STUDIES ON *Paira* CROPPING IN RICE BASED CROPPING SYSTEM IN LOWLYING AREAS

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BY

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DEDICATED

TO

My Father

Late Aswini Kumar Paul

Bidhan Chandra Krishi Viswabidyalaya

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C E R T I F I C A T E

This is to certify that the work recorded in the thesis entitled "Studies on paira cropping in rice based cropping system in low lying areas" submitted by Shri Ananda Mohan Paul for the award of the Degree of Doctor of Philosophy in Agronomy of the Bidhan Chandra Krishi Viswavidyalaya, is a faithful and bonafide research work carried out under our joint supervision and guidance. The results of the investigation reported in the thesis have not so far been submitted for any other Degree or Diploma. The assistance and help received during the course of investigation have been duly acknowledged.

(B.N. Chatterjee)

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C O N T E N T S

ABSTRACT

Field and Net House Experiments were carried out in the Gangetic alluvial plains (Entisol soil) in the three consecutive years (1984-85 to 1986-87) under rainfed condition, with the objectives to study and find out :

(i) the productivity of *rabi* crops *viz.* linseed (cv. B-67), peas (cv. B-22), lentil (cv. B-77) and *Lathyrus* (cv. Nirmal), a variety of low neurotoxin content as substitute crops of *Lathyrus* (cv. local) grown as *paira* crop (or relay) either with a sole *aman* rice crop of long duration variety (cv. Swarna) or with an intercrop of rice in alternate paired rows of early (cv. MW 10) and late (cv. Swarna) varieties;

(ii) the suitable package of practices for the *rabi* crops to augment their production under *paira* cropping as against conventional method of crop establishment;

(iii) the effect of pre-sowing seed treatment (with Na_2HPO_4) to improve the stand establishment, growth and development of the *paira* crops and

(iv) the effect of fertilizer application as top dressing on the performance of the *Rabi* crops.

Stand establishment was better under conventional method of crop establishment than under *paira* cropping. Peas and lentil showed 18.1 and 16.5 % lesser stand establishment under *paira* cropping than under conventional tillage, respectively; linseed, however, showed better performance in this

regard than others. Through Net House Experiments it was further confirmed that stand establishment of peas are more adversely affected than other winter crops under different submergence durations. Stand establishment of lentil was adversely affected when submergence after sowing was more than 24 hours but in case of linseed it was better even at 36 hours of submergence. Stand establishment of *Lathyrus* varieties was least affected due to varied periods of submergence, even upto 72 hours. Pre-sowing seed treatment and fertilizer top dressing had no significant effect on stand establishment under *paira* cropping.

Mean shoot dry matter accumulation was higher (15 %) in winter crops grown under conventional tillage (which followed early variety of rice 'MW 10' and where both fertilizer and seeds could be drilled and loose soil mulch could be provided) than under *paira* cropping. Again *paira* cropping following intercrop of 'early 'MW 10' + late 'Swarna' rice recorded better shoot dry matter accumulation (9.2 %) than under *paira* cropping, following sole crop of late 'Swarna' rice. Higher shoot dry matter accumulation was recorded in peas and *Lathyrus* varieties than lentil and linseed. Pre-sowing seed treatment increased shoot dry matter accumulation significantly in winter crops under different situations. Fertilizer top dressing (20 kg N + 40 kg P_2O_5 / ha) also increased shoot dry matter accumulation in winter crops. The highest increase in shoot dry matter accumulation due to fertilizer top dressing (45 %) was recorded in linseed under *paira* method of crop establishment.

Root dry matter accumulations were more at 60 and 105 days after sowing upto 60 cm of soil depth, in winter crops established under conventional tillage than under *paira* cropping. Again *paira* crops following intercrop of 'MW 10' + 'Swarna' rice showed higher root dry matter accumulation than those recorded in *paira* crops following sole crop of 'Swarna' rice. Amongst all winter crops, maximum root dry matter production was recorded in peas and the minimum was recorded in linseed. Pre-sowing seed treatment and fertilizer top-dressing increased root dry matter production in winter crops significantly.

The mean grain yields of all the winter crops grown under conventional tillage (1667 kg / ha), was higher than that under *paira* cropping following intercrop of 'MW 10' + 'Swarna' rice (1529 kg / ha) and those following sole crop of 'Swarna' rice (1389 kg / ha).

The mean grain yield was highest in *Lathyrus* (Nirmal) (1835 kg / ha) followed by local variety of *Lathyrus* (1739 kg / ha) and peas (1714 kg / ha) and the lowest was recorded in linseed (883 kg / ha). Pre-sowing seed treatment (10.6 %) and fertilizer top dressing (25.2 %) increased mean grain yields of winter crops grown under *paira* cropping, significantly. The highest benefit of fertilizer top dressing was recorded in linseed (61 %). The productivity of crops was high due to increase in the number of either pods or capsules / ha.

From monetary point of view, the highest productivity was recorded in peas (Rs.7,288 / ha). Though the overall grain yield of linseed was lower than the grain yield of lentil and *Lathyrus* yet from the monetary point of view the advantage of linseed growing.

with adequate fertilization under paira cropping was similar to lentil and Lathyrus (Nirmal). The productivity (Rs. / ha) of lentil was higher than that of Lathyrus (local). The highest productivity in terms of energy output (MJ / ha) point of view, was recorded in Lathyrus (Nirmal) followed by Lathyrus (local) and the lowest was in lentil. Linseed showed higher energy output (MJ) than lentil due to the higher energy value in linseed seeds per unit weight.

The total soil moisture loss was much higher under paira cropping than those under conventional tillage, as bulk of moisture was lost through evaporation from the surface of the soil at the early stage of crops establishment. The water use efficiency (WUE) was maximum in Lathyrus (Nirmal), 12.2 kg / mm / ha under conventional tillage and least (1.18 kg / mm / ha) in linseed under paira crop. The WUE was much higher in winter crops under conventional tillage than under paira cropping. The WUE under paira cropping, from pre-sowing treated seeds, and adequately fertilized treatments were 1.32, 2.60, 1.70, 2.49 and 2.40 kg / mm / ha in linseed, peas, lentil, Lathyrus (Nirmal) and Lathyrus (local), respectively. Thus, it was concluded that, in lowland rice cultivated field peas can be grown most profitably as paira crop and can be a good substitute crop for Lathyrus, by broadcasting the seeds in standing aman rice, 10 - 12 days prior to it's harvesting. From the point of view of monetary advantage, linseed, with proper fertilizer management (20 kg N + 40 kg P_2O_5 / ha) as paira crop will be as good as lentil and Lathyrus (cv. Nirmal with low neurotoxin content and maturing 10 - 15 days later than Lathyrus local). Rabi crops following mixed cropping of early and late varieties of rice, yielded better (10 %) than those following late variety of rice, mainly because of better utilization of profile stored soil moisture.

LIST OF ABBREVIATIONS

Benzene Hexachloride	B.H.C.
Centimetre	cm
Critical difference	CD.
Days after sowing	DAS
Fertilizer with 20 kg N+40 kg P_2O_5/ha	$F_{20}+F_{40}$ or F_1
Gram	g
Hectare	ha
Hour	h
Kilogram per hectare	kg / ha
Lathyrus (local)	Lathyrus-L
Lathyrus (Nirmal)	Lathyrus-N
Milligram	mg
Millimetre	mm
Millijule per hectare	MJ/ha
Not significant	N.S.
Quintal	q
Rice	R
Rupees	Rs
Square metre	m^2
Standard error of mean	S.Em
Water use efficiency	WUE

CHAPTER 1

INTRODUCTION

1. INTRODUCTION

In eastern India comprising West Bengal, Bihar, Orissa, Assam, eastern U.P. as well as in Central India (comprising rice growing areas in Madhya Pradesh) rice fields remain submerged with varying water depth, during the monsoon months. Rice, usually the tall indica varieties, are generally cultivated in such areas. The productivity of *aman* or wet season rice in lowland, are generally low due to poor drainage conditions, poor radiation receipts during the season, improper choice of varieties and management practices. Where the stagnation is high, mixed seeds of early and late varieties are broadcasted to get the most from the unpredictable rainfall condition. The rice crop in low lying situations are usually harvested late in November and it may extend even in the first week of December. Due to this reason establishment of *rabi* crops after harvesting of *aman* rice in lowland get delayed, more so when one wants to establish the crop following conventional tillage. Land preparation can only be taken up after the soil get bit dried up for proper tillage. The productivity of winter (*Rabi*) crops is much dependent on the prevailing temperature conditions as well as to the extent of moisture stored in the soil profile. Winter condition prevailing in eastern India is usually short and mild.

In some parts of India (West Bengal, Bihar, parts of Assam, Orissa and Uttar Pradesh and Madhya Pradesh) as well as in Bangladesh, relay cropping (*Paira* / *utera*) of *Lathyrus sativus* L., which is also known as grass pea, in lowland *aman* rice is practised. The seeds of *Lathyrus* are broadcasted in standing rice, 15 - 30 days prior to its harvest, when the soil remain submerged or in saturated condition. After sowing the water is drained out after 10 to 24 h. In India lentil and *Lathyrus* occupy about 10.0 and 15.6 lakhs hectares of land, respectively with respective total productions of 4.4 and 6.0 lakhs tonnes. About 92 % of the total area of *Lathyrus* cultivation is confined in West Bengal, Bihar and Madhya Pradesh, contributing about 95 % of the total production. Out of total area under *Lathyrus* more than 80 % of the crops is established through *utera* (*paira*) condition. Likewise lentil too occupies a sizable area under *utera* system (Roy Sharma *et al.*, 1982).

The *Lathyrus* varieties that are being cultivated have high neurotoxin (L-α-β Diamino propionic acid). Due to this, lathyrism disease is caused to the regular consumers of *Lathyrus* grains. The neurotoxin contents of *Lathyrus* usually vary from 0.23 to 1.5 per cent (Dwivedi, 1983). For this reason the World Health Organisation has banned its cultivation to stop its consumption. So there is a great need of finding out a substitute crop or a variety of *Lathyrus* having low neurotoxin content, which can grow well by utilizing profile stored soil moisture after harvesting of late sown *aman* rice. Only at very few research stations (Bareilly, Dholi and Kanpur) this type of work has so far been taken up. Roy Sharma *et al.*, (1982) reported that through proper management productivity of lentil under relay (*utera* / *paira*) cropping can be as high as 15.9, 16.3 and 10.4 q / ha as found at Bareilly, Kanpur and Dholi, respectively.

Winter condition in the Gangetic plains of West Bengal, is shorter and milder than that prevails in Bihar and U.P. From the available published literature it appeared that not much work has been done in this line in West Bengal where the area under Lathyrus is 89,000 hectares in 1984-85, higher than any other individual grain legume crop, with an average yield of 584 kg / ha. Further in many areas these are utilised as a fodder crop to meet the demands of high yielding milch cows.

In the research work presented in this thesis consists of the findings of a number of field and net house experiments carried out with the following objectives :

i) to evaluate the productivities of a number of Rabi (winter growing) crops viz : lentil, peas, linseed and Lathyrus (local as well as of a variety containing low neurotoxin)

ii) to find out the effects of pre-sowing seed treatment and fertilizer application on the productivity of the Rabi crops established under paira cropping and

iii) to find out the relative merits and demerits in the establishment of rabi crops with minimum tillage as a relay (paira) crop as compared to the crop established under conventional tillage methods, following early,late and intercropped 'early and late varieties' of rice.

CHAPTER 2

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

In Eastern and in North Eastern India comprising the States of Assam, Bihar, Eastern Uttar Pradesh, Orissa and West Bengal, rice is the pre-dominant crop cultivated in kharif season. Although a good array of dwarf high yielding short duration rice varieties are available yet tall and long duration varieties are predominantly cultivated during kharif season in medium to lowland situations. These long duration rice varieties are usually harvested between mid-November and mid-December, when sowing of rabi seeds after usual land preparation becomes late. Under such situation *Lathyrus sativus* L. (now onwards will be referred as *Lathyrus*)is cultivated widely as relay (Paira) crop.

In West Bengal *Lathyrus* occupies the highest acreage amongst all grain legumes or pulses as post monsoon rabi season crop. But most of the *Lathyrus* varieties cultivated in farmer's field contain high amount of neurotoxin, causing lathyrism, a disease seen amongst its consumers, for which Government was been forced to ban its cultivation to avoid health hazard. But, at the same time, it is also necessary to suggest an alternative crop to the farmers, with suitable package of practices, to tap the untapped resource of available water, remaining in the soil after the harvest of kharif rice.

In this chapter an effort has been made to review the literature on experiments done in this direction and on the establishment and growth of winter grain legume or oilseed crops under adverse situations.

2.1 Relay cropping

Relay cropping is inter sowing of seeds of the following crop in the preceeding annual crop, 1 to 2 week before harvesting (Swaminathan *et al.*, 1970). Relay planting at ICRISAT, Hyderabad also indicated encouraging potentialities for effective soil and water source utilization and increased yield (Krantz and Associates, 1974). Relay cropping is designed to use the second season after monsoon, even under rainfed condition. This practice helps to overcome post monsoon land preparation problems, take advantage of late monsoon rains to aid establishment and make efficient use of residual moisture left after the *kharif* crop (ICRISAT, 1974). Since many of the monsoon season crops mature during the period when the monsoon rainfall is Waning , relay - planting of the post monsoon crops 1 - 3 weeks before harvest of rice offers a method of reducing the risk of failure in establishing a second crop (Krantz and Associates, 1974). House *et al.*, (1968) emphasized the extreme importance of timeliness in relay planting operations. Although relay cropping is normally not practised in the rainfed semi-arid tropics, the development of high yielding short season varieties has opened new avenues for relay cropping in such areas, especially in the black soils, which have high water holding capacity. Studies conducted at ICRISAT, Hyderabad showed that growing a maize crop instead of the traditional fallow land treatment during the rainy season had no effect on post rainy season crops. Yields of sorghum, chickpea, pigeonpea and safflower were just as good after maize as after the traditional fallow. While after rainy season sorghum, yields of the post-rainy season crops were a little lower than those after maize. In monetary terms, maize with chickpea was best, followed by maize with sorghum, then maize with pigeonpea. Post rainy season pigeonpea and sorghum were better as relay crops (sown on 12 September, before harvest of the first crop on 30 September) than as sequential crops (sown on 1 October immediately after the harvest of the first crop), but chickpea was markedly better as a sequential crop. Sequential cropping was directly compared with maize / pigeonpea or sorghum / pigeonpea intercropping and was found that the best sequential systems of maize-chickpea and sorghum-chickpea averaged 12 % higher gross return than intercropping. On an average, early sowing of relay crops increases the chances of having sufficient moisture for good crop establishment in the post-rainy season, a factor which is of paramount importance in unfavourable seasons (ICRISAT, 1976; 1977; 1978; 1979 and 1980).

2.2 Deployment of reserve materials in seeds for initial growth

Seeds characteristically contain relatively large amount of food reserves which support growth and development of the seedling until it can establish itself as a photosynthesizing, autotrophic plant. These reserves are for the most part, but not exclusively, laid down as discrete, intracellular bodies and include lipid, protein, carbohydrate, organic phosphate and various inorganic compounds.

There are great differences among seeds in their content of food reserves. Carbohydrates, mainly starch, predominate in the cereals, though protein and lipids are also present. Oil-seeds store lipids as their main reserves but high levels of protein, together with even higher amounts of starch and little lipid are found in legumes.

During maturation loss of moisture is bound to happen and water is essential for the hydration of seeds as the initial step towards germination. The amount of water taken up by an imbibing seed depends upon a number of factors (e.g. size, hydrostability of contents etc.) but in absolute terms it is quite small and often may not exceed 2 - 3 times the dry weight of the seed. For establishment and subsequent growth of the seedling, large amount and sustained water supply is required. Two major factors have to be considered when water uptake by seed is dealt with and these are (i) water relations of the seed, and (ii) the relationship between the seed and its substrate. When seed is planted in soil its rate of imbibition and subsequent germination may be determined by impedance due to soil matrix and the degree of contact of the seed with the soil moisture (Bewley and Black, 1978). Hydrolysis of food matter in the seed triggers up the respiration mechanism.

Respiration during initial water uptake, germination and early growth require a supply of readily available substrate other than that derived from hydrolysis of the major stored reserves, since the later only becomes available after embryo growth has commenced. The dry seeds of 81 species of monocots and dicots were analysed and found that all of them contained sucrose, 70 contained the tri-saccharide raffinose and 35 contained the tetra-saccharide stachyose. The distribution and levels of these sugars are available. For example in <u>Pinus</u>

thunbergii the content of stachyose, raffinose and sucrose is 0.3, 0.22 and 0.12 g / 100 g dry seed, respectively whereas in soybean the proportions are 5.2, 1.9 and 8.0 g / 100 g dry seed (Bewley and Black, 1978).

