S_2	0.63	0.68	0.64	0.65	0.68	0.71	0.66
	S_3	0.62	0.66	0.65	0.68	0.66	0.67	0.65
Mean		0.63	0.67	0.67	0.66	0.66	0.68	

SE_m for tillage	0.023
SE_m for interculture	0.010
SE_m for interculture at the same level of tillage	0.025
SE_m for tillage at the same level of interculture	0.031

Table 13 Effect of tillage and interculture on uptake of nitrogen at harvest (kg/ha)

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	53.40	57.29	96.48	72.12	71.12	84.95	72.56
	S_2	43.26	59.67	67.33	76.11	61.63	80.58	64.76
	S_3	45.03	53.38	64.08	68.34	75.84	67.88	62.42
	Mean	47.23	56.78	75.96	72.19	69.53	77.80	

C.D (0.05) for tillage	18.25
C.D (0.05) for interculture	6.44
C.D (0.05) for interculture at the same level of tillage	16.08
C.D (0.05) for tillage at the same level of interculture	22.09

Tillage treatments had significantly higher values compared to no-tillage treatments. But there were no significant differences between the two no-tillage treatments and the different tillage treatments. Treatment M_6 (Sowing and then ploughing) recorded the highest value, while Treatment M_1 (Sowing on stubbles) recorded the lowest value.

Among interculture treatments raking and weeding on 15th and 30th day (S_1) recorded significantly higher values compared to raking and weeding on 15th day (S_2) and raking and weeding on 30th day (S_3) which were on par.

No significant difference between raking and weeding was observed under Treatments M_1, M_2 , M_4 and M_5. In treatment M_3 and M_6 raking and weeding twice recorded significantly higher values. Here again raking and weeding on 15th day (S_2) and raking and weeding on 30th day (S_3) were on par.

Under raking and weeding twice on 15th and 30th day (S_1) one ploughing (M_3) recorded significantly higher value compared to other tillage treatments. Under raking and weeding on 15th day (S_2) sowing on stubbles (M_1) recorded significantly lower value compared to other tillage treatments. Same trend was observed under raking and weeding on 30th day (S_3) also.

5.5.2 Phosphorus uptake at harvest

Data on phosphorus uptake at harvest are presented in Table 14 and the analysis of variance in Appendix VI.

Tillage treatments had significantly higher values when compared to no-tillage treatments. But there were no significant differences between the two no-tillage treatments and the different tillage treatments. Treatment M_3 (One ploughing) recorded the highest value of 22.62 kg/ha while treatment M_1 (Sowing on stubbles) recorded the lowest value of 13.71 kg/ha.

Interculture had significant effect on phosphorus uptake. Raking and weeding twice recorded significantly higher values when compared to raking and weeding on 15th day (S_2) and raking and weeding on 30th day (S_3). Interaction had no effect.

5.5.3 Potassium uptake at harvest

The data on potassium uptake at harvest are presented in Table 15 and the analysis of variance in Appendix VI.

Tillage treatments had significantly higher values when compared to no-tillage treatments. But there were no significant differences between the two no-tillage treatments and the different tillage treatments. Treatment M_3 (One ploughigg) recorded the highest value

Table 14 Effect of tillage and interculture on uptake of phosphorus at harvest (kg/ha)

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Interculture	S_1	16.78	23.00	24.84	21.15	21.10	24.94	21.98
	S_2	12.15	16.10	22.75	21.18	18.24	22.58	18.83
	S_3	12.22	12.83	20.27	20.31	20.87	18.72	17.54
	Mean	13.71	17.34	22.62	20.88	20.08	22.08	

C.D (0.05) for tillage 4.37

C.D (0.05) for interculture 1.99

SE_m for interculture at the same level of tillage 2.40

SE_m for tillage at the same level of interculture 2.84

Table 15 Effect of tillage and interculture on uptake of potassium at harvest (kg/ha)

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	25.86	30.49	44.48	35.95	33.85	37.26	34.65
	S_2	18.69	27.29	33.32	35.21	30.48	38.44	30.57
	S_3	19.62	23.03	32.21	29.64	32.05	31.88	28.07
	Mean	21.38	26.93	36.67	33.60	32.13	35.86	

C.D (0.05) for tillage 6.68

C.D (0.05) for interculture 2.03

C.D (0.05) for interculture at the same level of tillage 5.10

C.D (0.05) for tillage at the same level of interculture 7.76

of 36.67 kg/ha while treatment M_1 (Sowing on stubbles) recorded the lowest value of 21.38 kg/ha.

Raking and weeding twice (S_1) recorded significantly higher value of 34.65 kg/ha when compared to other levels of interculture. Similarly raking and weeding on 15th day (S_2) recorded significantly higher value when compared to raking and weeding on 30th day (S_3).

Interactions had significant effect on potassium uptake. Under treatment M_1 and M_3 (Sowing on stubbles and One ploughing) raking and weeding twice recorded significantly higher values when compared to other levels which were on par. Under treatment M_2 (Chemical tillage with 'Lasso') also raking and weeding twice recorded significantly higher value. Raking and weeding on 15th day was on par with the other two levels. Under treatments M_4 and M_6 (Ploughing twice and sowing and then ploughing) raking and weeding on 30th day recorded significantly lower value when compared to other levels of interculture. However, under treatment M_5 (Ploughing twice) interculture had no influence on potassium uptake.

Under raking and weeding twice (S_1) treatments M_3 and M_6 (One ploughing and Sowing and then ploughing) recorded significantly higher values when compared to other treatments which were on par. Treatments M_4 and M_5 (Ploughing twice and Ploughing thrice) were on par. Similarly no tillage treatments (M_1 and M_2) were also on par.

Under raking and weeding on 15th day (S_2) and raking and weeding on 30th day (S_3) tillage treatments had significantly higher values of potassium uptake over no-tillage treatments. But there were no significant differences between the two no-tillage treatments and the different tillage treatments. Treatment M_6 (Sowing and ploughing) recorded the highest value of 38.44 kg/ha while treatment M_1 (Sowing on stubbles) recorded the lowest value of 18.69 kg/ha under raking and weeding on 15th day (S_2). Treatment M_3 (One ploughing) recorded the highest value of 32.24 kg/ha and treatment M_1 (Sowing on stubbles) recorded the lowest value of 19.62 kg/ha under raking and weeding on 30th day (S_3).

6 Soil chemical analysis

6.1 Total nitrogen content

The data on total nitrogen content of soil are presented in Table 16 and the analysis of variance in Appendix VII.

The data revealed that the total nitrogen content of soil was not influenced by the different levels of tillage, interculture and their interactions.

Table 16 Effect of tillage and interculture on total nitrogen content of soil at harvest (percentage)

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	0.072	0.070	0.085	0.084	0.055	0.070	0.073
	S_2	0.074	0.106	0.072	0.091	0.076	0.059	0.079
	S_3	0.095	0.072	0.066	0.066	0.065	0.061	0.071
Mean		0.080	0.083	0.075	0.080	0.065	0.063	

SE_m for tillage	0.0087
SE_m for interculture	0.0062
SE_m for interculture at the same level of tillage	0.0151
SE_m for tillage at the same level of interculture	0.0150

6.2 Organic carbon status

The data on organic carbon content of soil are presented in Table 17 and the analysis of variance in Appendix VII.