Sucrose and raffinose in the embryo are depleted during the first 24 h of imbibition, sucrose levels declining rapidly within the first 6 - 9 h followed by utilization of raffinose after 14 h (Bewley and Black, 1978). This sequence of di and oligo-saccharide hydrolysis and oxidation has also been found in a number of dicot and gymnosperm seeds, often with the sucrose utilized before radicle emergence and then raffinose or stachyose during subsequent early growth, prior to mobilization of the major stored reserves. There are exceptions though. For example, in soybean both raffinose and stachyose levels decline by about 50 % over the first 48 h after imbibition starts, during which time germination occurs and rootlets are formed. Sucrose, which is more abundant than the other two oligo saccharides, only declines between the second and fourth day after imbibition starts (Bewley and Black, 1978).

Mobilization of reserves from seed for the growth and maintenance of germinated seed has been of interest to the researchers since long time back and a voluminous literature has accumulated. In this review, work on only those crops where cotyledons are the major storage organs especially the non-endospermic ones; are being reviewed.

2.2.1 Reserve mobilization in non-endospermic dicotyledonary crops

Isolated axes of peas are not dependent on the reserve material of the cotyledons during the initial stages of radicle elongation. Reserves of carbohydrate, protein and fat in the radicle itself must be sufficient for these early events, and sucrose, raffinose and stachyose probably serve as respirable substrate. But after these early events have passed, the further development of the root and shoot systems depends upon the contributions from the cotyledons. Their stored materials are hydrolysed and transported into the axis which probably controls the mobilization atleast for the first 48 hours after the start of imbibition. Mobilization of starch and protein reserves in intact legume cotyledon commences after the radicles has started to elongate.

Mobilization of reserve matter in this type of grain legume may be either biphasic or linear and gradual. Cotyledons of many legumes contain cell wals which are rich in hemicelluloses. Mobilization of these components have been studied in Pisum, Phaseolus and Lupinus and the product of hydrolysis are largely unknown (Bewley and Black, 1978).

2.2.2 Reserve mobilization in endospermic dicotyledonary leguminous crops

Between the seed coat and cotyledons of legumes of the trifoliate lies a well-developed endosperm, the tissue containing the reserve carbohydrate. Outermost layer of this endosperm is the aleurone layer which, unlike the rest of the endosperm is made up of living cells devoid of galactomannan reserves which is a large polymer of mannose attached to single unit of galactose at the end. Endospermic reserves of leguminous seeds appear to be less necessary for the survival of the developing seedling. Indeed, from an evolutionary point of view, the galactomannan may possibly have been retained because of its high capacity to hold water; interestingly, many plants of the tribe Trifolieae appear to have spread out from the dry regions of the eastern Mediterranean. There is no control practically by the embryo on mobilization of the reserves in the endosperm (Bewley and Black, 1978).

2.2.3 Patterns of reserve mobilization in cotyledons of legume seeds

Some interesting work on reserve hydrolysis in legumes has recently been carried out (Bewley and Black, 1978) whose exhaustive studies of 500 legume species have revealed that there are eight basic patterns of hydrolysis of reserves from the cotyledons which are as follows :-

a) hydrolysis starts randomly at abaxial side of cotyledon e.g. Acacia, Vicia, Pisum, Lathyrus, Cassia, Trifolium; b) hydrolysis starts around vascular strands at abaxial side of cotyledon e.g. Vicia faba, Glycine max; c) hydrolysis starts at abaxial side of cotyledon but mobilization delayed particularly around vascular strands e.g. Phaseolus spp., Vigna umbellata, Arachis hypogaea etc; d) hydrolysis starts randomly and simultaneously at ab- and adaxial sides of cotyledon e.g. Lupinus spp., Lens spp. e) hydrolysis starts around vascular strands at adaxial side of cotyledon e.g. Prophocarpus spp.; Tetragonolobus spp. f) hydrolysis starts at adaxial side of cotyledon but mobilization gets delayed particularly around vascular strands e.g. Vigna radiata, Vigna mungo; g) hydrolysis starts randomly at the centre of the cotyledon e.g. Piptanthus spp. Hovea spp. and hydrolysis begins at the centre of cotyledon but mobilization delayed particularly around vascular strands e.g. Phaseolus vulgaris, Vigna sinensis, Dolichos lablab.

2.3 Germination of seeds under waterlogged or submerged condition

The term germination is used to designate those processes beginning with the imbibition of water by a dry seed and ending when a portion of the embryo penetrates the seed coat. The major factors responsible for seed germination are - water, temperature, oxygen and in some cases light. The seeds imbibe water during germination and swells up. The dry seeds are frequently able to withstand a broad range of temperature, but after the germination process has been set in motion by the imbibition of water, most seeds appear to tolerate a much narrower range of temperatures. Most of the winter crops like peas, lentil, linseed etc. require an optimum temperature of 20°C for germination (Sinha, 1977). Considering this, submergence may play an important role in influencing the temperature which in turn may modify germination. Of course, time of sowing will have some effect in this regard. When the temperature rises, oxygen becomes less soluble in water and a small quantity reaches the embryo. The embryo then receives very little oxygen because less is dissolved in the integuments and more is fixed by the phenolic compounds. In all cases, the higher the temperature the less oxygen is available to the embryo. This is more important in the seeds of the families Leguminosae and Malvaceae which produce hard seed coat and entire absorption system particularly of water is very much reduced (Basu, 1984).

2.4 Pre-sowing seed treatment in relation to germination, seedling vigour, growth and yield of crops

2.4.1 Stand establishment and seedling vigour

For successful crop production, it is essential to have a vigorous stand of crop with desired plant population. Early fast growth, usually referred as 'pick up', is related to high seedling vigour. Early seedling vigour is necessary to avoid adverse environmental condition like drought etc. (Rao et al., 1971).

Austin et al., (1969) attributed the improved germination of hardened carrot seeds (subjected to three 24 h imbibition dehydration cycles) to germination advancement and enlargement of the embryo within the seeds, a view which was shared by Hegarty (1970). Singh and Tomar (1972) studied the effect of soaking rice seeds in various chemicals on germination and seedling vigour and found that soaking in 1 % sodium hydrochloride solution enhanced germination percentage and rate of elongation of plumule and radicle. Simak (1976) described the advantages of soaking tree seeds in polyethylene glycol (PEG) to improve the speed and percentage of germination.

Dayanand et al., (1972) found that seed soaking in water could hasten the germination of wheat seeds by 2 - 2.5 days. Khan and Chatterjee (1981) reported that number of wheat plants emerged from soaked seeds were significantly more than that was obtained from unsoaked seeds. Gupta (1975) observed that pea seeds treated with 0.1, 1 or 50 ppm solution of GA, NAA, Coumarin, NAA + Coumarin, GA + Coumarin and NAA + GA for 24 h have shown accelerated germination and seedling growth rates with GA and with 0.1 and 1 ppm NAA or Coumarin and the attributes were delayed with 50 ppm NAA or Coumarin; in combinations, GA multiplied the delaying effect of 50 ppm Coumarin but not that of NAA on germination and it increased the stimulating effects of the lower concentrations of NAA and Coumarin on seedling growth.

2.4.2 Growth and yield of crops as related to pre-sowing seed treatments with chemicals

Seed soaking in chemicals also improves the crop performance under adverse condition. Many workers have studied the effect of seed treatment with different chemicals and reported increases in crop yields (Abhichandani and Ramiah, 1951; Pawar et al., 1960; Mehrotra et al., 1967; Salim and Todd, 1968; Barthakur et al., 1973; Basu et al., 1974, 1975; Basu, 1977; Singh and Chatterjee, 1980; Bhattacharjee et al., 1984 and Chatterjee et al., 1985). Narayanan and Gopalakrishnan (1949) obtained 40 % increase in yields by soaking rice seeds in a 20 % solution of $K_3 PO_4$. Abhichandani and Ramiah (1951) observed higher grain yield of rice by treatment with $K_2 HPO_4$. At the Central Rice Research Institute (CRRI), Cuttack Iswaran et al., (1962) reported an increase of 10 - 15 % in yield due to soaking paddy seeds for 24 h in 2 M, M and M/2 solution of $KH_2 PO_4$, $K_3 PO_4$, $NH_4H_2PO_4$, NaH_2PO_4, Na_2HPO_4, $(NH_4)_2SO_4$ and NH_4NO_3. Narayanan et al., (1958) recorded appreciable increases in grain and straw yields by pre-soaking treatments in nutrient solutions. Mehrotra et al., (1967) found that soaking rice seeds in 15 and 20 % solution of KH_2PO_4 for 18 hours before sowing produced increased grain yield than non-soaked (control) seeds. Sinha (1969) observed that crops raised from rice seeds soaked in 1 M K_2HPO_4, reduced spikelet sterility greater than those where plants were raised from seeds soaked in distilled water. Basu et al., (1975) observed that seed treatment with sodium phosphate (di-and mono-basic), oxalic acid, sodium chloride, urea and sodium molybdate enhanced vigour and viability of seeds like gram, *Lathyrus*, lentil, greengram etc. and salts like NaCl, Phenols, vitamins at low concentrations (10^{-5} to 10^{-3} M) improved the germinability of seeds.

Singh and Chatterjee (1980) reported that pre-sowing seed treatment with NaCl, Na_2HPO_4, Al $(NO_3)_3$, Co $(NO_3)_2$ or Agromin (containing Zn, Fe, Cu, Mn, Mg, B and Mo) caused 14 - 26 % increase in grain yield of rice. Crops raised from treated seeds outyielded those raised from untreated seeds (control) and gave higher tiller number per unit area and higher shoot and root lengths in the seedling stage. The best effect was always obtained from crops raised from seeds treated with Na_2HPO_4 solution, and this was usually followed by water soaking and soaking in Al $(NO_3)_3$ solution.

Singh et al., (1972) reported an augmenting effect of the different treatments in lower concentration with phytohormones (IAA, NAA, 2, 4-D) while they observed that the higher concentration showed adverse effect. IAA and NAA showed better effect than 2, 4-D. IAA increased grain yield, number of grains, length of pods while NAA increased the straw weight and 100 grain weight. In comparison to IAA and NAA, 2, 4-D had least response to all the characters. Rao (1975) while working with phytohormones (IAA, NAA, GA_3 and 2, 4-D) on pea and groundnut reported increased number and size of pods and yield in both the crops when used singly or conjointly. Raj (1978) reported seeds of barley (New Pusa-21 and Spartan-5027) when pre-treated with distilled water and ascorbic acid showed enhancing effect upon the growth of the plants. Chatterjee and Singh (1983) found that crops raised from pre-sowing treated seeds with Na_2HPO_4, Al $(NO_3)_3$ and Co $(NO_3)_2$ increased the root and shoot growth and ultimately increased the grain yield of barley. The increase in grain yield was maximal in Na_2HPO_4 treated seeds (37 % above the untreated seeds) which was followed by Al $(NO_3)_3$. Bhattacharyya et al., (1984) obtained similar results with blackgram. Pre-sowing seed-treatment with Na_2HPO_4, various concentrations of polyethylene glycol (PEG) or their combinations caused 13 - 74 % increase in grain yield over control. All these chemicals used for pre-sowing seed-treatment gave better results than crops raised from water soaked seeds. The crops raised from treated seeds outyielded those raised from untreated control. The crops raised from pre-sowing treated seeds had greater root and shoot lengths and lower water saturation deficit in leaves than the plants raised from untreated seeds.

Misra and Dwivedi (1980) conducted an experiment with 12 wheat varieties under rainfed conditions and found that seed treatment with 2.5 % KCl solution increased dry weight of shoots, yields of straw and grain significantly over control. Chemical seed soaking with dilute solutions of NaCl (10^{-3}M) or sodium phosphate (di-basic, 10^{-4}M) proved better than water for improving field performances and productivity of tomato (Mitra and Basu, 1979). Wiebe (1982) found that pre-treatment of seeds with carbowax (PEG) increased yields of carrots, leeks and parsley. ✓

Kundu and Basu (1981) found that pre-sowing seed soaking in solutions of NaCl (10^{-3}M), di-sodium phosphate (10^{-4}M) or sodium thiosulphate (10^{-5}M) increased the growth and yield of carrot. Basu and Dey (1983) reported that seed treatment with water containing sodium phosphate (monobasic, 10^{-4}M), P-hydroxy-benzoic acid (10^{-3}M) and P-aminobenzoic acid (10^{-3}M) increased the yield of sunflower and these treatments proved better than soaking with water alone.

Helton and Dilbeck (1982) observed that when peas (cv. Alaska and Garfield) seeds were treated with different conc. (5, 10, 15, 20, 25 or 30 %) of H_2O_2 for different length of time (7.5, 15, 30, 45 and 60 minutes) and thereafter grown in petridish and in a greenhouse showed increase in shoot length, number of nodes, root volume, root weight and shoot weight at maturity. Moreover the pea seeds were disinfected with H_2O_2 without damage by most treatments and overall immersion of the seeds in 30 % H_2O_2 for 45 minutes was the optimum treatment.

2.4.3 Effect of pre-sowing seed treatment on growth of roots in crop plants

The studies on development of roots are very important with regard to drought tolerance of crop plants. Lundegradh

(1942) recognized root development as an important factor in determining plant's adaptability to dry conditions. Bhan *et al.* (1973) studied the development of root as an index of drought resistance in sorghum. The drought resistance may depend largely on avoidance mechanisms such as deep root systems which can absorb soil moisture from a greater depth (IRRI, Research highlight for 1975). There is no doubt that vigorous and rapid development of roots contributed considerably to drought resistance and yields of those crops grown in rainfed condition. Pre-sowing seed treatments can improve the ability of crop plants to tolerate drought.

The pre-sowing seed treatment of fingermillet in distilled water produced more extensive root system and consequently yield was increased (Dawson, 1965). Singh and Chatterjee (1980) reported that pre-sowing seed treatment of rice in Na_2HPO_4, water and $Al\ (NO_3)_3$ resulted in better root growth. Plants from treated seeds showed higher dry matter accumulation in roots. Correlation studies further confirmed that the treatments having better root development, particularly at lower depths, showed increased grain yield ($r = 0.79$) under rainfed condition. Chatterjee and Singh (1983) found high positive correlation ($r = 0.85$) between ash free dry weight of roots of plants and grain yield of barley.

Sen Gupta *et al.*, (1984) reported that pre-sowing treatment of blackgram seeds with water, Na_2HPO_4, various concentrations of PEG or their combinations increased length and dry weight of roots and these resulted in better extraction of soil moisture. Correlation studies showed that there was high positive correlation between grain yield and total soil moisture extraction by plants ($r = 0.86$) under rainfed condition.

2.5 Merit and demerit of *Lathyrus* cultivation

2.5.1 Merits of *Lathyrus* cultivation

It is a temperate crop. It is cultivated in the cold winter months in the Indian sub-continent. It can grow well under moderate temperatures ranging from 10 - 30°C (May, 1979).

Lathyrus is the hardiest of the pulse crops because it can tolerate waterlogging as well as drought. It can be grown in areas of low rainfall (300 - 500 mm) and also in areas of high rainfall (upto 1500 mm). This attribute of tolerance to extremeties of flooding and drought has made it very popular in drought prone areas where heavy rains may occur for brief periods.

Lathyrus can be cultivated over many types of soils ranging from very poor marginal soils to rich black cotton soils. Lathyrus is cultivated as a second season crop in low lying rice fields in clay soils which remain wet for a longer time (Nezamuddin, 1970). It can withstand drought periods and moderate soil salinity, better than peas (Serov, 1974). The grain is used as a complementary or sole source of calories and proteins, mostly by the poor and landless labourers. The grains can be boiled whole, but most often they are processed through a 'dal' mill to obtain split dal. It is used as 'besan' through grinding. In many parts of Madhya Pradesh / U.P. roti (leavened bread) made out of Khesari is a staple food for landless labourers during the lean periods. There are reports that Lathyrus seeds are used in homeopathic medicine and its leaves as pot herbs. The tender leaves are used as green vegetable. The young plants are used by many farmers as fodder for cattle. The green fodder is reported to be harmful to horses but safe for cattle and sheep (Kay, 1979). In studies at BARI, (Bangladesh Agricultural Research Institute) Joydebpur, fodder yields of 7 - 10 t / ha were obtained in intercropping with maize without affecting grain yields of maize (Gowda and Kaul, 1982).

2.5.1.1 Low toxin content of Lathyrus

Now a days low toxin Lathyrus varieties are being evolved which are not harmful on consumption. Nirmal (KH-1), is a selection from a local material that outyielded all other varieties having low neurotoxin content (0.2 %). The grain contains 27.2 % protein (Pulses and oilseed in West Bengal Directorate of Agriculture, Government of W.B. 1972).