Tillage treatments had significant effect. Between tillage and no-tillage treatments, no-tillage treatments recorded higher values for organic carbon content when compared to tillage treatments. But there were no significant differences between the two no-tillage treatments and the different tillage treatments. Chemical tillage with 'Lasso' (M_2) recorded the highest value of 0.76 per cent while ploughing twice (M_4) recorded the lowest value of 0.58 per cent.

Interculture had no effect on the organic carbon content of soil.

Under no-tillage treatments, M_1 and M_2 raking and weeding had no influence on organic carbon status. Under one ploughing treatment, raking and weeding twice had significantly higher values when compared to other levels of interculture. Among tillage treatments M_6 and M_4, interculture had no effect on organic carbon content. Under M_5, raking and weeding twice recorded significantly higher values when compared to raking and weeding on 15th day. Raking and weeding on 30th day was on par with the other two levels.

Table 17 Effect of tillage and interculture on organic carbon content of soil at harvest (percentage)

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	0.75	0.77	0.73	0.46	0.71	0.65	0.68
	S_2	0.74	0.78	0.68	0.62	0.52	0.60	0.66
	S_3	0.74	0.73	0.46	0.65	0.55	0.61	0.62
Mean		0.74	0.76	0.62	0.58	0.59	0.62	

C.D (0.05) for tillage	0.122
SE_m for interculture	0.034
C.D (0.05) for interculture at the same level of tillage	0.173
C.D (0.05) for tillage at the same level of interculture	0.184

Under raking and weeding twice, treatment M_4 (Ploughing twice) recorded significantly lower values when compared to other levels of tillage. Under raking and weeding on 15th day, tillage treatments had no effect. Under raking and weeding on 30th day treatment M_3 (One ploughing) recorded significantly lower value when compared to other tillage levels.

6.3 Available phosphorus content of soil

The mean value are presented in Table 18 and the analysis of variance in Appendix VII.

Similar to the total nitrogen content, the build up of available phosphorus in soil was also not influenced by different levels of tillage, interculture and their interactions.

6.4 Available potassium content of the soil

The mean values are presented in Table 19 and the analysis of variance in Appendix VII.

It can be seen from the Table that neither the levels of tillage and interculture nor their interactions could produce any pronounced influence on the available potassium content of soil.

Table 18 Effect of tillage and interculture on available phosphorus content of soil (kg/ha)

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	34.65	48.05	22.10	42.10	38.55	42.60	38.01
	S_2	47.80	41.85	29.20	53.30	43.66	37.25	42.17
	S_3	35.26	57.20	30.45	43.85	45.25	36.93	41.49
Mean		39.24	49.03	27.25	46.42	42.47	38.93	

SE_m for tillage	10.834
SE_m for interculture	4.215
SE_m for interculture at the same level of tillage	10.324
SE_m for tillage at the same level of interculture	13.728

Table 19 Effect of tillage and interculture on available potassium content of soil (kg/ha)

		Tillage						Mean
		M_1	M_2	M_3	M_4	M_5	M_6	
Inter-culture	S_1	53.75	61.70	61.50	60.00	61.00	63.00	60.15
	S_2	55.90	50.00	59.00	64.80	57.00	63.10	58.30
	S_3	50.90	61.35	44.50	68.00	67.20	60.00	58.66
	Mean	53.52	57.68	55.00	64.27	61.73	62.03	

SE_m for tillage	4.601
SE_m for interculture	2.758
SE_m for interculture at the same level of tillage	6.756
SE_m for tillage at the same level of interculture	7.180

7 Economics of cultivation

The economics of cultivation of cowpea under different levels of tillage and interculture are presented in Table 20.

Among the tillage levels, the maximum returns and net profit were obtained from one ploughing and sowing treatment. Among the interculture treatments raking and weeding on 15th and 30th day gave the maximum returns and net profit.

Table 20 Economics of cultivation of cowpea under different levels of tillage and interculture for one hectare

Treatments	Cost of production excluding treatments	Additional cost of treatment	Total cost of production	Yield in kg/ha	Value (in Rs.)	Profit (in Rs.)
a) Tillage						
Sowing on stubbles	1600	-	1600	629.73	1889.19	229.19
Chemical tillage with Lasso @ 1.5 kg ai/ha	1600	120	1720	645.62	1936.86	216.86
One ploughing and then sowing	1600	300	1900	1043.34	3030.02	1130.02
Two ploughing and then sowing	1600	500	2100	956.65	2869.95	769.95
Three ploughing and then sowing	1600	700	2300	936.81	2810.43	510.43
Sowing and then ploughing	1550	300	1850	983.85	2961.58	1101.55
b) Interculture						
Raking and weeding on 15th and 30th day	1600	600	2200	563.29	2889.87	689.87
Raking and weeding on 15th day only	1600	300	1200	856.02	2568.06	668.06
Raking and weeding on 30th day only	1600	300	1900	778.69	2336.07	436.07

<u>Cost of inputs</u>

Cost of labour - Men - Rs. 15/-day Women - Rs. 12/-day

Cost of Lasso for 1 litre - Rs.40/-

Price of grain - Rs. 3.00/kg

Cost of one ploughing Rs. 300/ha
Cost of two ploughing Rs. 500/ha
Cost of three ploughing Rs. 700/ha

Cost of raking and weeding once -Rs.300/ha
Cost of raking and weeding twice -Rs.600/ha

Discussion

DISCUSSION

The present investigation is an attempt to find out the response of cowpea in summer rice fallows to different tillage and intercultural operations. The results are discussed below.

Effect of tillage

The role of tillage on the various physico-chemical properties of the soil, drymatter content of weeds, growth, yield and chemical composition of the grain are discussed as under.

It is observed that the soil moisture content at various growth stages viz. at the time of sowing, branching, flowering and pod formation, did not reveal any significant variation in accordance with the variation in tillage levels. The probable reason for the low retention of moisture by various tillage treatments might be that the sandy loam soils with high infiltration rates would have drained the soil water to greater depths. This is in conformity with the findings of Goncharov et al. (1976) that differences in ploughing depth did not affect the moisture regime.

Significant effect due to tillage on the drymatter content of weeds and weed growth was reported by

Beaumer and Bakermans (1973). In the present investigation also the drymatter content of weeds at 15th, 30th, 45th and 60th days after sowing significantly increased in the no-tillage treatments, compared to tillage treatments. However, in the plots where seeds were sown on the stubbles, highest drymatter content of weeds was recorded. It is quite obvious that the weed growth of the previous crop would have a regenerating effect in the successive cropping season with the supply of nutrients and moisture. This is in agreement with the findings of Beaumer and Bakermans (1973); Malik _et al._ (1973); Greenland (1975) and Mahto and Sinha (1980).

The influence of tillage on the growth characters viz. height of the plant, number of leaves, drymatter production, dry weight of root nodules and root characters have also been studied. It is observed that tillage has significant effect on the plant height and number of leaves. The effect is more pronounced for the single tillage treatments before or after sowing and continued throughout the growth stages.

This clearly indicates that in sandy loam soils where high infiltration rate is a limiting factor for the supply of moisture and the destruction of structure of the soil due to increased number of tillageswas deterimental to plant growth. However, the adverse effects of sowing on stubbles of the previous crop are well manifested by the low degree of plant growth indicating that the paddies are to be tilled at least once. As the plant height is a reflection of growth and development and is brought about by increased cell division and cell enlargement, the tillage practice has facilitated proper crop growth.

The data revealed that the drymatter production also increased on account of tillage treatments. It is quite natural that the number of leaves increased with increase in plant height. As the number of leaves increased there happened more leaf surface to harness the solar radiation resulting in an increased rate of photosynthesis. This higher production of photosynthetes is translocated and reflected in the drymatter production. However, it is observed that the increased drymatter production is achieved only during the later stages of plant growth indicating that the treatmental effects are manifested only at the later growth stages. As stated earlier, tillage treatments created more congenial soil atmosphere and good weed control at 15th and 30th day and hence the plants could grow better resulting in increased drymatter production. Similar results have been reported by Simon (1973); Simon and Skrdleta (1978) and Choudhary et al. (1978).

Though the values recorded for root spread and length have not come to the levels of significance, a conspicuous higher trend has been observed in the single tillage treatment. The root length and spread are increased compared to the other treatments. The lowest values were for the treatment in which the seeds are sown directly on the stubbles indicating that the unploughed soil has offered a considerable resistance for the penetration of roots. However, 'Lasso' application did not influence this character. The conspicuous increase in the root length and root spread in the case of single ploughing treatment over two or three ploughings shows that the soil structure has been broken and rendered it less suitable for a coarse grain crop like cowpea. Similar results were also reported by Chopart and Nicou (1976); Smittle and Threadgill (1977) and Ramos et al. (1979).

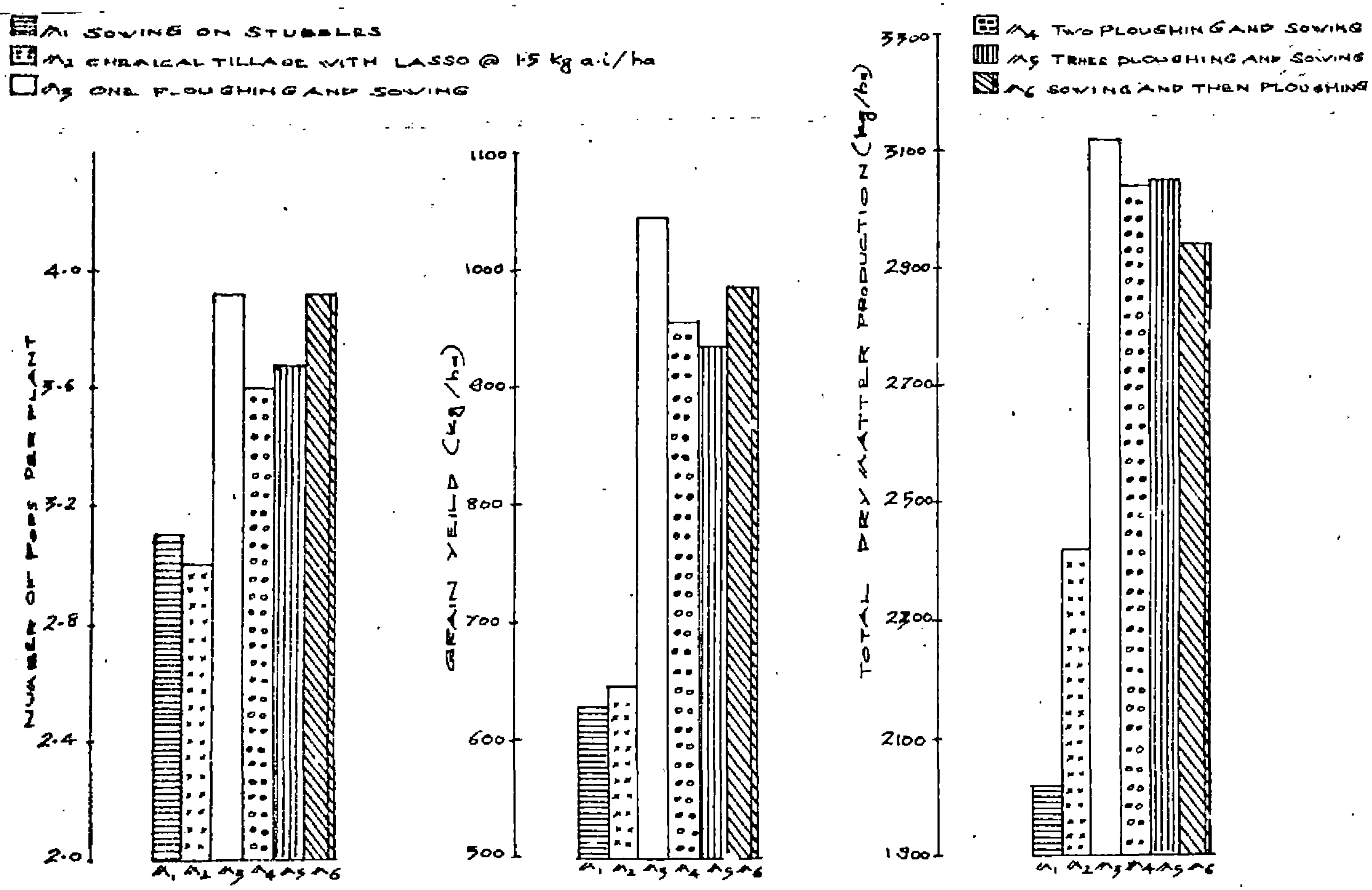
As regards to nodule production the treatments have no significant effect. But the highest nodule production was seen in the treatments where seeds were sown on the stubbles of previous crop. The slightly lower values recorded under herbicidal treatment might be due to the lag phase created on the bacterium in the soil. However, tilling the soil once, twice or thrice did not show any consistent effect on nodule drymatter production, suggesting that there happened an imbalance in the carbon requirement of the bacterium for further multiplication. The lower values of organic carbon content of soil at the time of harvest supports the above statement. Masefield (1957); Simon and Skrdleta (1978) and Klittich et al. (1981) also reported decreased rates of nodulation with cultivation.

The yield attributes viz. length of pod, number of seeds per pod and seed test weight remained unaffected by tillage while the number of pods per plant increased. As seen earlier the height of plants together with the number of leaves increased with increasing levels of tillage. It is obvious that the increased photosynthetic rate has contributed to a larger extent at the start of the reproductive phase by way of increasing the number of pods per plant. Although the number of pods per plant increased, the number of seeds per pod, and pod length did not show any significant variation. Thus the increased number of pods per plant failed to contribute directly to the total production of grain under no-tillage treatment when compared to tilled ones. On the contrary, where the crop has received the tillage treatments, the major contribution was by the increased number of pods per plant and thus a total increased output. The lower values for bhusa yield under no-tillage treatments could be explained on the basis of the above facts resulting in the poor growth of the crop in general compared to other tillage treatments.