2.5.2 Demerits of *Lathyrus* cultivation

Although *Lathyrus* cultivation as *paira* crop needs little management, but yields are usually poor because of poor population of crop plants due to low seed rate, substantial amount of seeds fail to reach the surface of the soil, seeds may not germinate well due to high / low moisture condition, microbial attack and poor attachment of the seeds to soil surface, damage to plants at the time of harvesting of the rice, lack of moisture at critical period of crop growth and unsuitability of the variety sown. Roy Sharma *et al.*, (1982) reported that the low yield of *Lathyrus* may be due to wide range of growing condition and poor management system. Besides low yield of *Lathyrus* it creates lathyrism due to it's toxin content (L -α- β Diaminopropionic acid). Siddiq *et al.* (1978) expressed same view about the toxin content in *Lathyrus*. Young (1927) concluded from it's survey work conducted in Rewa district, M.P. that lathyrism may occur when this legume predominates in the diet, when the general population is suffering from starvation and avitaminosis in a famine year, lathyrism is more common in bad years than in normal years. In an area in which lathyrism was particularly prevalent, the deficiency disease 'nightblindness' was also notoriously prevalent. He also concluded from his survey report that Mohammedan village using as much *Lathyrus sativus* as their Hindu neighbours but supplementing their diet by substances which tend to restore the dietary balance, lathyrism was unknown. Roy *et al.* (1963) in their experiment conducted on one day old chicks gave intra-peritoneal injections of 0.2 to 0.6 ml of *Lathyrus sativus* extract from the first day of experimentation. It was observed that in a number of birds receiving such injections, symptoms suggestive of neural involvement were produced. The common abnormality frequently noted was retraction of head and twisting and stiffening of neck paralysis resulting in inability of the bird to stand and move about was also noted in some instances. Murti and Seshadri (1964) reported two kinds of lathyrism recognised *viz.* Osteolathyrism (odoratism) where pathological changes occur in bones resulting in skeletal deformities and neurolathyrism in which the muscles of the limbs, especially of the legs, are paralysed sometimes resulting in convulsions and death in severe cases.

Dwivedi (1983) reported in his article that lathyrism can strike anyone - even an urban dweller whose diet contains 25 per cent Khesari dal for 45 days to six months. As reported, males are more prone to lathyrism than females, in ratio being 10 : 1.

2.5.3 Detoxification of Lathyrus

Since a considerable percent of land area (4 %) under pulses cultivation is occupied by lathyrus so it's cultivation cannot be banned totally as it is a major item of food in many places in India and also in Bangladesh. Hence, problem of lathyrism must be tackled in other ways (Gowda and Kaul, 1982). Two possible ways to minimise the risk of lathyrism are,

(1) Physico-ehemical detoxification : This involves educating the consumers, especially house-wives, in simple and effective methods of detoxification. Many methods are found to be reliable in removing toxic factor : (i) boiling the seeds in water and draining away the first wash, (ii) soaking the seeds over night and draining away of excess water, (iii) steeping the dehusked seeds / dal in water, (iv) par-boiling the seeds, similar to rice par-boiling and (v) roasting of seeds at 150°C for 20 minutes.

(2) Genetic detoxification

This method involves selection and breeding for low toxin lines. Screening of germ plasm, has resulted in identifying several lines that have low toxin content.

2.6 Substitute cropping of lathyrus

Lathyrus is a temperate crop. It is cultivated in the cold winter months in the Indian sub-continent where temperature ranges between 10 - 30°C (Kay, 1979). Lathyrus is the hardiest of the pulse crops because it can tolerate both flood and drought (suitable for cultivation in rainfall ranging between 300 - 1500 mm annually). This attribute of tolerance to extremeties of flood and drought has made it very popular in rice-fallows of low-lying situations where the crop primarily experiences drought excepting at the beginning or in the event of heavy rains during growth period when flooding may occur for brief periods (Nezamuddin, 1970). It can be cultivated over many types of soils ranging from very poor marginal soils to rich black cotton soils. It can tolerate soil salinity better than peas (Serov, 1974).

Inspite of all these favourable points in favour of *Lathyrus*, Government discourages its spread and cultivation for a simple reason that it can cause, upon continuous consumption, a neurological disorder called lathyrism. Lathyrism usually occurs in younger members of the very poor households who continuously for 3 - 6 months consume non-boiled *Lathyrus* seeds as a source of 1/3 to 1/2 of their protein calorie needs. Rao *et al*., 1969; Kaul and Islam, 1981 have reported that the incidence of disease is specially more in drought years when consumption of this crop is more. Tareque (1981) believes that poverty and malnutrition are the major factors causing lathyrism. Several authors (Sharma and Padmanabhan 1969; Rao *et al*., 1969; Kaul and Islam, 1981) also considered that the disease is a result of food deficit, poverty and improper methods of consuming the seeds.

Although low neurotoxin content varieties, physico-chemical de-toxification methods and a vitamin C rich diet is reported to reduce the risk of the disease (Ahmed and Jahan, 1981) yet one can not obviate the risk of lathyrism because the cases of adulteration is rampant. This necessitates the cultivation of some alternate crops in place of *lathyrus*. Broadcasting is the most common method of planting *lathyrus*. The seeds are broadcast either into a standing crop of rice about a week before harvest, or directly into stubbles after the harvest, of rice. No tillage is given in either practice.

When sown in upland conditions with tillage, it may be line sown behind the plough. The first system is called the paira system of cultivation. Any crop can be grown during the condition provided they adjust to the system mentioned earlier. Sowing of gram, lentil, khesari, linseed or berseem in the standing rice field in the month of November or early in December and then draining out the water from the rice paddies, if required, is extensively practised by the farmers in the eastern region. The yield potential of the second unirrigated crop is usually not high, only 3 - 8 q / ha of pulses and oilseeds (Chatterjee and Maiti, 1984).

2.7 Minimum tillage and crop production

2.7.1 Effect of minimum tillage on soil moisture availability

In a double crop system, where time factor is rather important, the seedbed preparation for the second crop succeeding the first, has to be done as expeditiously as possible (Singh *et al.*, 1980a). A good amount of moisture is lost through evaporation during land preparation. Sometimes this loss of moisture may be critical for germination of crops grown in the post-rainy season under rainfed conditions. Minimum tillage technique which is based on the principle of causing least soil disturbance and having maximum of crop residue on the soil surface ensure more storage of moisture than that of conventional tillage (Lal, 1975).

The no tillage system of soil management with crop residues (or mulches) may maintain the productivity of some tropical soils by eliminating soil erosion and by preserving soil structure, soil organic matter, and nutrient and water holding capacity (Greenland, 1975 and Lal, 1976). One of the main advantages of no-tillage is conservation of soil and water, but the latter is partially related to the crop residue left on the surface as a mulch (Moody, *et al.*, 1963; Triplett *et al.*, 1968; Greb *et al.*, 1970). Many researchers have indicated that the potential of mulches for suppressing evaporation lie only in the first two stages of the process, probably by decreasing turbulent transfer of water vapour through the atmosphere (Lemon, 1956; Bond and Willis, 1969, 1970). Hanks and Woodruff (1958) and Hunks et al., (1961) have shown that depth of mulching also increase soil moisture storage, whilst no-tillage improves water conservation by increasing the infiltration rate and water holding capacity (Shanholtz and Lillard, 1969; Miller and Sharder, 1976; Lal, 1976).

Ospina et al. (1957) found in Columbia that the use of plough often resulted in heavy erosion. Kannegieter (1967, 1969) reported from Ghana that a short *Pueraria* fallows combined with mulch tillage gave effective soil protection against erosion and improved soil moisture storage. Minimum tillage generally causes a decrease of large, mostly air filled pores and thus reduce aeration. In minimum tillage soils the relative increase in the amount of medium to small pores are the consequences for holding more water. Water holding capacity is related to the organic matter, especially on sandy soils; this was confirmed by Van ouwerkerk and Boone (1970), who found that water content at pF 2 changed more in conjunction with organic matter content than with soil porosity. Hence, in the top 6 cm of the minimum tillage soils, a higher water content at pF 2 was found than in the ploughed soil, whereas the reverse was true in the layer at 11 - 16 cm.

Similarly, minimum tillage resulted in higher mean volumetric moisture content in the upper 30 - 60 cm soil layer than conventional tillage on soils situated in the sub-humid regions of North America on gently sloped silt loams planted with maize (Harrold et al., 1967; Amemiya, 1968).

Mannering et al. (1966) reported that minimum tillage for maize, in comparison with conventional tillage, increased infiltration and reduced soil erosion. Shanholtz and Lillard (1969) also reported that the water use efficiency of maize crops grown on no-tilled and normal tilled soils was 81 and 57 % respectively. Regardless of the greater water extraction, visible wilting of maize and sugarbeet was delayed for hours or days, which indicated an enhanced depletion of soil water on undisturbed soil.

Blevins _et al._ (1971) working on maize reported that the average yield of maize sown on herbicide - killed grass sod were about 10 % higher than when sown with normal tillage. No tillage treatments had higher volumetric moisture content to a depth of 60 cm during most of the working season. The greatest differences occur in the upper 0 - 8 cm depth. Beyond a depth of 60 cm, system of tillage had little influence on soil moisture during the growing seasons. The decrease in evaporation and the greater ability to store moisture under no-tillage produces a greater water reserve. This can often carry the crop through periods of short-term drought and avoid the development of detrimental moisture stresses in the plant. Greater differences in total available water always early in the growing season were previously supported by Shanhaltz and Lillard (1969). Zero-tillage methods could be expected to increase water conservation in dry farming regions (Baeumer and Bakermans, 1973).

2.7.2 Effect of minimum tillage on stand establishment

It is obvious that the soil surface remain dry at the time of seeding, which is completely due to the climatic conditions or technical requirements of minimum tillage. In this context if the seeds are broadcasted over the surface it may be eaten up by grain feeding animals. In order to minimise the failure of germination of seeds, seeds are to be placed into the close contact with the moist soil by means of minimum soil disturbance. Rhixon (1969) reported that mean stand establishment achieved by minimum tillage was about 20 % less than by normal tillage method. This is due to the technical difficulties of bringing the seeds in contact with the soil in _paira_ method of cultivation / placing seeds at proper depth of soil which is always covered with stubbles or too hard to allow sufficient penetration. Debruck (1971) reported a higher number of emerged plants in minimum tillage than in conventional tillage on light to medium textured soil. This happened to be the case in which a lack of available soil moisture restricted seedling emergence on tilled soils. Stranak (1968) observed more rapid absorption of water by seeds on untilled soils. Therefore, higher rates of seedlings emergence can be expected from minimum tilled soil than from normal tilled soil during warm and dry periods.

2.7.3 Effect of minimum tillage on the root growth

As regards the root density or weight, the amount of roots observed at different growth stages and soil layer tended to be lower on zero-tilled soil (Newbould et al., 1970; Cannel and Ellis, 1972). This difference in root mass was accompanied by shallower rooting in undisturbed soils, especially during early vegetative growth phases. In minimum tilled soil, the extension rate of seminal root axes was slower but yet lateral branching started earlier and thus led to the production of a dense but shallow seminal root system on soils with no-tillage operation. No differences were found between the effects of tillage treatments on the length and frequency of adventitious roots of wheat (Baeumer and Bakermans, 1973). Therefore, final rooting weight and the pattern of soil depth distribution at the ripening stage may be similar on tilled and untilled soil (Baeumer et al., 1971). However, on sandy soils in the Netherland, shallow rooting persisted until harvest, probably owing to mechanical impedence of the soil to root penetration. Yueruer (1972) working on barley reported that the restricted axial growth of roots was compensated by greater radial growth i.e. by a larger diameter of the seminal root axes. Barbar (1971) also obtained similar result while working on maize and pointed out that roots were finer and longer / g of root in tilled soil than in untilled soil and greater weight per unit root length of maize observed in unploughed soil.

Kaul et al. (1970) while working with maize, Ganga hybrid 101, at the students farm on a sandy loam soil indicated that all other deep tillage and maximum preparatory tillage gave increase in root weight over rest of the treatments. Deep tillage proved significantly better over no cultivation.

2.7.4 The effect of minimum tillage on the growth and yield of crops

Stibbe and Ariel (1970) worked on sorghum and cotton in Israel under semi-arid climatic condition and reported that in a year of partial drought when all crop yields were reduced, zero-tillage gave slightly superior yields, but when moisture was adequate it depreseed yields by upto 40 % . On the other hand, Lewis (1972) working in U.S.A observed an equal lint yield of cotton produced by normal and zero-tillage methods. Gouthaman and Sankaran (1976) from their field experiments conducted in two seasons to compare the efficiency of various types of tillage treatments combined with different weed control methods, observed that there was no significant difference in yield among conventional tillage, minimum tillage and no-tillage. On the other hand Shear et al. (1961) obtained significantly higher corn yield from zero-tillage over conventional tillage method of cultivation. Jones et al. (1968) obtained yields of corn in zero-tillage which were comparable to or ranged from 18 - 39 % above yields from conventional turn plow tillage.

Working in Georgia Nelson et al. (1977) reported that maize and sorghum grain yields with or without irrigation did not differ significantly for conventional tillage or no-tillage sowings made on the same date. No-tillage maize and sorghum produced higher yields when sown early after small grain crops. Irrigation increased overall mean grain yields of maize and sorghum under both conventional tillage and no-tillage sowings by 30 and 15 % , respectively but not always significantly. Lower yield increases under no-tillage was attributed to the higher initial water content of the soil. Early sowings without tillage responded to irrigation to a greater extent than did late sowings. Lal et al. (1978) reported that under irrigated condition both maize and cowpea under no-tillage yielded more than with conventional ploughing. Water use efficiency of maize established without tillage was 18.3, 17.5, 57.8 and 100 % greater than with tillage at irrigation frequencies of 2, 4, 8 and 12 days, respectively.

In southern Alberta (Canada), Lindwall and Anderson (1981) observed that repeated applications of herbicides were as effective as tillage for controlling weeds during the summer - fallow seasons. Crop residue and soil moisture conservation were greatest when weeds were controlled with herbicides instead of tillage. Wheat yields from treatments involving little or no tillage during the fallow season were consistently greater than those from conventionally tilled treatments. Shear and Moschler (1969) while comparing effect of no-tillage, tillage in alternate years and conventional tillage on corn, equal annual applications of phosphate mixed in tilled soil and applied to the surface of untilled soil resulted in more available phosphorus accumulation in the upper 5 cm of the untilled soil. The total amount of available phosphorus for the upper 20 cm of soil was greater in untilled soil despite the fact that available phosphorus was lower than in tilled soil in two of the 5 cm increments below the surface layer. Potassium availability was not affected by tillage or method of application. No benefit was derived in grain yield from tillage in alternate years as compared with no-tillage. An average increase in corn grain yields and equal or better stover yields from no-tillage as compared with conventioal tillage was found.

Triplett and Van Doren (1969) worked on no-tillage and conventional tillage in corn growing as mono crop for 6 years, and reported higher grain yields in no-tillage than under conventional tillage treatments at all nitrogen levels. Phosphorus and Potash were applied uniformly in all the treatments of the experiment. Bandel et al. (1975) reported from their experimental results conducted in Maryland that no-till corn with low to moderate rates of nitrogen, often showed more pronounced nitrogen deficiency symptoms than did conventionally tilled corn. With sub-optimal nitrogen rates, nitrogen deficiency symptoms were more severe throughout the season on untilled than on the cultivated plots. However, the optimal level of applied nitrogen for grain and dry matter yields did not differ with tillage method.

Agboola (1981) conducted an experiment, comprising eight treatments for four years and concluded from the result that tillage and fertilizer application reduced the organic matter content of the soil by 19 and 33 % . No tilled plots produced more corn grain yield than tilled plots though the difference was not pronounced. Kckert (1984) while conducting experiment on no-tillage and conventional tillage, corn were planted on a series of planting dates over a three years period, on a moderately well-drained canfield silt-loam located at Wooster, Ohio. Under these conditions tillage system had no effect on development or yield. However, conventional tillage corn often silked earlier than no-tillage corn under cooler conditions and yielded more in a wetter than normal year. Date of planting had the same effect on yield in both tillage treatments.

Thomas et al. (1984) studied the growth and development of grain sorghum, grown on a heavy clay soil in a humid subtropical climate, under no-tillage and conventional tillage. Soil water contents were not significantly different between the tillage treatments, but there were consistent trends towards more soil water under no-tillage throughout sorghum development in both the years of experimentation.

Kaul et al. (1970) from their experiment conducted with maize indicated that increase in tillage intensity resulted in increasing grain yield. Deep tillage proved superior to all the treatment combinations in increasing the grain yield. In U.S.A Oveson and Appleby (1971) observed that wheat yields were significantly lower in untilled than in tilled plots.

Davies and Cannel (1975) reviewed the results presented for field experiments in the U.K. during the period 1957-74, in which they concluded that in early experiments before 1970, average yields of winter wheat after direct drilling in unploughed soil were less than after ploughing but in later experiments there was little difference as compared with ploughing.

In Hungry, Sipos (1972) reported from a long-term experiment (1968-71) that no-tillage direct sowing led to substantial loss of yield and inefficient use of fertilizer in maize. Similar results were also reported from Iran by Hakimi and Erami (1973). In Ohio (U.S.A), zero-tilled soybeans produced slightly less than normally planted stands at 4 locations, whereas at one location higher yields were observed during a period of 6 or 3 years, respectively (Baeumer and Bakermans, 1973). In India, winter wheat (Chatterjee and Khan, 1978) winter maize (Khan and Chatterjee, 1981a) and greengram (Khan and Chatterjee, 1982a) were successfully established under irrigated condition through minimum tillage with the aid of pre-sowing herbicide application and produced slightly lesser yields than normal sowing (conventional tillage). Similar observations were also made in the case of greengram (Khan and Chatterjee, 1982b) grown as relay crop prior to harvest of jute and upland rice and blackcumin (Khan and Chatterjee, 1982c) grown on conserved soil moisture under rainfed condition. In all above mentioned trials conventional tillage always gave slightly superior yields, though not significantly more in all cases, than minimum tillage where there was no surface residue as mulch.

2.8 Sowing of mixture of aus and aman seeds in lowlying areas to overcome the risk of drought or heavy rains in the late season

In the lowlying areas more particularly in the beel areas, both in West Bengal and Bangladesh, rice is directly seeded as a mixed culture of aus (harvested in autumn) aman (harvested in winter). In case of early severe drought the aus crop may be affected and in case of early cessation of rainfall the late duration crop is affected. A mixed culture of two groups of rice, is done to overcome the risk of crop failure, either due to no rainfall in early months or due to early cessation of rainfall. After the harvest of rice crop fields are again put to a paira crop, generally *Lathyrus*. There is no systematic record of published work, providing information on the productivity of crops following a sole crop as against an intercrop of rice.

2.9 Soil moisture status in winter

In Eastern Gangetic plains, covering West Bengal / Bangladesh, usually very low or no rainfall is received during winter. But at the same time, depending upon topographical, situation of these lands, a fairly good amount of available soil moisture remain stored in 1 m deep soil profile, ranging from 150 mm in heavy soils to 80 mm in light soils. Michalyna and Hedlin (1961) found that increase in stored soil water in fallow over that in the cropped land gave higher wheat yield. In general, the deeper the water is stored in the soil, the more slowly it will be removed by evapotranspiration (Robins, 1967). Black (1973) reported that average available water stored to a depth of 1.5 m was positively corrrelated with mean grain yield of wheat.

Haise *et al.* (1960) reported that where available soil moisture is adequate and plant response is obtained with added N, water use efficiency and dry matter production are markedly increased. Under limited moisture condition, similar increases in water use efficiency with N fertilizer used are observed but with lower dry matter production.

The study of availability of moisture under dry farming conditions in relation to time of planting showed that the crops planted in the early stages of rainfall provided better utilization of moisture and its availability during the crop growth. Late planting had shown that there was a deficit of moisture in the effective root zone at the later stage of crop growth which resulted in the low yield (Dayal *et al.*, 1973). Only those crops performed better under dry farming conditions which could tap moisture from deeper soil layers. In general, moisture extraction progressively occurred from deeper soils with the advancement in the age of crops. It was observed that 90 % of the total moisture required by the crop was extracted from 60 cm depth by wheat, 90 cm by gram, barley, toria and from 120 cm by *rai*. It indicated that *rai* is most efficient and gram, barley and *toria* were moderately efficient but wheat was least efficient in utilizing sub-soil moisture (Singh and Rathi, 1974).

Batra *et al.* (1976) from Hissar reported that in years with 150 ± 25 mm soil moisture in the profile, *taramira* crop might be given preference; in season with 227 ± 50 mm profile moisture mustard be selected; and in seasons ending with soil profile moisture status much above 227 mm moisture, gram was the best crop for achieving optimum water use efficiency. They also reported that for oilseed crops adequate moisture content for germination was found to be 10 per cent in a soil having 15 - 16 per cent water at field capacity. The moisture percentage should be between 10 - 12 per cent for the gram crop.

Working at Varanasi Singh *et al.* (1977) reported that gram and barley were found to be superior to wheat and linseed for grain production under rainfed condition. Linseed was the poorest in grain production. Total moisture use of grain was highest followed by barley, wheat and linseed. Studies conducted in New Delhi on the yield and moisture utilization pattern of selected dryland crops grown on conserved soil moisture showed that barley (EB 3) and sarson (BSH 1) proved to be more efficient in terms of better yields and higher moisture use efficiency and also showed the lowest per cent mortality as compared to gram (G 24), linseed (NP-RR 9), lentil (L 9-12) and wheat (Kalyan Sona). The moisture utilization pattern of these crops showed that *sarson*, barley and gram extracted moisture from deeper layers (50 - 125 cm) of the soil profile. Wheat proved to be most efficient crop in utilization of stored soil moisture under dryland conditions.

Chatterjee and Sen (1977) reported that amongst oilseeds safflower (Nag 7) and linseed, amongst pulses gram (B 108), field peas (B 22) and lentil (B 77) and amongst cereals barley (K 125) yielded 10, 8, 21, 13, 11 and 19 q / ha, respectively. The moisture extraction at lower soil depths by gram, peas and safflower was higher than in the other crops in winter. Barley with its fibrous roots utilized good amount of moisture conserved in top soil. The water use efficiency under rainfed condition was highest in barley (31 kg / mm) followed by gram (16.6 kg / mm) and peas (10 kg / mm).

Saha _et al._ (1980) reported that under rainfed condition, the amount of water left after the harvest of _Kharif_ crops was insufficient to raise _rabi_ crops, which could be cultivated only after _Kharif_ fallow. Total amount of available water in _rabi_ season after _kharif_ fallow varied from 111.6 to 203 mm. Among the _rabi_ crops barley, mustard and safflower could use this available soil water more efficiently.

Jain and Reddy (1981) compared the grain yield and economic returns obtained from different crops, grown in sequence or in relay on residual soil moisture in deep black soils of Hyderabad. They reported that pigeonpea utilized moisture from deeper layer of soil profile and produced the highest average seed yield (2,820 kg / ha) and gave maximum income (Rs.7,050 / ha) which was significantly more than the income from any other crop tried during both the years of experimentation (1977 and 1978). Wheat and chickpea yielded more when sowing was delayed (late October onwards) when the daily mean temperature was below 25°C. Black gram and cowpea produced more yields when sown early (late September to early October) by making full use of the surface soil moisture.

Khan and Chatterjee (1982) reported that in the light sandy loam or silty clay loam soils of Nadia district in West Bengal, sowing of greengram or blackgram in between the harvested rows of direct seeded rice of jute with minimum cultivation' (without ploughing but with subsequent weeding and hoeing) between 15 August and 10 September, is possible. This provided yield to the tune of 8 - 10 q / ha of greengram / blackgram. Singh (1983) conducted a 4 years field study on the aridsoils of Bawal (Haryana) and reported high soil moisture (182 - 199 mm in 1 m soil profile) increased the grain yield of mustard by 43 % and that of chickpea by 23.3 % over low soil moisture (134 - 154 mm in 1 m soil profile). Giri and Balerao (1984), reported that under rainfed condition in winter, amongst all the varieties of peas, variety L 116 gave the highest grain yield (10.3 q / ha) in first two years of experimentation. Saharia (1985) reported that peas sown on 20th October in 1981-82 at the Regional Research

Station Shillongani, Nowgong, gave the best performance in all the sowing dates. The yield recorded was 16.6 q / ha.

2.10 Summary and scope of work

From the foregone literature it is clear that _Lathyrus_ is very potential crop and is successfully grown during post monsoon season in rice fallows in humid sub-tropics. Due to late release of land by rice crop, relay planting in the standing rice 10 - 20 days before harvesting is the most prevalent system of crop growing. Inspite of potentiality of _Lathyrus_ its cultivation is not very extensive. On the contrary government imposed a ban during mid-sixties on the cultivation, because it has been reported that continuous consumption of _Lathyrus_ causes an incurable disease known as lathyrism for a neurotoxin (BOAA) content in the seeds. Although physico-chemical detoxification methods are there yet risk can not be avoided completely and genetic detoxification methods are time consuming. But for the time being if alternative crops can be searched out possibly that will be the best alternative. Therefore there is a great scope of studying the feasibility of growing alternate crops as a substitute of _Lathyrus_. That means a suitable crop has to be searched out, which can establish well as a _paira_ crop and provide stable yield as much as _Lathyrus_. Further, agronomic management practices need also to be searched out to increase their productivity with measures like seed treatment or fertilization etc.

CHAPTER 3

MATERIALS AND METHODS

3 MATERIALS AND METHODS

To study the productivity of Khesari or grasspeas (*Lathyrus sativus* Linn. cv. Nirmal and Local), peas (*Pisum sativum* Linn. cv. B 22), lentil (*Lens esculenta* Moench cv. B 77) and linseed (*Linum usitatissimum* Linn. cv. B 67) as relay (*paira* or *utera*) crop in rice follows in winter, two field experiments were carried out in three consecutive years 1984-85, 1985-86 and 1986-87 in the Viswavidyalaya farm ('C' Block), Kalyani, West Bengal. The farm is situated at 23.5^{O}N latitude, 89^{O}E longitude and at an altitude of 9.75 m above the mean sea level.

The other three pot experiments to study the effect of different periods of submergences, on the germinability of pre-sowing treated and untreated seeds on seedling growth were conducted in a net house situated near the Faculty of Agriculture building at Kalyani during the years 1984, 1985 and 1987.

3.1 Experimental soil

The physico-chemical properties of the experimental soils, where the field experiments were conducted, have been summarised in Tables 3.1 (a, b and c). The soil of the Experiment Number 1 was mostly sandy clay loam in texture (Table 3.1a). The bulk density of the soil ranged from 1.39 in 75 - 90 cm layer to 1.48 in 0 - 15 cm soil layer and the field capacity of the soil ranged from 21.23 to 22.92 % at different layers (Table 3.1b).

Table 3.1a Mechanical composition of the experimental soils

Soil depth in cm	Particulars			Texture
	Sand %	Silt %	Clay %	
Experiment No.1				
0 - 15	68.20	14.70	17.10	Sandy loam
15 - 30	64.04	15.25	20.71	Sandy clay loam
30 - 45	66.45	13.03	20.52	Sandy clay loam
45 - 60	64.50	14.46	21.04	Sandy clay loam
60 - 75	63.05	15.57	21.38	Sandy clay loam
75 - 90	61.79	17.21	21.00	Sandy clay loam
Experiment No.2				
0 - 15	65.20	17.85	16.95	Sandy loam
15 - 30	61.30	19.50	19.20	Sandy loam
30 - 45	59.50	21.40	19.10	Sandy loam
45 - 60	61.60	20.30	18.10	Sandy loam
60 - 75	58.80	23.50	17.70	Sandy loam
75 - 90	60.40	21.10	18.50	Sandy loam

Table 3.1b Physical properties of experimental soils

Soil depth (in cm)	Bulk density (g/cc)	Field capacity (% dry wt. basis)	Permanent wilting point (% dry wt. basis) 15 atm. tension
Experiment No. 1			
0 - 15	1.48	22.21	7.3
15 - 30	1.46	21.56	7.2
30 - 45	1.42	21.86	7.8
45 - 60	1.43	22.92	7.8
60 - 75	1.42	22.41	8.0
75 - 90	1.39	21.23	7.6
Experiment No. 2			
0 - 15	1.43	21.46	5.9
15 - 30	1.44	20.54	5.0
30 - 45	1.47	21.30	5.3
45 - 60	1.46	20.49	7.0
60 - 75	1.44	21.79	7.6
75 - 90	1.45	20.02	7.2

Table 3.1c Chemical properties of the experimental soils

Organic %	Total N %	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	pH (1:2.5)
Experiment No. 1				
0.67	0.076	39.0	122.0	6.7
Experiment No. 2				
0.57	0.069	37.0	118.0	7.1

The soil where Experiment Number 2 was conducted was basically of sandy loam in texture (Table 3.1a). The bulk density of the soil ranged from 1.43 in the top 0 - 15 cm layer to 1.47 at 30 - 45 cm soil layer and the field capacity of the soil ranged from 20.02 to 21.79 % at different layers (Table 3.1b). The soils of both the experiments were low in potassium and were neutral in soil reaction (Table 3.1c).

Methods used to determine different physicochemical properties of experimental soils have been summarised in Table 3.2.

3.2 Cropping history of the experimental field

The fields under experimentation were under rice in the previous years. Two crops of rice (in kharif and boro seasons), for general seed multiplication were taken during the years 1981, 1982 and 1983. The experimental crop was planted in the year 1984 kharif season.

3.3 Climatic condition

In this region, the seasons are classified broadly, as winter (November to February), summer (March to May) and rainy (June to October) seasons. The climate is classified as sub-tropical humid climate where summer and winter are both short and mild. The details of the climatic conditions pertaining to the period of experimentation are presented in Table 3.3 (a) and 3.3 (b).

Table 3.2 Methods of analysis of different physico-chemical properties of the experimental soils

Particulars	Methods used
1. Bulk density	Dastane (1972)
2. Field capacity and permanent wilting point	Dastane (1972)
3. Mechanical analysis of soil	International pipette method (Piper, 1966)
4. Soil pH	Determined with Beckman pH meter by using soil water suspension (1 : 2.5) following the method as described by Jackson (1973)
5. Organic carbon	By rapid titration method as described by Walkley and Black (1934).
6. Total nitrogen	Modified Macro-kjeldahl method (Jackson, 1973).
7. Available phosphorus	Used Bray-1 extractant (Bray and Kurtz, 1945) and determined colorimetrically (Jackson,1973)
8. Available potassium	By Flame photometer method (Murh <u>et</u> <u>al</u>., 1965).

3.3.1 Rainfall

In this part of West Bengal monsoon generally commences from the second week of June and continues upto middle of October. The long term average annual rainfall is 1,457 mm but the bulk of it is received from June to October. During the years of experimentation the departures of total annual rainfall from the long term average, were -482.6 mm, -429.1 mm and +486.4 mm in 1984, 1985 and 1986, respectively. The rainfall receipts in 1984, 1985 and 1986 were 902.5, 989.7 and 1699.7 mm during May to October, respectively. The rainfall receipts during the <u>Rabi</u> season (November to March) were 34.3, 31.1 and 337.4 mm in 1984-85, 1985-86 and 1986-87, respectively. About sixty per cent of the total rainfall (i.e. 34.3 and 15.3 mm of rainfall in 1984-85 and in 1985-86, respectively) has been added to the water loss made by different winter crops. The rainfall pattern during the winter months is presented in Fig. 3.1.

3.3.2 Relative humidity

The monthly mean maximum relative humidity (Table 3.3b) varied from 95.8 % in October, 1984 to 80.8 % in February, 1984. In 1985 it varied from 93.0 % in July to 70.0 % in October and 90.0 % in October, 1986 to 74.0 % in March, 1986, respectively.

The monthly mean minimum relative humidity varied from 69.1 % in July to 21.4 % in March, 1984, 79 % in July to 35 % in March, 1985 and 74 % in July to 37 % in February and March 1986, respectively.