The effect of tillage was well pronounced on the grain yield. Treatments receiving tillage operations are found to be superior over no-tillage treatments. Among the tillage treatments single tillage treatment recorded the highest output of the grain compared to two or three tillages. This clearly explains the importance of the soil structure for the crop growth. Increased number of tillage definitely showed a negative trend indicating the destruction of soil structure and its adverse effects on growth parameters which contributed to the low grain production. Though the root nodule weight was more in the case of undisturbed soil, it failed to contribute to the production of grain by way of increased nitrogen fixing

EFFECT OF LEVELS OF TILLAGE ON NUMBER OF PODS, GRAIN YIELD AND TOTAL DRY MATTER PRODUCTION

FIG. 3



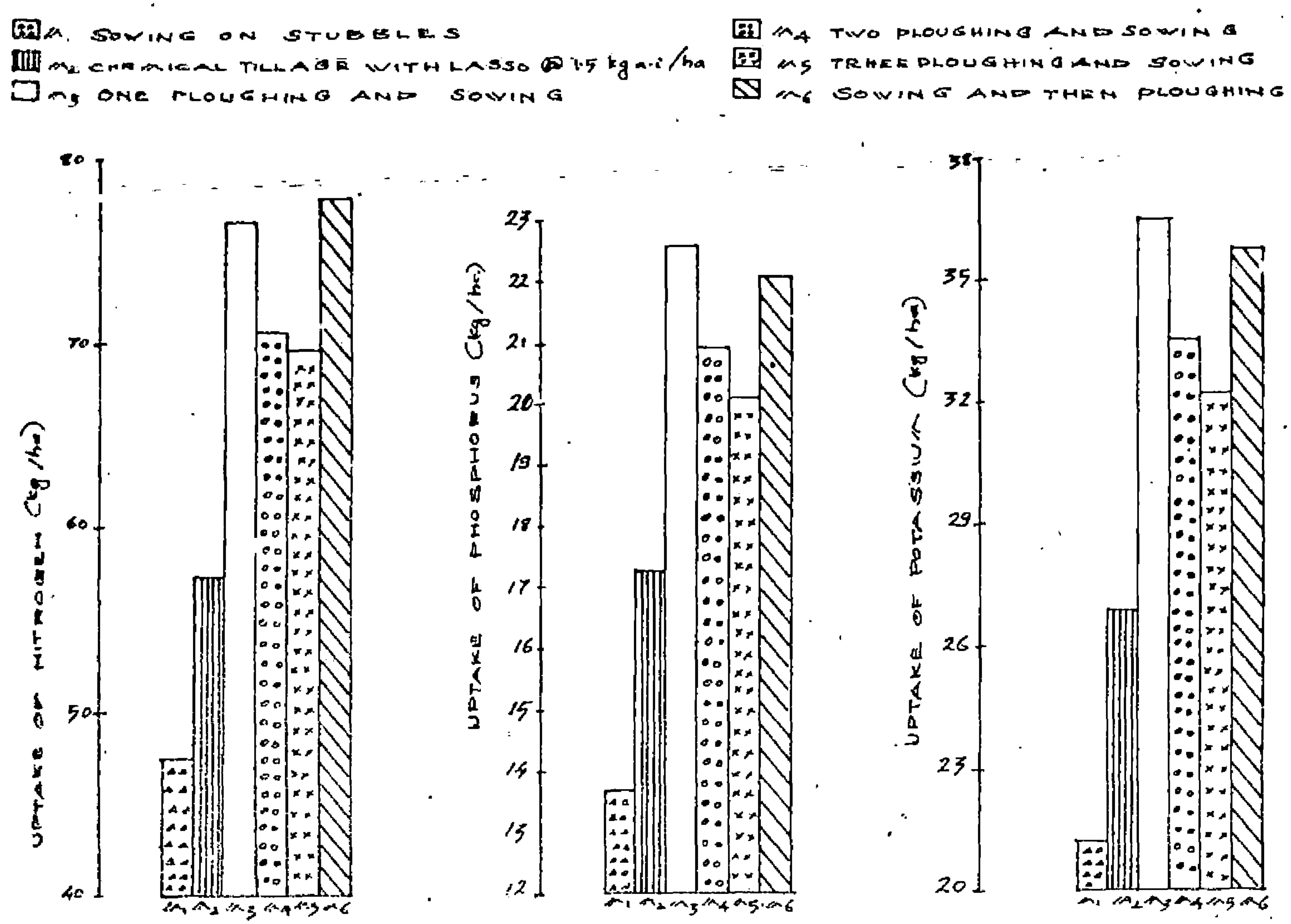
system. Thus it is revealed that the grain yield of cowpea under the sandy tracts depends on the soil structure to a greater extent. Hence it could be concluded that a moderate ploughing of paddies is sufficient for higher cowpea production. This is in agreement with the findings of Ofori and Nandy (1969); Nennau (1970); Sanford et al. (1973); Vander (1976); Chopart et al. (1976); Ketcheson (1980); Mullins et al. (1980) and Porter et al. (1981).

From the results it is noticed that the harvest index did not show any significant variation. Though it is not statistically significant, a clear trend has been observed with harvest index. The lower values recorded under no-tillage treatment clearly indicate that the translocatory system was not effectively functioned as compared to other treatments. This is well illustrated by the increased weight of bhusa in these treatments with low grain production.

The nutrient content of plant parts were found to be unaffected by tillage treatments. Although the percentage nutrient composition of the plant parts were unaffected, the uptake of major nutrients like nitrogen, phosphorus and potassium were found to be higher under tillage treatments as observed by Rowse and Stone (1977). This might be due to the increased accumulation of drymatter specially through grain production under tillage treatments. The protein content of grain was also found to be unaffected by the tillage treatments. This result agrees with the findings

EFFECT OF LEVELS OF TILLAGE ON UPTAKE OF NITROGEN, PHOSPHORUS AND POTASSIUM

FIG-4



of Singh (1970) and Simenov and Vanchev (1978).

Tillage treatments showed no significant effect on the total nitrogen, available phosphorus and exchangeable potassium content of soil. This is in conformity with the findings of Talati and Mehta (1963). The organic carbon content of the soil at the end of the experimentation gave significant variations among the treatment means. Ploughing more than once brought about a marginal reduction inthe organic carbon content of soil. In the undisturbed soils, the organic carbon is substantially high and this is slightly supplemented by the addition of 'Lasso'. The results are well explained on the basis of the decomposition of organic matter incorporated into the soil by way of repeated tillages, where the organic matter was depleted by exposing to the high temperature of the tropical climate. On the other hand, under no-tillage treatments the stubbles were well preserved in the soil and a low rate of decomposition would have operated. Hence, a marginal increase in organic carbon content over zero tillage treatment was observed. Similar results were also recorded by Blevins *et al.* (1977) and Zuo and Lal (1979).

Effect of interculture

In addition to the tillage the effect of intercultural operation was also evaluated in the present study. The beneficial effect of interculture is attributed to its efficiency in removing weeds and further incorporation into the soil (Sreenivasan, 1953); conserving soil moisture to optimum level (Chandra mohan, 1969) and increasing soil aeration (Seshadri, 1962).

Contrary to the expected positive effects of interculture on soil moisture conservation, the results of the present investigation did not show any significant variation. Though weeding and raking lowered down the weed population and formed a soil mulch to reduce evapouration, it failed to show any significant effect on the soil moisture retention. This might be probably due to the inherited porous nature of the sandy loam soils, for increased percolation loss of soil water.

The results of the present investigation however, revealed the favourable influence of raking on weed control.

Although raking and weeding had no effect during the initial period, from 30th day onwards, it had significant effect. Raking and weeding on 15th and 30th day recorded lower weed dry weight at later stages of crop growth and resulted in better crop growth enabling them to smother the weeds at later stages. Raking twice resulted in better control of weeds when compared to raking only once on 15th day or at 30th day. Thus the present investigation clearly established the beneficial effect of interculture on weed control. This is in conformity with the findings of Jain et al. (1972) and Rachie and Roberts (1974).

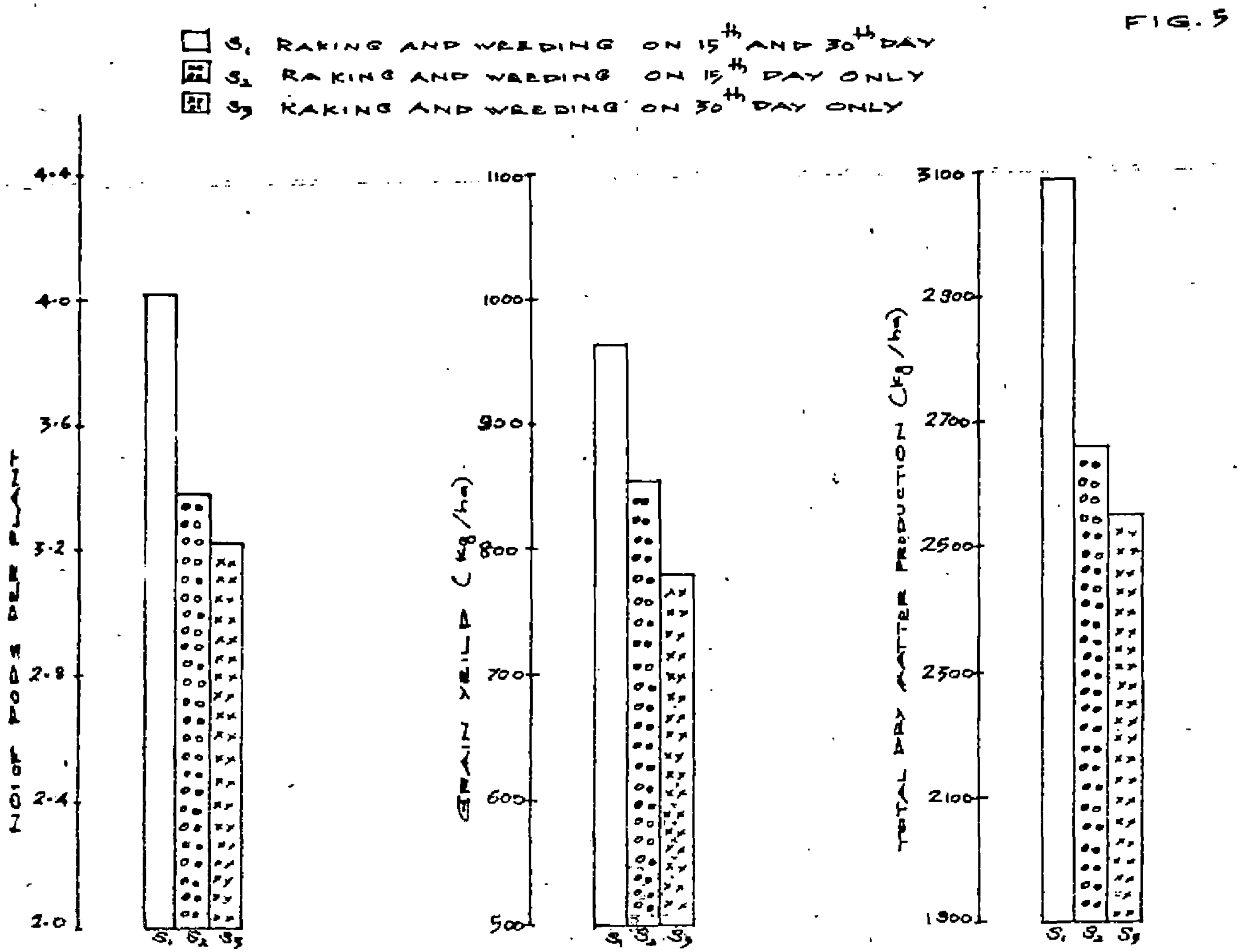
It is seen that the growth characters viz. height of plants, number of leaves per plant, drymatter production etc. are influenced by different raking and weeding treatments only at the later growth stages of the crop. The lower effects seen during the initial stages of crop growth may be due to the time lag for the manifestation of the treatments. The marked effects of interculture seen at the later growth phase might be due to the cumulative effects by raking and weeding on 15th and 30th day. There is no doubt that raking had influenced the breaking of soil crustations and helped in better aeration . In addition to weed control, uniform supply of soil water and better soil aeration created by raking increased the plant growth.

As the plant height increases the photosynthetic activity also increased simultaneously through the production of more number of leaves. It is quite natural that the increased photosynthetic apparatus would perceive more solar radiation and thus the pronounced photosynthetic rate. Thus on the whole, a simultaneous increase in drymatter production has been observed under a good plant canopy. Besides the increased photosynthetic activity in the crop canopy, weeding has enabled the crop to reduce the competition with the growing weeds for water and other nutrients. Raking would have conserved the soil moisture and resulted in better plant growth (Singh (1975); Retinam et al. (1976) and Sasidharan (1981)).

Results revealed that interculture had significant effect on root spread and root length. Raking besides removing the mechanical impedance improves the soil physical conditions resulting in least resistance to the spread and penetration of roots. However, intercultural operation had no significant effect on root nodules suggesting that the soil physical conditions did not show any effect on the nodule production.