Table 3.3 (a) Monthly meteorological data pertaining to the years of experimentation

Months	Maximum temperature (°C)					Minimum temperature (°C)					Rainfall (in mm)				
	LTA	1984	1985	1986	1987	LTA	1984	1985	1986	1987	LTA	1984	1985	1986	1987
Jan	25.4	24.3	26.4	25.4	25.8	9.9	12.1	11.7	12.3	11.4	7.6	22.2	19.6	11.7	0.0
Feb	27.8	28.9	29.7	28.4	29.0	13.2	14.8	14.6	15.3	14.7	7.9	4.7	9.7	3.6	130.0
Mar	32.9	34.9	36.2	34.7	33.0	19.9	20.7	23.1	20.5	20.2	23.4	Trace	Trace	15.8	25.9
Apr	36.8	35.5	37.2	35.9		23.9	24.7	25.0	24.6		62.3	40.1	9.0	31.2	
May	36.4	35.1	35.5	34.8		25.1	27.1	24.2	25.2		102.6	47.2	83.2	185.4	
Jun	36.6	31.9	34.1	34.0		25.0	28.2	26.0	27.7		274.3	281.9	240.5	284.5	
Jul	32.3	33.0	31.4	31.8		26.7	29.2	25.4	26.5		285.6	161.8	192.1	263.4	
Aug	32.6	32.7	32.4	33.7		24.7	25.7	25.8	26.7		291.1	220.4	214.6	138.2	
Sep	32.7	32.6	32.4	32.2		25.5	25.4	25.4	26.2		267.2	72.0	141.7	429.8	
Oct	30.2	32.4	31.5	30.9		23.8	24.3	24.1	23.4		114.7	119.2	117.6	398.4	
Nov	29.4	30.4	29.1	30.1		16.1	18.2	17.1	16.5		17.2	0.2	Nil	174.5	
Dec	25.9	27.1	26.6	27.0		11.2	11.3	13.1	14.6		3.2	4.8	Nil	7.0	
Total											1457.1	974.5	1028.0	1943.5	

LTA = Long term averages (monthly mean of 20 years from 1964 to 1983)

Table 3.3 (b) Meteorological data pertaining to the years of experimentation

Months	Maximum relative humidity (in %)				Minimum relative humidity (in %)				Wind velocity (in km/hr)			
	1984	1985	1986	1987	1984	1985	1986	1987	1984	1985	1986	1987
Jan	86.2	84.2	85.2	84.0	54.3	45.7	42.0	40.0	2.1	1.3	1.1	1.5
Feb	80.8	84.5	82.6	71.8	25.3	38.5	37.0	38.0	3.9	2.3	1.3	1.8
Mar	92.7	81.9	74.0	72.7	21.4	35.0	37.0	33.8	6.6	2.4	3.1	3.2
Apr	91.1	80.5	83.0		43.1	38.6	47.0		7.0	4.5	5.0	
May	90.8	80.4	82.0		53.8	53.4	51.0		8.3	6.3	3.6	
Jun	88.6	86.0	87.0		66.2	69.0	[illegible]		5.8	3.3	4.8	
Jul	90.2	93.0	88.0		69.1	79.0	74.0		5.0	2.8	2.2	
Aug	92.6	91.0	87.0		68.4	75.0	67.0		5.1	2.4	2.4	
Sep	95.6	91.0	89.0		58.2	74.0	72.0		4.9	2.6	3.8	
Oct	95.8	70.0	90.0		51.4	52.0	61.0		2.9	2.1	2.5	
Nov	91.2	89.1	87.0		26.0	38.0	42.0		1.9	0.9	1.4	
Dec	88.2	85.6	83.0		36.3	41.0	46.0		2.6	1.3	1.9	

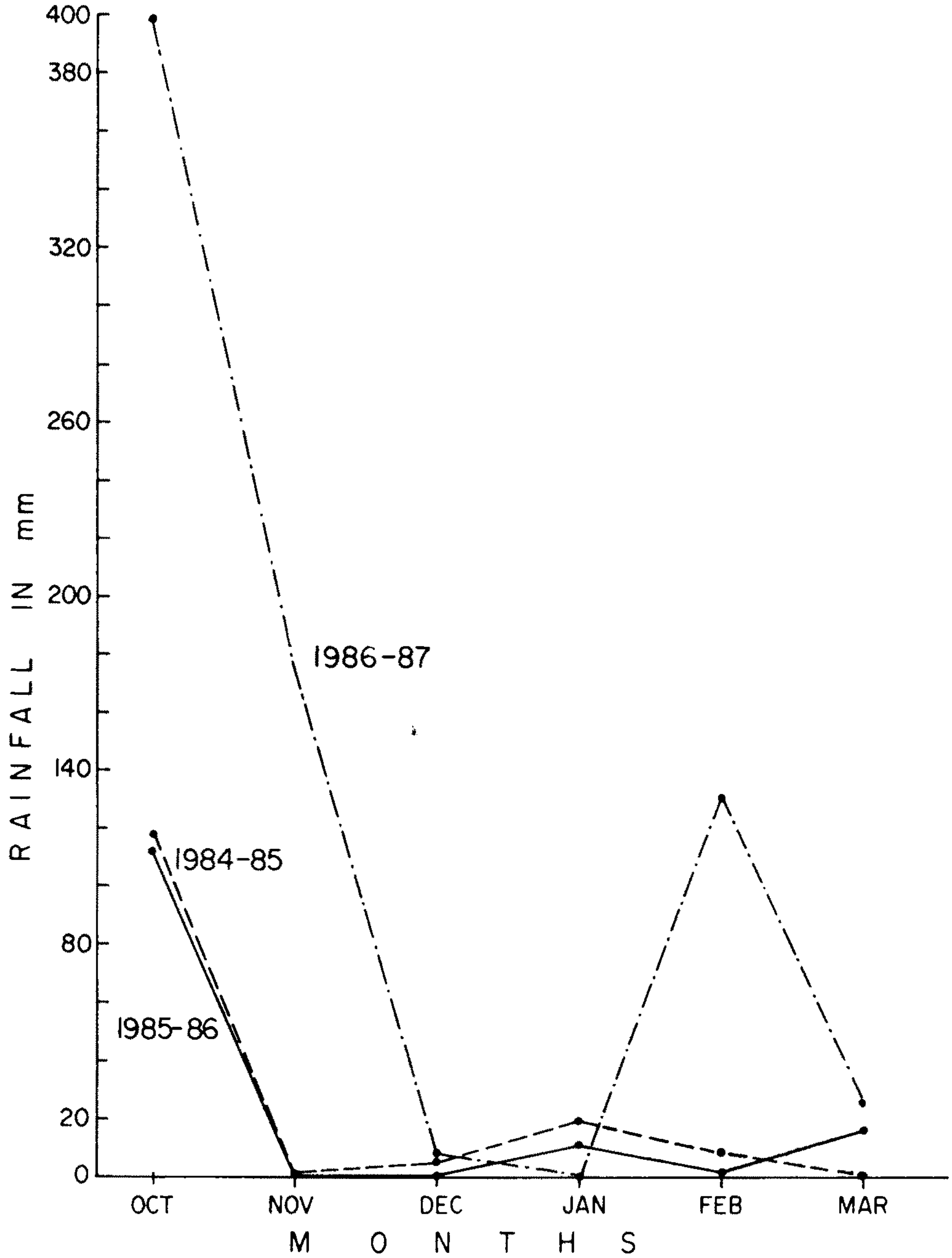


FIG.3.1 RAINFALL IN WINTER MONTHS.

3.3.3 Temperature

The monthly mean maximum temperatures varied from 24.3^{o}C in the month of January, 1984 to 37.2^{o}C in the month of April in 1985, during the years of experimentation. The mean monthly minimum temperatures varied from 11.3^{o}C in December, 1984 to 29.2^{o}C in July, 1984. The maximum and minimum air temperatures during the winter months have been represented in Fig. 3.2.

3.3.4 Wind velocity

The monthly average wind velocity during the period under report varied from 0.9 km / h in the month of November, 1985 to 8.3 km / h in the month of May, 1984.

3.4 Experimental details

3.4.1 Net House Experiments

The objectives of the experiments were to compare the effect of different periods of submergence (i) on stand establishment of few grain legumes viz. peas, lentil, Lathyrus (Nirmal and local) and one oilseed crop linseed and (ii) on seedling growth (both shoot and root) when sown on puddled soil and in soil prepared with conventional tillage.

3.4.1.1 Net House Experiment Number 1

The experiment was conducted inside a Net House adjacent to the Agriculture Faculty building at Kalyani in reinforced cement concrete (R.C.C.) pots of 50 cm x 50 cm x 100 cm size, in winter months (Oct - Nov) of 1984.

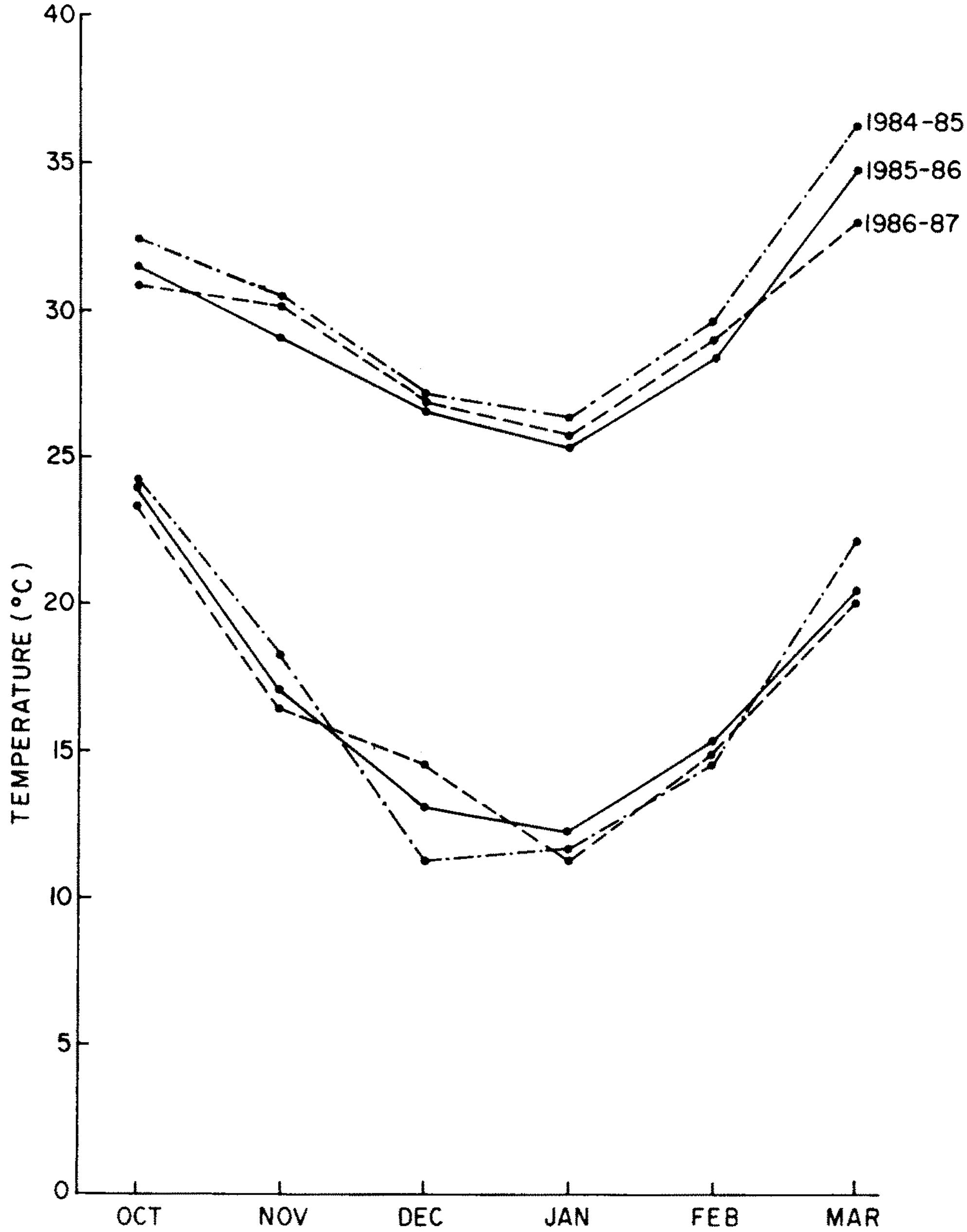


FIG. 3.2 AIR TEMPERATURE (MAXIMUM AND MINIMUM) CONDITIONS IN WINTER MONTHS.

The experiment was laid out in split plot design (sub-sub). The main plot treatments comprised of five crops *viz.* peas, lentil, *Lathyrus* (improved and local) and linseed. The sub plot treatments consisted of three different periods of submergence with one control. The submergence treatments consisted of (i) sowing of seeds on puddled soil with no standing water, (ii) sowing of seeds on puddled soil with 5 cm of standing water but drained, 12 h after sowing of seeds, (iii) sowing of seeds on puddled soil with 5 cm of standing water but drained, 24 h after sowing of seeds and (iv) sowing of seeds in conventionally tilled soil. The sub-sub plot treatments consisted of two seed treatments *viz:* (i) seeds soaked before sowing in aqueous solution of disodium hydrogen orthophosphate (Na_2HPO_4 5×10^{-4} M) for 4 h and then allowed to dry for two hours to remove excess water, (ii) control (unsoaked seeds).

Thus, there were 40 (5 x 4 x 2) pots. The experiment was replicated three times; each pot had three compartments. Ten seeds were sown in each replication in the compartment, on 31st October, 1984 as per layout. The cultivars used were B 22, B 77, Nirmal and local and B 67, in cases of peas, lentil, *Lathyrus* and linseed, respectively. The experiment continued for 26 days after sowing.

3.4.1.2 Net House Experiment Number 2

The experiment was conducted inside the Net House utilized to conduct the Net House Experiment Number 1, again during Dec - Jan, 1984-85.

The experiment was repeated with some slight modification. As in Net House Experiment Number 1, the main plot treatments comprised of five crops viz: peas, lentil, *Lathyrus* (Nirmal and local) and linseed. The sub-plot treatments consisted of four different periods of water submergence viz : sowing of seeds (i) on puddled soils with no standing water (ii) on puddled soil with 5 cm of standing water and drained, after 12 h sowing of seeds (iii) puddled soil with 5 cm of standing water and drained, 24 h after sowing of seeds (iv) puddled soil with 5 cm standing water and drained, 36 h after sowing of seeds and (v) sowing of seeds in conventionally tilled soil. Due to slow infiltration of water a constant head of water for 12, 24 or 36 h could not be maintained meticulously. The water lavels were corrected thrice during the day time. In sub-sub plots, two seed treatments were (i) seeds soaking in aqueous solution of disodium hydrogen orthophosphate (Na_2HPO_4 $5 \times 10^{-4}M$) for 4 h, two hours before of sowing (ii) control (sowing of unsoaked seeds).

The experiment was conducted in 50 (5 x 5 x 2) pots and was replicated three times and three compartments in each pot served the purpose of three replications for each treatment combination. Ten seeds were sown in each replication on 9 December, 1984. The experiment continued for 32 days. The same (as in Experiment no. 1) cultivars of different crops were used in this experiment as well.

3.4.1.3 Net House Experiment Number 3

To analyse closely some of the treatment differences observed in the field experiments, another Net House Experiment was conducted in 1987 inside the Net House utilized for Net House Experiment Number 1 and 2, with similar objective but different set of treatments. The experiment was laid out in split plot (sub-sub) design. The main plot treatments comprised of 5 crops as in Net House Experiment Number 1 and 2. The sub plot treatments consisted of sowing of seeds on puddled soil (i) with no standing water (ii) with 5 cm standing water for 24 h after sowing of seeds (iii) 5 cm of standing water for 72 h after sowing of seed and (iv) control (i.e. sowing in conventionally tilled soil). Sub-sub plot treatments consisted of (i) pots shaded with loose straw simulating shade provided by the maturing rice crop to the paira crop seeds sown, 7 - 10 days before harvest of rice, (ii) without any shade (seeds directly exposed to the atmosphere. The seeds sown in conventionally tilled soil were sown 3 cm below soil surface.

To conduct this experiment 40 (5 x 4 x 2) pots were used. The experiment was replicated 4 times and each pot, with four compartments, served the purpose of 4 replications. Ten seeds were sown in each replication on 21 February, 1987. The experiment continued only for 8 days.

3.4.1.4 Bio-metrical observations recorded in Net House Experiments

The stand establishment of seeds were counted 8 days after sowing. The length of shoots and roots and their dry weights were measured thrice at intervals of 7 days, from 12 days after sowing onwards in the case of Net House Experiment No.1. In case of Experiment No. 2, the lengths of shoots and roots and their dry weights were measured thrice, at intervals of one week, from 18 days after sowing onwards. In Net House Experiment No. 3, the stand establishment and the length of shoots were measured once only 8 days after sowing.

3.4.2 Field Experiment Number 1

Performance of winter crops established after conventional tillage following an early variety of rice and as paira crop following an intercrop of late variety and early + late variety of rice, in alternate paired rows.

In our survey work it was observed that in the low lying areas where *Lathyrus* is extensively grown as paira crop following rice, a mixed culture of rice (early + late varieties) are sown. The *Lathyrus* varieties are broadcasted in the standing crop of late rice, 7 - 10 days before the anticipated date of harvest of rice crop.

To simulate this culture of establishing paira crop, a field experiment was conducted with the objective to compare the productivity of a few winter crops sown through conventional tillage after the harvest of early variety of rice as against the performances of winter crops, broadcasted in the standing rice field (either sole or in the intercrop of early and late varieties) 7 - 10 days before harvesting rice, in lowlying situation.

3.4.2.1 Lay out and design

The experiment was laid out in split plot design. The main plots consisted of methods of crop establishment (i) conventional method of establishment of winter crops in the plots following sole crop of early variety of rice (ii) relay or paira sowing of winter crops following late variety of rice as sole crop (iii) relay or paira sowing of winter crops following paired row planting of early and late varieties of rice. The sub plot treatments comprised of five winter crops - four grain legumes (lentil, peas, Lathyrus - Nirmal and local) and one oilseed crop (linseed). The varieties of winter crops remaining the same as stated in the Net House Experiments. Thus, there were fifteen number of treatment combinations.

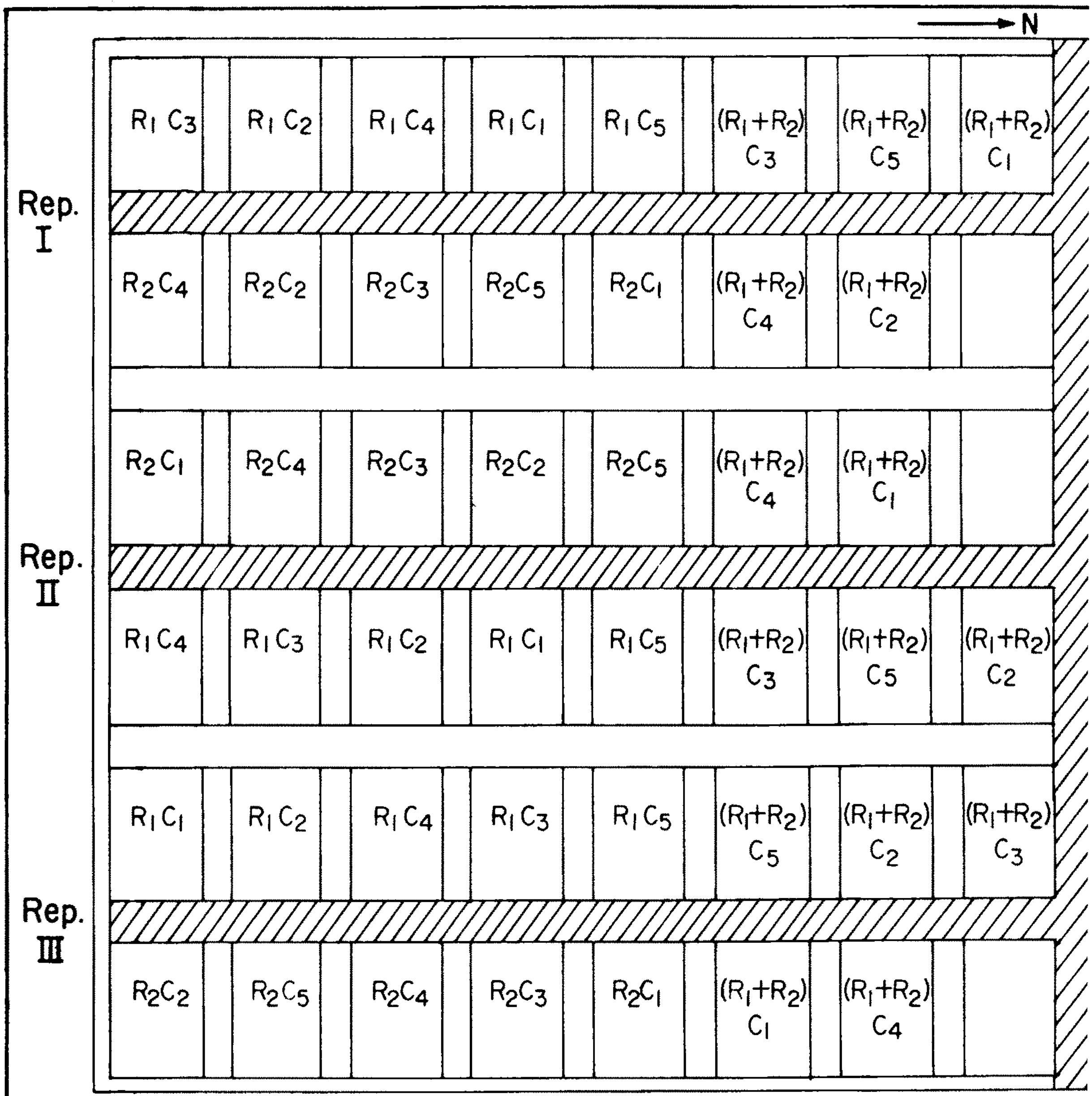
The plot size of the sub plot treatment was 15.9 sq.m (5.3 m x 3 m). There were three replications (Fig. 3.3) and as such the total number of plots were 45 (3 x 5 x 3).

The experiment was repeated in three seasons 1984-85, 1985-86 and 1986-87. For future references these experiments have been designated as Field Experiment No. 1 (1984-85), Field Experiment No. 1 (1985-86) and Field Experiment No. 1 (1986-87).

3.4.2.2 Details of the base crop 'rice'

A short duration semi-dwarf high yielding variety of rice cv. MW 10 and one long duration tall high yielding rice variety cv. Swarna were grown as sole crops separately and also as mixed culture of two varieties 'MW 10' and 'Swarna' in alternate paired rows.

Rice crops as detailed above were transplanted on 10, 11 and 6 July in the years 1984, 1985 and 1986, respectively. The crop was managed as per the recommended package of practices



LEGEND: [hatched box] Irrigation / Drainage channel. C_3 = Lentil

[open box] Bund C_1 = Linseed

R_1 = Short duration rice 'MW 10' C_2 = Peas

R_2 = Long duration rice 'Swarna' C_4 = Lathyrus (Nirmal)

R_1+R_2 = 'MW 10' + 'Swarna' C_5 = Lathyrus (Local)

Plot size: 5·3m X 3m

FIG. 3.3 LAYOUT OF THE EXPERIMENT NO. 1.

for the *kharif* rice crop. Rice plots were fertilized at the rate of 60 (20 + 20 + 20) kg N, 30 kg P_2O_5 and 30 kg K_2O / ha in the forms of urea, single super phosphate and muriate of potash. The crop was transplanted on puddled soil at 20 cm x 15 cm spacing with 2 - 3, 23 - 27 days old seedlings, per hill.

The 'MW-10' variety of rice matured (seed to seed) in 105 days and were harvested on 26, 27 and 19 September during the 1984, 1985 and 1986 *Kharif* seasons, respectively, leaving a stubble of 7.5 cm. The late variety of rice 'Swarna' matured (seed to seed) in 143 to 150 days and were harvested on 7, 10 and 9 November in 1984, 1985 and 1986 *aman* seasons, respectively.

3.4.2.2.1 Description of experimental crop varieties of rice, grain legumes and oilseed

Amongst the two rice varieties (i) 'MW-10' is a cross between 'MTU 5' x 'Wai Koku' varieties, seeds are short and bold, kernels white, matures in 100 - 105 days and (ii) 'Swarna' is a long and bold seeded, plants are tall, matures in 140 days, very suitable in lowlying areas, a cross between 'RPW 6' - 13 x 'Sona'. Shows higher yield potentiality than 'Pankaj'.

Amongst the grain legumes, (i) lentil, cv. B 77 is a selection from the local variety of Jorhat (Assam), matures in 120 days and has protein content 27 % , (ii) peas, cv. B 22 is a small seeded, long duration variety with mottled seed coat. It bears large number of pods. It has been developed from local material and out-yields the bold, white-seeded entries. The grain contains 27.9 % protein. It matures in 120 days,

(iii) *Lathyrus*, cv. Nirmal is a selection from a local material that out yields all other varieties. It has low neurotoxin contents (0.2 %). The grain contains 27.2 % protein and it matures in 130 days. The local variety is a collection from the local farmers of Chandamari village, maturing in 120 days.

The linseed variety cv. B 67 is a recommended variety of West Bengal. It matures in 120 days.

3.4.2.3 Establishment of winter crops following rice

(i) Sowing of winter crops through conventional method : One day after broadcasting the seeds of winter crops under *paira* method water was drained out from all the rice plots in the area. After another 2 - 3 days the plots having the early variety ('MW 10') of rice, which was harvested about 42 - 46 days before the harvest of late variety ('Swarna') of rice, were dug out through spade; later on after bit of drying the seedbed was prepared (by removing weeds and breaking the clods) for sowing the winter crops. The plots were fertilized with 20 kg N and 40 kg P_2O_5 / ha in the form of urea and single super phosphate. With handhoe the winter crops were established in solid rows 20.5 cm apart. Thus, the winter crops were established through conventional tillage, 7 - 12 days after the broadcasting of seeds as relay or *paira* sowing. The seed rates used were 18, 25, 25, 25 and 9 kg / ha in cases of lentil, peas, *Lathyrus* (Nirmal), *Lathyrus* (local) and linseed, respectively.

(ii) Sowing of winter crops as *paira* crop in the standing field of rice without tillage : The seed rates were 25 % higher than the rates used in establishing of winter crops in drills through conventional method. The 'Swarna' variety of rice was harvested 7 - 10 days after sowing of winter crops in different years (see calender of operation for Field Experiment No.1). After about another 5 days fertilizers were applied to the crops @ 20 kg N and 40 kg P_2O_5 / ha in the forms of urea and single super phosphate.

Simultaneously, one weeding and cutting of the stubbles at the ground level were resorted to. The crop was infested with the weed Argemone maxicana at a later stage and so another hand weeding was done to remove them.

After the flowering of the crops the rat burrows were noticed and precautions were taken to minimise rat damage through poison baiting.

3.4.2.3.1 Calender of operations

The calender of operations followed in the case of winter crops during the three consecutive seasons are presented in Table 3.4.

3.4.3 Field Experiment Number 2

Studies on the performance of winter crops established as paira crop, with and without pre-sowing treated seeds and fertilizer, following a late maturing variety of rice.

The objective of this experiment was to find out (i) the productivity of winter crops as paira crop broadcasted in the standing crop of late variety of rice 'Swarna', 7 - 10 days before the anticipated date of harvesting of rice, in low

Table 3.4 Calender of operations performed in different winter crops in three consecutive years (1984-85, 1985-86 and 1986-87)

Operations	1984-85		1985-86		1986-87	
	Conven-tional	Paira	Conven-tional	Paira	Conven-tional	Paira
1. Date of sowing	4.11.84	26.10.84	9.11.85	30.10.85	14.11.86	2.11.86
2. Fertilizer application	4.11.84	12.11.84	9.11.85	15.11.85	14.11.86	14.11.86
3. First weeding	22.11.84	11.11.84	28.11.85	14.11.85	10.12.86	12.11.86
4. Second weeding	15.1.85	12.1.85	9.1.86	7.1.86	10.1.87	10.1.87
5. Date of harvest						
Linseed	6.3.85	27.2.85	7.3.86	28.2.86	11.3.87	2.3.87
Peas	2.3.85	23.2.85	8.3.86	26.2.86	11.3.87	28.2.87
Lentil	2.3.85	24.2.85	7.3.86	24.2.86	11.3.87	28.2.87
Lathyrus (Nirmal)	14.3.85	7.3.85	18.3.86	14.3.86	23.3.87	15.3.87
Lathyrus (local)	7.3.85	24.2.85	7.3.86	28.2.86	14.3.87	2.3.87
6. Duration (days)						
Linseed	122	124	118	121	117	120
Peas	118	120	119	119	117	118
Lentil	118	121	118	117	117	118
Lathyrus (Nirmal)	130	132	129	135	129	133
Lathyrus (local)	123	121	118	121	120	120

lying situation, (ii) the effect of seed treatment on the productivity of winter crops as <u>paira</u> crop and (iii) the response of the winter crops established as <u>paira</u> crop to the applied fertilizer.

3.4.3.1 Lay out and design

The experiment was laid out in split plot (sub-sub) design. The main plot treatments comprised of 5 crops <u>viz</u>: lentil, peas, <u>Lathyrus</u> (Nirmal and local) and linseed. The sub plot treatments consisted of two seed treatments <u>viz</u>: (i) seeds soaked in aqueous solution of disodium hydrogen orthophosphate (Na_2HPO_4 5 x 10^{-4} M) for 4 h, two hours before sowing and (ii) control (unsoaked seeds). The sub-sub plot treatments comprised of two fertilizer treatments <u>viz</u>: (i) application of 20 kg N + 40 kg P_2O_5 / ha in the form of urea and single super phosphate and (ii) control (no fertilizer). Thus, there were twenty treatment combinations.

The plot size of the sub-sub plot treatment was 12.5 sq.m (5 m x 2.5 m). The experiment was replicated thrice. Thus, total number of plots (Fig. 3.4) were 60 (5 x 2 x 2 x 3).

The experiment was repeated in three seasons 1984-85, 1985-86 and 1986-87. For future references these experiments also have been designated as Field Experiment No.2 (1984-85), Field Experiment No.2 (1985-86) and Field Experiment No.2 (1986-87).

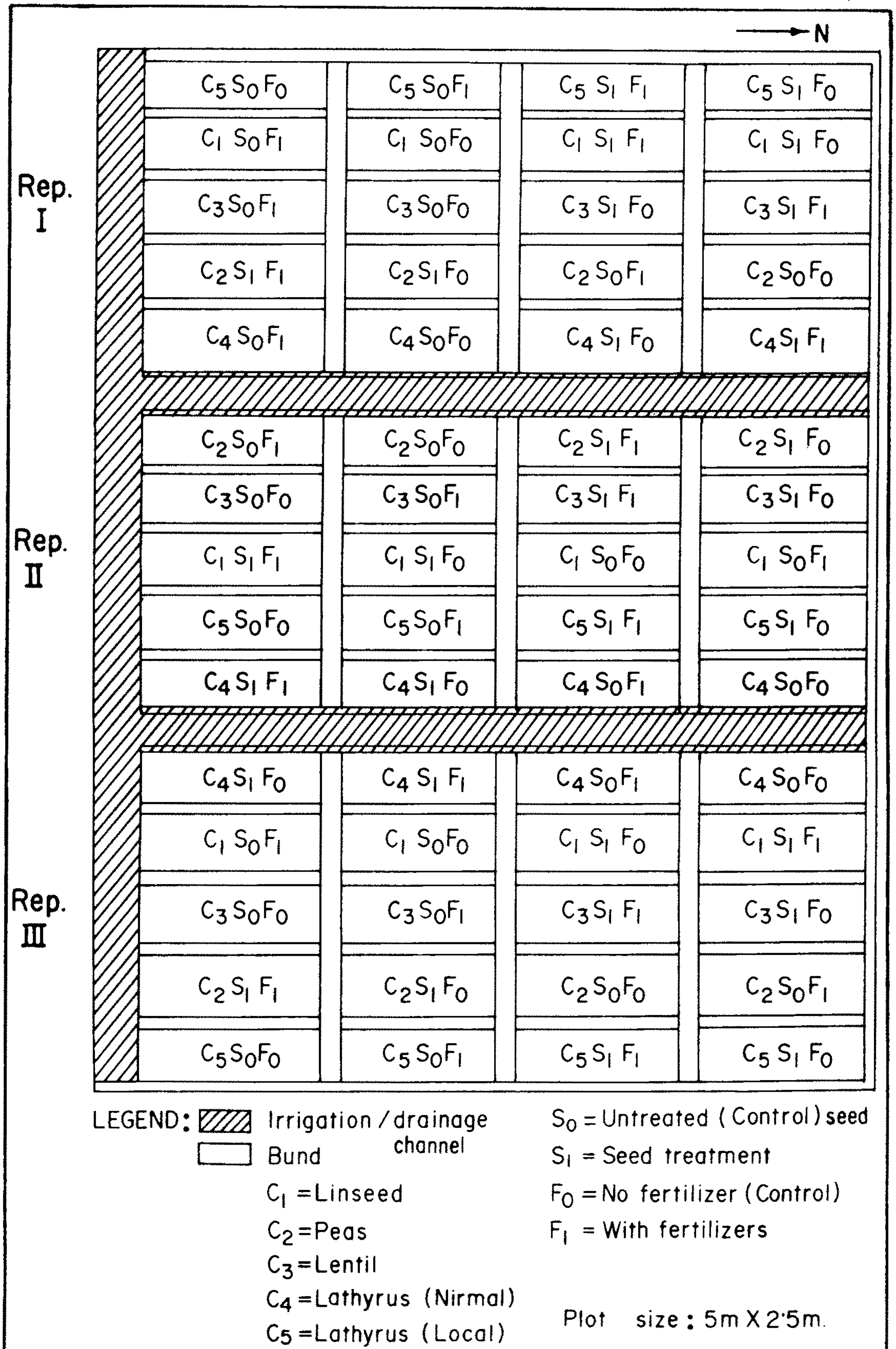


FIG.3.4 LAYOUT OF THE EXPERIMENT NO. 2.

3.4.3.2 Details of the base crop 'rice'

'Swarna', the long duration tall, high yielding variety, suitable for lowlying situation was grown as sole kharif rice. It was transplanted on 17, 16 and 14 July in the years 1984, 1985 and 1986, respectively. The crop was managed as per the recommended package of practices for the kharif rice crop. The plots were fertilized at the rate of 60 (20 + 20 + 20) kg N, 30 kg P_2O_5 and 30 kg K_2O / ha in the forms of urea, single super phosphate and muriate of potash. The crop was transplanted on puddled soil at 22 cm x 15 cm spacing with 2 - 3 seedlings (30 - 33 days old) per hill.

The crop matured in 145 to 150 days and were harvested on 9, 10 and 9 November in 1984, 1985 and 1986 aman seasons, respectively.

3.4.3.3 Establishment of winter crops as paira crop following rice

The seed rates used here were the same as was used in establishing the winter crops as paira crop in Field Experiment No.1. The seeds of grain legumes (lentil, peas, and both the varieties of Lathyrus) and oilseed (linseed) were sown by broad-casting seeds in standing rice ('Swarna') crop, having 3 - 5 cm high water in the field which was draied after 24 h. After 7 - 11 days of sowing of the winter crops as paira crop in different years, (see calender of operation for Field Experiment No.2) rice crop was harvested, leaving about 7.5 cm of stubbles in the field. After about five to seven days fertilizer was applied to the crops @ 20 kg N and 40 kg P_2O_5 / ha, in the form of urea and single super phosphate.

The first weeding operation including cutting of the stubbles at the ground level were made at the time of fertilizing the crop. The crop was infested with the weeds Euphorbia hirta, Blumea lacera, Scoparia dulcis, Vernonia cinerea and Argemone maxicana at the flowering stage of the crop, hence the second weeding was done to remove these weeds.

The peas crop was dusted with B.H.C. 10 % dust to control Catterpillar infestation in 1986-87. Precautions were taken to minimise rat damage through poison baiting after flowering of the crop.