EFFECT OF LEVELS OF INTER CULTURE ON NUMBER OF PODS, GRAIN YEILD AND TOTAL DRY MATTER PRODUCTION

FIG. 5

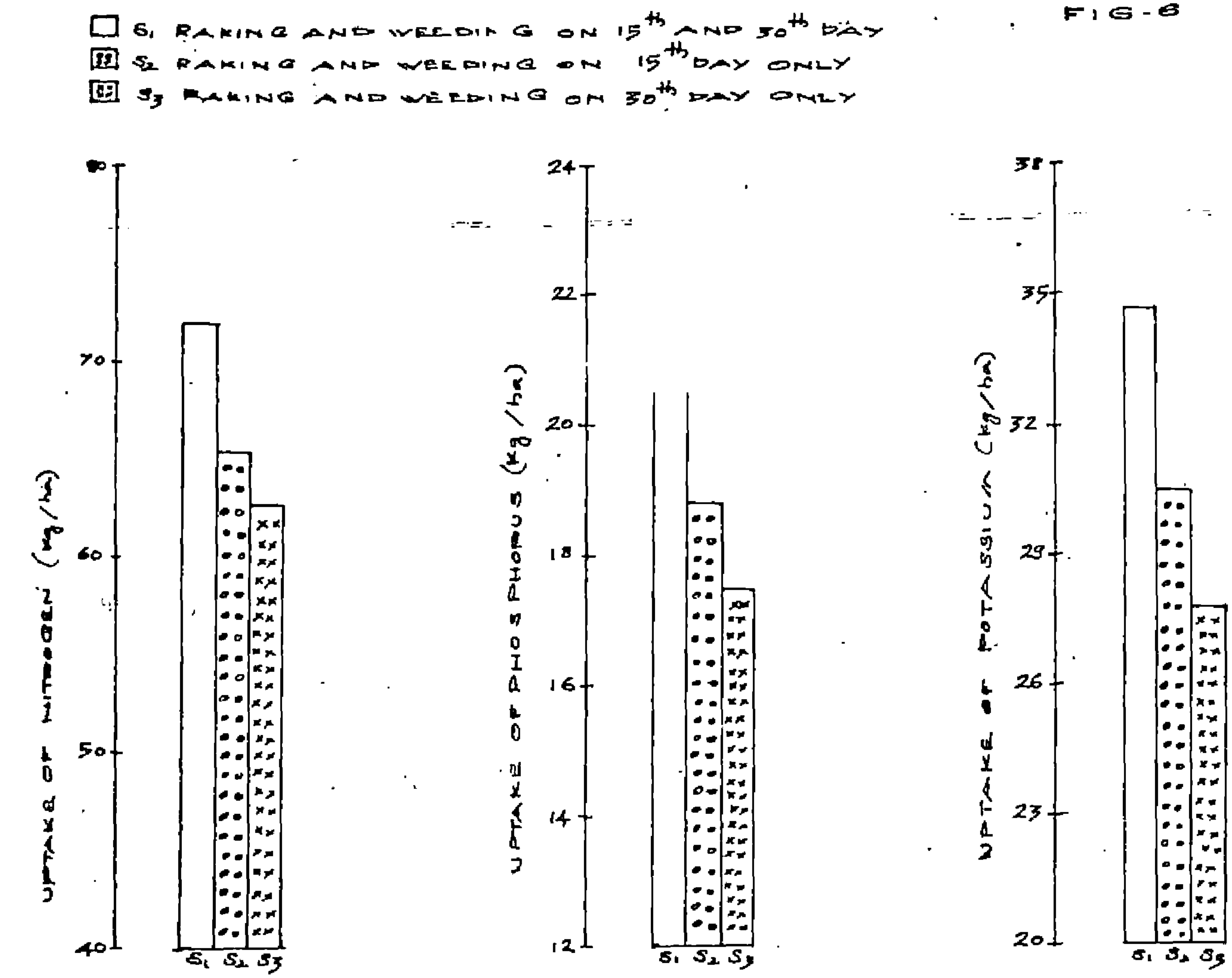


Yield attributes viz. number of pods per plant, pod length and number of seeds per pod were found to show significant variation due to interculture. However, seed test weight was found to be unaffected. The intercultural operations promoted favourable soil conditions not only for vegetative growth but also for reproductive growth. Plant growth characters like height, number of leaves, and drymatter production increased with interculture. This enabled the plant to produce more photosynthates which would have been translocated to the increased sink ie. the pods. Due to this effect the number of seeds per pod and pod length also showed significant variation resulting in increased yields. This is in conformity with the findings obtained by Jain *et al.* (1972); Ali *et al.* (1974); Pahuja *et al.* (1974) and Burnside (1979). The effect of raking and weeding on bhusa yield could also be explained on the basis of above facts.

The nutrient composition of the various plant parts did not show any significant variation. However, the uptake of nutrients differed significantly. This is because of the difference in drymatter accumulation in different treatments as presented in Table 8.7. Besides, intercultivation

EFFECT OF LEVELS OF INTERCULTURE ON UPTAKE OF NITROGEN, PHOSPHORUS AND POTASSIUM

FIG-6



might have provided better aeration to soil and resulted in better root growth. Due to better root growth larger amounts of nutrients would have been absorbed from the soil. These factors explain the reasons for the variations in the nutrient uptake. The data presented in Table 9, revealed that the protein content of the grain remained unaltered by the interculture treatments.

The economics of cowpea cultivation under different levels of tillage and interculture is presented in Table 20. Data revealed the fact that tillage is essential for successful crop growth. It is also observed that the number of tillage operations can be reduced to the minimum. This is indicated from the result that maximum profit was obtained in the treatment in which sowing was done after one ploughing. Thus minimum tillage had a dual role ie. reducing the cost of cultivation and at the same time increasing the yield resulting in maximum net profit.

Interculture done twice resulted in better yields when compared to one interculture in any one of the stages. Although the yield was increased under two raking and weeding the net profit was only marginal on account of increased cost.

Summary

SUMMARY

An experiment was conducted at the Rice Research Station, Pattambi, during summer season of 1980-81, to evolve suitable agro-techniques for raising cowpea in summer rice fallows. The experiment was laid out in the split-plot design with levels of tillage in main plots and levels of interculture in sub-plots. Six levels of tillage (sowing on stubbles, chemical tillage with "Lasso" @ 15 kg ai/ha, one ploughing and then sowing, two ploughings and sowing, three ploughings and sowing, and broadcasting and then ploughing) and three levels of interculture (raking and weeding on 15th day only, raking and weeding on 30th day only and raking and weeding both on 15th and 30th day) were tried in all combinations. The results of the experiment are summarised below.

1. The initial soil moisture content at the time of sowing under various tillage treatments did not show any significant difference. The same trend was observed throughout the growth phase ie. at the time of branching, flowering and pod formation. Intercultural operation and their combinations with the tillage operation also showed the same trend.

2. The drymatter content of weeds showed a progressive increase throughout the growth phase in the treatment in which the seeds were sown on stubbles. However, "Lasso" application after sowing on the stubbles did not show any conspicuous reduction of weed drymatter content over ploughing treatments. Different levels of ploughing gave comparatively better control of weeds during the crop growth. Raking treatments during the early growth phases have brought down the weed drymatter, for a period of 15 days from the date of imposing the raking treatments. Weeds recovered soon after. Data at different growth phases indicated that weeding and raking at 15th and 30th days reduced the weed growth to minimum levels.

3. Different tillage treatments showed an increase in plant height throughout the crop growth compared to no-tillage levels. Single ploughing substantially recorded higher values compared to two, three and sowing and then ploughing treatments. The effect of weeding and raking at 15th and 30th days of crop growth was manifested on the plant height only at later growth phases ie. 60 days after sowing and at harvest.

4. "Lasso" application had a marginal influence on the production of leaves per plant at different growth

phases, but had no superiority over tillage treatments. Among tillage treatments, single ploughing before sowing or after sowing showed a positive trend on the production of number of leaves per plant from 40 days to harvest. Weeding and raking at 15th and 30th days always recorded better results over any other treatment.

5. Though there is no significant difference among treatments, with respect to drymatter production per plant, a consistent and progressive trend was maintained throughout. Single ploughing recorded better plant growth in terms of drymatter at 20th and 40th day after sowing. However, at 60th day after sowing the effects were well expressed. Raking at 30th day seems to be deleterious for drymatter production. Initial raking at 15th day was beneficial.

6. The dry weight of root nodules per plant was not significantly influenced by the different levels of tillage and interculture. However, the nodule production seems to be slightly higher in the case of direct drilling on stubbles when compared to other levels of tillage.