3.4.3.3.1 Calender of operations

The calender of operations followed in the case of winter crops during the three consecutive seasons are presented in Table 3.5.

3.5 Observations on winter crops recorded and the methods used in Field Experiments

3.5.1 Pre-harvest observations

A small area (2 m x 1 m) in the north of each plot was demarcated for taking biometrical observations including destructive samples.

3.5.1.1 Stand establishment

The number of plants / m^2 was counted in field experiments with the help of a one square metre quadrat randomly placed inside

Table 3.5 Calender of operations performed in winter crops in three consecutive years (1984-85, 1985-86 and 1986-87)

Operations	1984-85	1985-86	1986-87
1. Date of sowing	30.10.84	30.10.85	2.11.86
2. Fertilizer application	15.11.84	16.11.85	15.11.86
3. First weeding	14.11.84	18.11.85	20.11.86
4. Second weeding	1.1.85	4.1.86	7.1.87
5. Pesticide dusting	-	-	10.1.87
6. Dates of harvesting			
Linseed	26.2.85	26.2.86	28.2.87
Peas	26.2.85	24.2.86	28.2.87
Lentil	2.3.85	26.2.86	1.3.87
Lathyrus (Nirmal)	12.3.85	11.3.86	16.3.87
Lathyrus (local)	26.2.85	24.2.86	27.2.87
7. Duration (days)			
Linseed	119	119	118
Peas	119	117	118
Lentil	123	119	119
Lathyrus (Nirmal)	133	132	134
Lathyrus (local)	119	117	117

the plot. Two such samples were taken from each plot and then average of the two samples was calculated. The first observation was taken at 45 days after sowing, after completing first weeding, and the second was made before harvest.

3.5.1.2 Soil moisture utilisation pattern

The relative amount of moisture extracted from different depths within the root zone were determined by measuring the soil moisture through thermogravimetric method (Dastane, 1972). Soil samples were collected at depth intervals of 15 cm upto a depth of 60 cm from two locations in each plot with the help of a 2.5 cm screw augar and moisture percentage was determined on an oven dry basis after drying the samples to a constant weight at 105^{o}C for 24 hours by using the following formula,

$M_W = \left(\frac{X - Y}{Y}\right) 100$ where, M_W = Moisture percentage,

X = Weight of wet soil in g and

Y = Weight of oven dry soil in g.

The soil samples were taken at 60 and 105 DAS to determine the soil moisture utilisation pattern of the crops grown under different methods of crop establishment and management.

Derived data: The bulk density of the soil was determined separately. The amount of profile stored moisture was depleted from the soil during the intervening period was calculated from the soil moisture percentages by using the following formula (Singh *et al.*, 1960).

$$Q = \sum_{i=1}^{n} \left(\frac{\Delta Mi}{100} \times BDi \times Di\right) + \text{Effective rainfall (within that period)}$$

Where Q = Quantity of moisture depleted (in mm),

ΔMi = Change in soil moisture percentage, on oven dry basis, during the intervening period for the i th soil layer)

BDi = Bulk density of the '1' th soil layer, (g / cc)

Di = Soil depth of the 'i' th layer (in mm),

n = number of soil layers.

Total soil moisture utilisation of the crops for a particular season was then calculated by adding all these Q values upto 105 DAS.

3.5.1.3 Dry weight of shoot / m^2

In an randomly selected area of 50 cm x 50 cm, 2 metre deep inside the north side of each plot all the plants were cut at ground level weighed in the field and about 200 gm of the sample were put in polythene bags, for moisture determination in the laboratory at 80^{o}C for 8 h. The observation was recorded at 90 days after sowing.

3.5.1.4 Methods for studying roots

To study the development of roots, an iron core sampler of 1 m length and 7.0 cm diameter, was used. Samples were collected at 60 and 105days after sowing of the crop. The core sampler body was marked at every 15 cm upto 90 cm length. The core sampler was perpendicularly placed over surface of soil which included one plant at the centre of the core. After cutting the above ground shoot the core sampler was pushed into the soil. Then it was forced to penetrate upto 15 cm depth. The root along with the soil was taken out from the core sampler and collected in separate polythene bags. In this way soil cores at every 15 cm depth interval, upto a depth of 60 cm, were taken out. Root samples so taken out from different depths were washed separately to remove soil particles on a sieve very carefully to avoid loss of roots. The roots were then transferred into brown paper packets and kept in a hot air oven at 80°C for 8 h to get a constant weight.

3.5.1.5 Number of nodules / plant

At 60 days after sowing, blocks of soil, 15 cm x 15 cm x 25 cm with one plant at the centre, were excavated. Two samples were taken randomly from each plot. These soil blocks along with the roots were put in buckets of water and with the help of a hand sprayer the roots were washed from soil contamination. The Rhizobial nodules from each of the samples, after washing were counted, to get the number of nodules / plant, upto 25 cm soil depth.

3.5.2 Post harvest observations

3.5.2.1 Number of pods or capsules / m^2

The number of pods / m^2 in lentil, peas, and *Lathyrus* and capsules / m^2 in linseed were counted from an area of 50 cm x 50 cm at two randomly located places, in each plot; then the average of the two readings was calculated and converted as number of pods or capsules / m^2.

3.5.2.2 Number of grains / pod or capsule

For the determination of number of grains / pod in lentil, peas and grasspeas and grains or seed / capsule in linseed 20 fruits were randomly collected from each plot and their total number of grains were counted. From these records the mean number of grains / pod or capsule was worked out.

3.5.2.3 Test weight of grains (100 grains weight)

Ten samples of 100 grains were taken separately from the harvest of each plot and weighed. From these the mean test weight of grains was calculated. The weights were expressed at 14 % moisture level.

3.5.2.4 Grain yield in kg / ha

An area of 3 m x 2 m was harvested from each plot excluding border areas and the area demarcated for destructive sample. The grains were then dried in sun, cleaned and their weights were determined along with their moisture contents. The grain yields were expressed at 14 % moisture level in kg / ha.

3.5.2.5 Productivity interms of Rs / ha

The grain yields in kg / ha so recorded for different crops were converted into Rs / ha by multiplying their market value as Linseed Rs.480 / per quintal.

Peas Rs.425/- per quintal

Lentil Rs.395/- ,,

<u>Lathyrus</u> Rs.245/- ,,

[Source: Market value of grain (Rupee value) has been collected from local market.]

3.5.2.6 Productivity in terms of energy output in MJ / ha

The grain yields in kg / ha for different crops were converted into their energy unit / ha by multiplying the energy factor (Binning et al., 1983) of respective crop as

lentil peas Lathyrus	14.7 MJ / kg of grain
Linseed	25.0 MJ / kg of grain

3.6 Methods of statistical analysis

The analysis of variance method (Cochran and Cox, 1955; Gomez and Gomez, 1976) was followed to statistically analyse the various data. The tables formulated by Fisher and Yates (1963) were consulted for the purpose of comparison of the F-values and for determination of critical differences at 5 % level of significance. Correlation between factors and pooled analysis were also determined by using standard procedures (Gomez and Gomez, 1976).

CHAPTER 4

RESULTS

4. RESULTS

4.1 Net House Experiment No.1

The experiment was carried out to study the stand establishment and initial growth of winter crops under different water regimes above the soil surface, and tillage.

4.1.1 Stand establishment

From the results summarised in Table 4.1 it is apparent that the best stand establishment (9 out of 10 seeds) was recorded in *Lathyrus* (Nirmal) on 8 days after sowing and the lowest establishment (6 out of 10 seeds sown) was recorded in peas which was significantly lower than those recorded in other crops. Under conventional tillage, stand establishment was very satisfactory; Out of 10 seeds sown, 9.7 plants could establish. On the other hand when the seeds were sown on the surface of puddled soil with no standing water the mean number of plants established were 6.5 out of 10 seeds sown. Stand establishment improved through stagnating water for different durations on the puddled soil. It may be mentioned here that due to slow infiltration of water, a constant head of water for 12 or 24 h could not be maintained effectively. The water levels were corrected thrice during the day time. The interaction between the crops and water regime & tillage was significant. Stagnation of water adversely affected the stand establishment of peas followed by *Lathyrus* (local). The *Lathyrus* (local) seeds, for reasons not very well known, showed slightly inferior stand establishment (7.6) to those recorded in the Nirmal variety of *Lathyrus*. The differences due to seed treatments were not significant.

Table 4.1 Effect of seed treatment, and water regime & tillage at the time of sowing of different crops on stand establishment at 8 days after sowing (Net House Experiment No.1, 1984)

Soil/Water regime (W)	Seed treatment (S)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathy-rus (Nirmal)	Lathy-rus (local)	Mean
Unpuddled (Tilled)	Treated	10.0	9.0	9.6	9.6	10.0	9.6
	Untreated	9.6	9.6	9.6	10.0	9.6	9.7
	Mean	9.8	9.3	9.6	9.8	9.8	9.7
Puddled (0 cm)	Treated	7.0	5.6	8.0	6.4	5.6	6.5
	Untreated	7.0	5.6	5.6	8.0	5.6	6.4
	Mean	7.0	5.6	6.8	7.2	5.6	6.5
Puddled (5 cm/12 h)	Treated	8.4	5.6	8.0	10.0	8.6	8.1
	Untreated	9.6	5.6	10.0	10.0	7.0	8.4
	Mean	9.0	5.6	9.0	10.0	7.8	8.3
Puddled (5 cm/24 h)	Treated	10.0	5.0	8.4	8.4	6.6	7.7
	Untreated	8.4	3.6	9.0	9.6	8.6	7.8
	Mean	9.2	4.2	8.7	9.0	7.6	7.8
Seed treatment (S)	Treated	8.8	6.2	8.4	8.6	7.6	7.9
	Untreated	8.6	6.0	8.4	9.4	7.6	8.0
Mean	Crops	8.7	6.1	8.4	9.0	7.6	
	C	W	S	CxW	CxS	WxS	CxWxS
S.Em ±	0.26	0.24	0.14	0.56	0.32	0.28	0.64
C.D. at 5%	0.85	0.69	N.S.	1.62	N.S.	N.S.	N.S.

4.1.2 Shoot length at 12 days after sowing

The length of shoots recorded at 12 DAS showed significant differences between plants ranging from 10.5 cm in Lathyrus (Nirmal) to 4.1 cm in linseed (Table 4.2). The length of shoot of lentil (5.4 cm) was significantly more than linseed. The plants were significantly taller when they were established on puddled soil submerged for 12 h. The lowest shoot length was recorded in plants raised on puddled soil with no standing water. Shoot length recorded in plants established on puddled soil with 24 h of standing water were significantly lower than those in 12 h of standing water. The interaction between crops and water regime & tillage was significant. It indicated that the growth of peas interms of length of shoot was appreciably and significantly affected when the plants were established on puddled soil without any standing water. So was the case, in case of lentil as well when compared with conventionally tilled lentil. The plants raised from treated seeds were significantly and appreciably taller than those established from untreated seeds. The interaction between crops and seed treatments was significant. The maximum advantage of seed treatment was observed in lentil followed by linseed and peas. The differences due to seed treatments were not very high in case of Lathyrus varieties.

4.1.3 Root length at 12 days after sowing

At 12 DAS the root length showed significant differences between the crops (Table 4.3) and only in case of linseed the root length exceeded shoot length by 1.8 cm. The root length of peas was very similar to that of Lathyrus (Nirmal) but showed

Table 4.2 Effect of seed treatment and water regime & tillage at the time of sowing of different crops on shoot length (cm), 12 days after sowing (Net House Experiment No.1, 1984)

Soil/Water regime (W)	Seed treatment (S)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathyrus (Nirmal)	Lathyrus (local)	Mean
Unpuddled (tilled)	Treated	4.7	7.2	6.8	9.3	9.3	7.5
	Untreated	4.1	7.6	4.7	9.4	9.1	7.0
	Mean	4.4	7.4	5.8	9.4	9.2	7.3
Puddled (0 cm)	Treated	4.4	6.2	4.8	10.8	9.1	7.1
	Untreated	3.8	5.6	4.8	9.8	10.0	6.8
	Mean	4.1	5.9	4.8	10.3	9.6	7.0
Puddled (5 cm/12h)	Treated	4.6	9.2	5.9	11.6	9.7	8.2
	Untreated	3.6	7.8	5.1	11.8	10.5	7.8
	Mean	4.1	8.5	5.5	11.7	10.1	8.0
Puddled (5 cm/24 h)	Treated	4.2	8.4	5.6	10.5	10.2	7.8
	Untreated	3.2	8.4	5.0	10.7	9.6	7.4
	Mean	3.7	8.4	5.3	10.6	9.9	7.6
Seed treatement (S)	Treated	4.5	7.7	5.8	10.5	9.6	7.6
	Untreated	3.7	7.3	4.9	10.4	9.8	7.2
Mean	Crops	4.1	7.5	5.4	10.5	9.7	

	C	W	S	CxW	CxS	WxS	CxWxS
S. Em ±	0.07	0.11	0.07	0.26	0.15	0.13	0.30
C.D. at 5%	0.23	0.32	0.20	0.75	0.43	N.S.	0.86

Table 4.3 Effect of seed treatment and water regime & tillage at the time of sowing of different crops on root length (cm), 12 days after sowing (Net House Experiment No.1, 1984)

Soil/water regime (W)	Seed treatment (S)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathy-rus (Nirmal)	Lathy-rus (local)	Mean
Unpuddled (tilled)	Treated	6.7	9.3	5.6	8.4	8.3	7.7
	Untreated	5.9	8.0	4.8	6.6	6.9	6.4
	Mean	6.3	8.7	5.2	7.5	7.6	7.1
Puddled (0 cm)	Treated	6.8	7.2	6.3	6.9	8.0	7.0
	Untreated	5.8	5.6	4.5	6.3	6.8	5.8
	Mean	6.3	6.4	5.4	6.6	7.4	6.4
Puddled (5 cm/12 h)	Treated	6.6	7.3	6.8	7.9	8.5	7.4
	Untreated	5.7	6.5	5.9	6.8	7.1	6.4
	Mean	6.2	6.9	6.4	7.4	7.8	6.9
Puddled (5 cm/24 h)	Treated	5.3	7.1	6.2	7.7	8.0	6.9
	Untreated	4.6	5.5	5.2	5.5	6.3	5.4
	Mean	4.9	6.3	5.7	6.6	7.2	6.2
Seed treatment (S)	Treated	6.3	7.7	6.2	7.7	8.2	7.2
	Untreated	5.5	6.4	5.1	6.3	6.8	6.0
Mean	Crops	5.9	7.1	5.7	7.0	7.5	
	C	W	S	CxW	CxS	WxS	CxWxS
S. Em ±	0.05	0.11	0.07	0.25	0.16	0.15	0.33
C.D. at 5%	0.16	0.32	0.20	0.72	N.S.	N.S.	N.S.

a significant edge over *Lathyrus* (local). The plants raised on puddled soil having standing water for 12 or 24 h showed slightly shorter length of roots than those growing on conventionally tilled soil. Conventionally tilled crops showed significantly longer root than those recorded in plants raised on puddled soil without or with 24 h of standing water. The interaction between crops and water regime & tillage was significant and it indicated that root length was appreciably reduced when the plants were established on wet soil with water submergence for 24 h, to start with. As in the case of shoots so was in the case of root, the plants raised from treated seeds were significantly taller than those from untreated seeds. The interaction between crops and seed treatments was not significant.

4.1.4 Shoot dry weight / plant at 12 days after sowing

The highest shoot dry weight / plant (36.8 mg) was observed (Table 4.4) in *Lathyrus* (Nirmal) followed by *Lathyrus* local (35.1); the treatment differences between the two variety were not significant. Both the *Lathyrus* varieties recorded significantly higher shoot dry weight / plant than rest of all crops except the difference between peas and that of *Lathyrus* (local) was not significant. The lowest shoot dry weight / plant (4.1 mg) was observed in linseed. Plants raised from seeds sown on puddled soil with 12 h of standing water had the highest shoot dry weight / plant (27.6 mg) followed by the treatment with 24 h of standing water on puddled soil and these two were significantly superior to shoot dry weight /

Table 4.4 Effect of seed treatment and water regime & tillage at the time of sowing of different crops on shoot dry weight/plant (mg), 12 days after sowing (Net House Experiment No.1, 1984)

Soil/Water regime (W)	Seed treatment (S)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathy-rus (Nirmal)	Lathy-rus (local)	Mean
Unpuddled (tilled)	Treated	4.0	30.7	10.7	33.9	32.3	22.3
	Untreated	3.5	29.0	9.7	31.4	29.6	20.6
	Mean	3.8	29.9	10.2	32.7	30.0	21.5
Puddled (0 cm)	Treated	3.9	30.1	10.6	33.8	27.3	21.1
	Untreated	3.2	25.5	8.2	30.8	25.4	18.6
	Mean	3.6	27.8	9.4	32.3	26.4	19.9
Puddled (5 cm/12 h)	Treated	5.9	37.6	12.6	45.0	43.9	29.0
	Untreated	3.8	35.7	11.1	38.4	41.9	26.2
	Mean	4.9	36.7	11.9	41.7	42.9	27.6
Puddled (5 cm/24 h)	Treated	4.6	39.0	12.5	41.5	43.2	28.2
	Untreated	3.7	36.6	9.6	39.8	37.0	25.3
	Mean	4.2	37.8	11.1	40.7	40.1	26.8
Seed treatment (S)	Treated	4.6	34.4	11.6	38.5	36.7	25.2
	Untreated	3.5	31.7	9.6	35.1	33.5	22.7
Mean	Crops	4.1	33.1	10.6	36.8	35.1	
	C	W	S	CxW	CxS	WxS	CxWxS
S. Em ±	0.89	0.24	0.27	0.53	0.61	0.55	1.23
C.D. at 5%	2.90	0.69	0.78	1.53	N.S.	N.S.	N.S.

plant obtained in plants established on conventionally tilled and puddled soil, without any standing water. The shoot dry weights were significantly more in plants raised on tilled than on puddled soil without any standing water. The interaction between crops and water regime & tillage was significant. This indicated that the shoot dry weights were significantly more in plants raised in tilled soil than on puddled soil (without any standing water) in case of peas and Lathyrus (local) but not in others. Further, stagnation of water for 12 h on puddled soil significantly increased shoot dry weight except in linseed. But where the duration of the stagnation was increased to 24 h only in case of Lathyrus (local) the dry weight accumulation was significantly reduced. The plants raised from treated seeds showed significantly higher shoot dry weight / plant than the plants raised from untreated seeds. The interaction between seed treatments and crops was not significant.