7. Though the values for root spread and root length were not significant, it is seen that single ploughing before sowing and after sowing is beneficial for

root spread as compared to other treatments. The effect of intercultural operations at 15th and 30th days were well manifested at the time of harvest with respect to root spread and length.

8. The dry weight of roots remained unaffected by the levels of tillage and the levels of interculture.

9. Number of pods per plant was significantly increased by the levels of tillage and interculture. Among tillage treatments ploughing before or after sowing recorded the maximum number. Cumulative effect of weeding and raking at 15th and 30th days was superior to any of the individual treatment.

10. Length of pods remained unaltered by tillage levels. Raking and weeding on 15th and 30th days significantly increased the length of pods.

11. The number of seeds per pod remained unaffected by tillage. But raking and weeding twice on 15th and 30th days showed a significant trend when compared to raking and weeding once in 15th day only or 30th day only.

12. Neither the levels of tillage nor the levels of interculture had any significant effect on seed test weight of grain.

13. The levels of tillage had a significant effect on the grain yield when compared to no-tillage treatments. Among the tillage treatment, one ploughing and sowing recorded the highest grain yield. Raking and weeding also had significant effect. Raking and weeding twice on 15th and 30th days recorded the highest grain yield among the intercultural treatments.

14. Bhusa yield was unaffected by the levels of tillage. But intercultural operations had significant effect. Raking and weeding on 15th and 30th day recorded the highest bhusa yield when compared to raking and weeding once, on 15th or 30th day.

15. Neither the levels of tillage nor interculture had any effect on harvest index.

16. The levels of tillage showed a significant effect on total drymatter yield. Tillage treatments had higher values of drymatter production when compared to no-tillage treatment. One ploughing and sowing recorded the highest drymatter yield. Raking and weeding twice on 15th and 30th day recorded the highest values for total drymatter production when compared to raking and weeding once on 15th or 30th day.

17. Tillage and interculture levels did not show any variation in the protein content of grain.

18. The nitrogen, phosphorus and potassium content of plant parts remained unaffected by the levels of tillage and interculture.

19. Levels of tillage and interculture showed significant variation on the uptake of nitrogen. Sowing and then ploughing among tillage treatment and raking and weeding twice among levels of interculture recorded highest values for uptake of nitrogen.

20. Phosphorus and potassium uptake by plant at harvest was significantly affected by the levels of tillage and interculture. One ploughing treatment among tillage levels and raking and weeding twice among levels of interculture recorded the highest values for uptake of phosphorus and potassium.

21. Total nitrogen, available phosphorus and exchangeable potassium content of the soil were found to be unaffected by the levels of tillage and interculture.

22. Among levels of tillage, no-tillage treatments recorded higher organic carbon content of soil. Interculture had no effect on organic carbon status.

23. Among tillage levels, ploughing once, and among levels of interculture, raking and weeding on 15th and 30th days recorded the maximum profit/ha.

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* Original not seen

Appendices

Appendix I

Mateorological data for the cropping period (1980-'81) and the average values for the past five years (1976-'77 to 1980-'81)

A - Cropping period B - Average of past five years

Standard week	Period		Total Rainfall (mm)		Mean maximum temperature (°C)		Mean maximum temperature (°C)		Relative humidity (%)		Bright sunshine hours	
			A	B	A	B	A	B	A	B	A	B
8	February	19-25	-	-	36.4	35.8	18.70	21.35	71	87.2	10.5	9.44
9		26-4	-	-	38.5	36.14	18.90	22.06	92	86.6	10.3	9.76
10	March	5-11	-	-	37.8	36.36	21.20	23.28	78	85.6	9.5	9.52
11		12-18	-	1.8	37.3	36.32	24.30	22.98	84	88.6	9.4	8.76
12		19-25	61.0	-	35.6	36.76	24.60	23.50	92	86.6	9.0	9.50
13		26-1	-	11.34	36.3	36.48	24.80	23.96	90	87.2	9.6	9.60
14	April	2-8	2.5	13.62	35.5	36.10	25.80	24.36	87	87.4	7.7	8.94
15		9-15	31.6	6.46	37.4	35.94	25.70	25.18	92	86.2	8.0	8.92
16		16-22	26.5	26.02	34.7	35.40	24.80	24.62	93	88.4	8.7	8.66
17		23-29	34.6	49.12	36.8	35.00	24.80	23.94	89	91.6	10.4	8.44
18		30-6	13.8	48.22	35.1	34.56	24.40	24.54	91	88.4	7.9	8.18
19	May	7-13	146.4	32.42	34.2	34.20	24.10	24.50	92	90.6	8.9	7.74
20		14-20	3.2	14.66	34.2	33.60	25.40	24.40	90	92.4	7.4	7.36

Appendix II

Analysis of variance table for soil moisture content of 0-30 cm depth at various stages of crop growth

Source	df	Mean square			
		Soil moisture at sowing	Soil moisture at branching	Soil moisture at flowering	Soil moisture at pod formation
Block	3	96.64*	48.07**	2.61	59.62*
Tillage (M)	5	20.31	13.23	28.03	28.24
Error 1	15	20.47	7.22	20.15	16.21
Interculture (S)	2	3.08	18.33	2.86	6.79
Interaction (M x S)	10	16.23	7.08	9.24	12.70
Error 2	36	11.57	6.58	6.93	8.38

* Significant at 5% level

** Significant at 1% level

Appendix III

Analysis of variance table for weed drymatter/m^2 at various stages of crop growth

Source	df	Mean square			
		Weed drymatter/m^2 at			
		15 DAS	30 DAS	45 DAS	60 DAS
Block	3	8386.19**	2340.46	802.92	1234.36
Tillage (M)	5	23005.79**	11338.26*	23458.99**	8815.23**
Error 1	15	1092.42	3308.89	4765.53	1339.12
Interculture (S)	2	1781.84	27406.69**	31571.28**	17209.91**
Interaction (M x S)	10	4108.76	1188.39	822.53	560.42
Error 2	36	1169.75	1158.75	1228.77	620.45

* Significant at 5% level

** Significant at 1% level

Appendix IV

Analysis of variance table for plant height and leaves per plant at various stages of crop growth

Source	df	Mean square: Plant height at 20 DAS	40 DAS	60 DAS	Harvest	Number of leaves per plant 20 DAS	40 DAS	60 DAS	Harvest
Block	3	8.60	37.31	5778.13	4562.56	0.258	10.96	42.39	9.81
Tillage (M)	5	3.108	302.88**	5830.98**	4678.85**	1.11	32.14**	38.86**	1.20
Error 1	15	4.86	51.07	474.91	375.82	0.3967	2.64	7.01	3.84
Inter-culture (S)	2	3.34	39.07	759.263*	691.145*	0.3583	5.57**	13.41**	1.062
Interaction (M x S)	10	1.92	5.31	180.308	222.58	0.1252	0.533	1.86	1.365
Error 2	36	1.499	27.26	191.50	201.34	0.1112	1.052	1.37	1.916

* Significant at 5% level

** Significant at 1% level

Appendix IV (Contd..)

Analysis of variance table for drymatter production per plant at various stages of crop growth, dry weight of root nodules at flowering, root spread, root length and root weight

Source	df	Mean square						
		Drymatter production at			Dry weight of root nodules	Root spread	Root length	Root weight
		20 DAS	40 DAS	60 DAS				
Block	3	0.042	4.89	11.0	0.0002095	13.96	0.549	0.114
Tillage (M)	5	0.164	4.80	15.98*	0.000928	5.51	11.51	0.143
Error 1	15	0.085	2.29	4.59	0.000364	7.99	6.64	0.138
Interculture (S)	2	0.0349	3.80*	3.26	0.0000233	66.25**	31.50**	0.252
Interaction (M x S)	10	0.0335	1.48	3.763*	0.0005539	2.02	5.19	0.086
Error 2	36	0.0521	1.18	1.326	0.0004759	5.40	6.68	0.116

* Significant at 5% level

** Significant at 1% level

Appendix V

Analysis of variance table for number of pods per plant, pod length, number of seeds per pod and seed test weight

Source	df	Mean square			
		Number of pods per plant	Pod length	Number of seeds per pod	Seed test weight
Block	3	0.858	3.747*	2.39**	5.70**
Tillage (M)	5	1.948*	2.83	0.47	1.39
Error 1	15	0.627	1.04	0.394	0.558
Interculture (S)	2	4.216**	4.00**	1.61*	0.0068
Interaction (M x S)	10	0.0613	0.865*	0.541	0.4088
Error 2	36	0.299	0.3817	0.452	0.4905

* Significant at 5% level

** Significant at 1% level

Appendix V (contd..)

Analysis of variance table for grain yield, bhusa yield, total drymatter and harvest index

Source	df	Mean square			
		Grain yield	Bhusa yield	Total drymatter yield	Harvest index
Block	3	478371.137**	4093175.55**	1985204.74*	14.40
Tillage (M)	5	391106.385*	653294.99	2364530.65*	0.722
Error 1	15	34088.163	277916.45	426078.495	0.76
Interculture (S)	2	206243.24*	602181.64*	1920367.92*	0.1758
Interaction	10	19359.607	123272.62*	151658.491	0.3499
Error 2	36	21258.072	52908.476	93315.165	0.243

* Significant at 5% level

** Significant at 1% level

Appendix VI

Analysis of variance table for protein content of grain, nitrogen content of grain, bhusa and husk and phosphorus content of grain, bhusa and husk

Source	df	Mean square						
		Protein content of grain	Nitrogen content of			Phosphorus content of		
			Grain	Bhusa	Husk	Grain	Bhusa	husk
Block	3	16.75*	0.453*	0.0699	0.0438	0.0074	0.060	0.0014
Tillage (M)	5	10.03	0.241	0.193	0.0508	0.0367	0.00228	0.0118
Error 1	15	4.90	0.127	0.369	0.0329	0.0165	0.022	0.0047
Inter-culture (S)	2	1.54	0.064	0.16	0.0254	0.024	0.005	0.0033
Interaction(M x S)	10	5.24	0.164	0.495	0.0332	0.0165	0.0745**	0.0018
Error 2	36	5.53	0.1256	3.146	0.0271	0.0135	0.0151	0.00221

* Significant at 5% level

** Significant at 1% level

Appendix VI (Contd..)

Analysis of variance table for potassium content of grain, bhusa and husk, and uptake of nitrogen, phosphorus and potassium at harvest

Source	df	Mean square					
		Potassium content of			Uptake of		
		Grain	Bhusa	Husk	Nitrogen	Phosphorus	Potassium
Block	3	0.074*	0.029*	0.0127	647.505	36.0145	199.93*
Tillage (M)	5	0.0179	0.0072	0.003	1719.771*	136.19**	414.224**
Error 1	15	0.0174	0.0068	0.0031	469.989	25.372	59.51
Interculture (S)	2	0.0044	0.0024	0.00125	571.04*	125.474**	264.579**
Interaction (M x B)	10	0.011	0.0047	0.00189	310.389*	16.85	28.895*
Error 2	36	0.0065	0.00251	0.0012	113.196	11.514	12.020

* Significant at 5% level

** Significant at 1% level

Appendix VII

Analysis of variance table for total nitrogen content of soil, organic carbon content, available phosphorus and available potassium content of soil

Source	df	Mean square			
		Total nitrogen content	Organic carbon content	Available phosphorus	Available potassium
Block	3	0.00097	0.275**	3053.95*	99.43
Tillage (M)	5	0.00084	0.0569*	699.15	221.28
Error 1	15	0.00045	0.019	704.36	127.06
Interculture (S)	2	0.00052	0.00019	119.48	23.33
Interaction (M x S)	10	0.00066	0.0323	131.014	139.79
Error 2	36	0.00045	0.0142	213.20	91.30

* Significant at 5% level

** Significant at 1% level

TILLAGE REQUIREMENTS OF COWPEA

BY

RAVI KUMAR P. K.

ABSTRACT OF A THESIS
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KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF AGRONOMY
COLLEGE OF AGRICULTURE
VELLAYANI, TRIVANDRUM

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ABSTRACT

An experiment was conducted at the Rice Research Station, Pattambi, during the third crop season of 1980-81 to evolve suitable cultural practices for raising cowpea in summer rice fallows. Six levels of tillage and three levels of interculture were tried in all combinations.

The study was undertaken with a view to find out the minimum tillage requirements of cowpea and to study the effects of different levels of interculture on the yield of cowpea.

The study revealed that tillage had no effect on the retention of soil moisture during the crop growth. Drymatter content of the weeds was found to be higher in no-tilled treatments. An increase in plant height, number of leaves and drymatter production, was observed at all the levels of tillage. But dry weight of root nodules remained unaffected. The root spread, length and weight of roots did not show any significant variation. Ploughing once, before or after sowing recorded the highest number of pods per plot. But the length of pods, number of seeds per pod and the test weight were

not influenced by tillage. Grain yield and total drymatter production were highest in single ploughing treatment. But bhusa yield and harvest index did not show any significant variation. The protein content of grain, nitrogen phosphorus and potassium content of plant parts revealed no variation due to tillage treatments. The uptake of nitrogen, phosphorus and potassium was found to be higher with tillage. The total nitrogen content, available phosphorus and exchangeable potassium were unaffected by tillage. But organic carbon content was found to be higher with no-tillage. Maximum production and net profit was obtained from single ploughing treatment.

Interculture had no effect on retention of the soil moisture. The drymatter content of weeds was found to be lower with two rakings and weedings at 15th and 30th day. The height, number of leaves and drymatter production were found to be increased with two rakings and weedings. Dry weight of nodule remained unaffected. Root growth was found to be higher with two interculture. Raking and weeding twice recorded higher values for number of pods, length of pods and number of seeds per pod. Seed test weight was found to be unaffected. Grain yield, bhusa yield and total drymatter production were found to be higher with two interculture. Grain protein content, nitrogen, phosphorus and potassium contents of plant parts revealed no variation due to interculture. Uptake of nitrogen, phosphorus and potassium was found to be higher with two interculture. The total nitrogen content, organic carbon content, available phosphorus and exchangeable potassium of soil did not show any variation with interculture. Maximum production and net profit were also obtained from raking and weeding twice.

Single ploughing with two raking and weeding on 15th and 30th day recorded the highest grain yield.