4.1.5 Root dry weight / plant at 12 days after sowing

The highest root dry weight / plant (12.6 mg) was observed (Table 4.5) in peas followed by Lathyrus - local (12.2 mg) and it was significantly superior to root dry weight / plant of Lathyrus varieties. The difference in root dry weight / plant between the Lathyrus varieties was not significant. The lowest root dry weight / plant (1.4 mg) was recorded in linseed and it was significantly lower than that of lentil. The different water regime & tillage caused significant differences in root dry weight / plant. Crops raised on conventionally

Table 4.5 Effect of seed treatment, water regime & tillage at the time of sowing of different crops on root dry weight/plant (mg), 12 days after sowing (Net House Experiment No.1, 1984)

Soil/Water regime (W)	Seed treatment (S)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathy-rus (Nirmal)	Lathy-rus (local)	Mean
Unpuddled (tilled)	Treated	1.7	15.8	6.0	13.7	12.3	9.9
	Untreated	1.5	10.6	5.2	12.7	12.1	8.4
	Mean	1.6	13.2	5.6	13.2	12.2	9.2
Puddled (0 cm)	Treated	1.2	11.2	4.8	12.1	11.8	8.2
	Untreated	1.2	10.2	4.3	11.6	10.1	7.5
	Mean	1.2	10.7	4.6	11.9	11.0	7.9
Puddled (5 cm/12 h)	Treated	1.3	14.3	5.4	12.4	12.6	9.2
	Untreated	1.1	11.1	4.6	10.8	11.0	7.7
	Mean	1.2	12.7	5.0	11.6	11.8	8.5
Puddled (5 cm/24 h)	Treated	1.3	14.4	6.2	12.4	15.2	9.9
	Untreated	1.3	13.5	5.1	10.6	12.2	8.5
	Mean	1.3	14.0	5.7	11.5	13.7	9.2
Seed treatment (S)	Treated	1.4	13.9	5.6	12.6	13.0	9.3
	Untreated	1.3	11.3	4.8	11.4	11.3	8.0
Mean	Crops	1.4	12.6	5.2	12.0	12.2	
	C	W	S	CxW	CxS	WxS	CxWxS
S. Em ±	0.12	0.16	0.09	0.35	0.20	0.18	0.41
C.D. at 5%	0.39	0.46	0.26	1.01	N.S.	N.S.	N.S.

tilled soil showed significantly higher root dry weight / plant than those raised on puddled soil with no standing water or with 12 h of submergence. Root dry weight / plant (9.2 mg) was recorded in plants established on puddled soil with 24 h of submergence and it was equal to those raised in conventionally tilled soil. The lowest root dry weight / plant (7.9 mg) was recorded in plants established on puddled soil with no standing water. The interaction between the crops and water regimes & tillage was significant. Crops raised on conventionally tilled soil showed significantly higher root dry weight / plant except in linseed and lentil than those raised on puddled soil with no standing water. Stagnation of water improved the dry weight of root only in case of peas over the treatment. The plants raised from treated seeds showed significantly higher root dry weight / plant than the plants raised from untreated seeds. The interaction between crops and seed treatment was however not significant.

4.1.6 Shoot length at 19 days after sowing

The highest shoot length (13.9 cm) was recorded (Table 4.6) in <u>Lathyrus</u> (Nirmal) closely followed by <u>Lathyrus</u> - local (13.6 cm), both of them had significantly longer shoot than peas (10.8 cm) and other crops. Peas again had significantly greater shoot length than linseed which in turn again had longer shoot than lentil. Plants raised on puddled soil with 12 h of standing water showed significantly higher shoot length (11.2 cm) than rest of the treatments (water regime &

Table 4.6 Effect of seed treatment and water regime & tillage at the time of sowing of different crops on shoot length (cm), 19 days after sowing (Net House Experiment No.1, 1984)

Soil/Water regime (W)	Seed treatment (S)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathy-rus (Nirmal)	Lathy-rus (local)	Mean
Unpuddled (tilled)	Treated	8.1	12.5	7.7	13.5	13.1	11.0
	Untreated	7.2	11.7	7.1	12.5	13.1	10.3
	Mean	7.7	12.1	7.4	13.0	13.1	10.7
Puddled (0 cm)	Treated	8.1	9.2	6.5	12.7	13.3	9.9
	Untreated	6.1	8.8	5.0	12.5	12.5	9.0
	Mean	7.1	9.0	5.8	12.6	12.9	9.5
Puddled (5 cm/12 h)	Treated	8.5	13.5	7.9	15.7	14.5	12.0
	Untreated	6.3	12.0	6.1	14.5	13.3	10.4
	Mean	7.4	12.8	7.0	15.1	13.9	11.2
Puddled (5 cm/24 h)	Treated	9.0	10.2	7.4	15.2	15.0	11.4
	Untreated	7.0	8.8	6.6	14.2	13.5	10.0
	Mean	8.0	9.5	7.0	14.7	14.3	10.7
Seed treatment (S)	Treated	8.4	11.3	7.4	14.3	14.0	11.1
	Untreated	6.6	10.3	6.2	13.4	13.1	9.9
Mean	Crops	7.5	10.8	6.8	13.9	13.6	

	C	W	S	CxW	CxS	WxS	CxWxS
S.Em ±	0.18	0.14	0.09	0.32	0.20	0.18	0.40
C.D. at 5%	0.59	0.40	0.26	0.92	N.S.	N.S.	N.S.

tillage), as well. Plants established on puddled soil with no stagnation of water recorded the lowest shoot length (9.5 cm). Shoot lengths recorded in plants raised on conventionally tilled and puddled soil with 24 h of standing water were similar. The interaction effect between crops and water regimes & tillage was significant. This indicated that the shoot length was adversely affected in case of lentil, peas and Lathyrus varieties when established on puddled soil without submergence but this phenomenon was not recorded in linseed. In peas, however, the shoot length was reduced where the stagnation of water was for a longer duration. Plants established with treated seeds showed significantly longer shoots than those plants, raised from untreated seeds.

4.1.7 Root length at 19 days after sowing

The highest root length (10.2 cm) was observed (Table 4.7) in Lathyrus (Nirmal) which was significantly different from rest of all other crops. The next highest root length (9.6 cm) which was significantly higher than lentil, linseed and peas was recorded in Lathyrus (local). The lowest root length (7.7 cm) was observed in lentil. Between lentil and linseed there was no significant difference in root length. Plants raised on different water regimes & tillage had significant differences in root length and the highest (10 cm) was recorded in the plants raised from seeds sown in conventionally tilled soil. The root lengths of plants raised on puddled soil with and without water stagnation did not differ

Table 4.7 Effect of seed treatment and water regime & tillage at the time of sowing of different crops on root length (cm), 19 days after sowing (Net House Experiment No.1, 1984)

Soil/Water regime (W)	Seed treatment (S)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathy-rus (Nirmal)	Lathy-rus (local)	Mean
Unpuddled (tilled)	Treated	8.4	11.2	9.0	11.6	12.1	10.5
	Untreated	7.8	10.0	8.0	10.8	10.2	9.4
	Mean	8.1	10.6	8.5	11.2	11.2	10.0
Puddled (0 cm)	Treated	9.0	8.7	8.2	9.4	9.3	8.9
	Untreated	7.6	8.6	7.2	9.0	8.1	8.1
	Mean	8.3	8.7	7.7	9.2	8.7	8.5
Puddled (5 cm/12 h)	Treated	8.0	8.3	7.3	10.8	9.2	8.7
	Untreated	7.4	7.2	6.9	9.9	8.6	8.0
	Mean	7.7	7.8	7.1	10.4	8.9	8.4
Puddled (5 cm/24 h)	Treated	7.3	9.0	7.8	10.4	9.8	8.9
	Untreated	7.0	8.1	6.7	9.6	9.5	8.2
	Mean	7.2	8.6	7.3	10.0	9.7	8.6
Seed treatment (S)	Treated	8.2	9.3	8.1	10.5	10.1	9.2
	Untreated	7.4	8.5	7.2	9.8	9.1	8.4
Mean	Crops	7.8	8.9	7.7	10.2	9.6	
	C	W	S	CxW	CxS	WxS	CxWxS
S.Em ±	0.12	0.12	0.08	0.27	0.17	0.16	0.35
C.D. at 5%	0.39	0.34	0.23	0.76	N.S.	N.S.	N.S.

significantly. The interaction effect between the crops and water regimes & tillage was, however, significant. In linseed the difference in root length between the plants raised on conventional tillage and puddled condition without any standing water was not significant; stagnation of water caused reduction in root length in linseed, peas and lentil. In Lathyrus on the other hand showed longer root in plants raised on puddled soil with stagnated water. The root lengths were significantly more in plants raised from treated seeds.

4.1.8 Shoot dry weight / plant at 19 days after sowing

Amongst all crops, peas showed (Table 4.8) the highest shoot dry weight / plant (63.7 mg). It was significantly higher than those of Lathyrus varieties. The treatment differences between two Lathyrus varieties were not significant. The lowest shoot dry weight / plant (11.7 mg) was recorded in linseed and it was significantly lower than the shoot dry weight of lentil. Plants raised on puddled soil with standing water for 12 h showed the highest shoot dry weight / plant (46.8 mg) and it was significantly superior to other water regime & tillage treatments. The lowest shoot dry weight / plant was recorded when the plants were established on puddled soil without any stagnation of water, and it was even lower than the root dry weight of plants established in tilled soil. The interaction between the crops and water regimes & tillage was significant and it indicated that except lentil the all other crops established on puddled soil without any stagnation of water had reduced shoot dry weight / plant. Increasing the duration of

Table 4.8 Effect of seed treatment and water regime & tillage at the time of sowing of different crops on shoot dry weight/plant (mg), 19 days after sowing (Net House Experiment No.1, 1984)

Soil/Water regime (W)	Seed treatment (S)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathy-rus (Nirmal)	Lathy-rus (local)	Mean
Unpuddled (tilled)	Treated	16.0	67.8	23.2	60.9	63.9	46.4
	Untreated	13.4	58.0	22.6	56.3	53.9	40.8
	Mean	14.7	62.9	22.9	58.6	58.9	43.6
Puddled (0 cm)	Treated	13.2	60.5	22.6	54.0	57.0	41.5
	Untreated	8.0	55.3	21.6	52.2	56.2	38.7
	Mean	10.6	57.9	22.1	53.1	56.6	40.1
Puddled (5 cm/12 h)	Treated	13.0	72.8	24.1	69.9	64.6	48.9
	Untreated	9.9	71.2	20.0	62.6	59.4	44.6
	Mean	11.5	72.0	22.1	66.3	62.0	46.8
Puddled (5 cm/24 h)	Treated	10.6	65.6	24.2	71.1	71.6	48.6
	Untreated	9.0	58.2	20.0	69.3	60.2	43.3
	Mean	9.8	61.9	22.1	70.2	65.9	46.0
Seed treatment (S)	Treated	13.2	66.7	23.5	64.0	64.3	46.3
	Untreated	10.1	60.7	21.1	60.1	57.4	41.9
Mean	Crops	11.7	63.7	22.3	62.1	60.9	
	C	W	S	CxW	CxS	WxS	CxWxS
S.Em ±	0.42	0.22	0.31	0.50	0.69	0.61	1.37
C.D. at 5%	1.37	0.64	0.90	1.44	N.S.	N.S.	N.S.

submergence after sowing of seeds on puddled soil from 12 to 24 h further improved the dry matter accumulation in *Lathyrus* varieties whereas it was reduced in case of peas and linseed; the water regime treatments had no significant effect in shoot dry weight variations in lentil. The plants raised from treated seeds showed significantly higher shoot dry weight / plant than that of untreated seeds. The interaction between crops and seed treatments was not significant.

4.1.9 Root dry weight / plant at 19 days after sowing

The highest and the lowest root dry weight / plant were 21.3 mg and 2.4 mg recorded (Table 4.9) in peas and linseed, respectively. The root dry weight observed in peas was significantly superior to the rest of all other crops. The next highest root dry weight / plant was (18.9 mg) recorded in *Lathyrus* (local) followed by *Lathyrus* (Nirmal); the difference between their root dry weights was also significant. The lowest root dry weight was recorded in linseed and it was significantly lower than the root dry weight of lentil. The highest root dry weight / plant (16 mg) was recorded in plants established on conventionally tilled soil. The lowest root dry weight / plant (12.6 mg) was observed in plants established on puddled soil without any stagnation of water and this was significantly lower than other root dry weights observed in plants established on puddled soil with 12 to 24 h of standing water. No significant difference, was however, observed between plants established on puddled soil having 12 and 24 h of standing water. The interaction between the

Table 4.9 Effect of seed treatment and water regime & tillage at the time of sowing of different crops on root dry weight / plant (mg), 19 days after sowing (Net House Experiment No.1, 1984)

Soil/Water regime (W)	Seed treatment (S)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathy-rus (Nirmal)	Lathy-rus (local)	Mean
Unpuddled (tilled)	Treated	2.4	25.4	10.0	22.1	24.4	16.9
	Untreated	2.3	22.4	8.9	20.1	21.1	15.0
	Mean	2.4	23.9	9.5	21.1	22.8	16.0
Puddled (0 cm)	Treated	2.7	20.1	9.2	17.8	18.0	13.6
	Untreated	2.0	18.1	7.0	16.0	15.0	11.6
	Mean	2.4	19.1	8.1	16.9	16.5	12.6
Puddled (5 cm/12 h)	Treated	2.5	22.6	12.4	17.4	20.8	15.1
	Untreated	2.4	19.1	9.8	15.4	16.2	12.6
	Mean	2.5	20.9	11.1	16.4	18.5	13.9
Puddled (5 cm/24 h)	Treated	2.3	22.8	9.7	18.2	18.5	14.3
	Untreated	2.2	19.5	7.9	16.2	16.8	12.5
	Mean	2.3	21.2	8.8	17.2	17.7	13.4
Seed treatment (S)	Treated	2.5	22.7	10.3	18.9	20.4	15.0
	Untreated	2.2	19.8	8.4	16.9	17.3	12.9
Mean	Crops	2.4	21.3	9.4	17.9	18.9	
	C	W	S	CxW	CxS	WxS	CxWxS
S.Em ±	0.20	0.23	0.16	0.51	0.36	0.32	0.72
C.D. at 5%	0.65	0.66	0.46	1.47	N.S.	N.S.	N.S.

crops and water regimes & tillage was significant indicating that plants raised on puddled soil without stagnation of water had reduced root dry weight / plant except in linseed and lentil. With increasing duration of water stagnation from 12 to 24 h after sowing, the dry matter accumulation in root increased in peas and *Lathyrus* (Nirmal) and there was a decline in dry matter accumulation in lentil and *Lathyrus* (local). Significantly more root dry matter / plant was produced in plants raised from pre-sowing treated than from untreated seeds.

4.1.10 Shoot length at 26 days after sowing

The highest shoot length (18.1 cm) was observed (Table 4.10) in *Lathyrus* (local), closely followed by peas (17.9 cm) and *Lathyrus* (Nirmal). The lengths of shoots of linseed and lentil were significantly lower than *Lathyrus* varieties and peas. The lowest shoot length (9.8 cm) was recorded by lentil, and it was significantly lower than linseed also. Crops raised under conventional tillage showed significantly better shoot length (16.1 cm) than those raised on puddled soil without or with standing water for 12 h, but no significant difference was observed with the shoot lengths recorded in plants raised on puddled soil with 24 h of standing water. The interaction between crops and water regimes & tillage was significant. Except lentil, increased shoot lengths were observed in all crops, when plants were raised on conventionally tilled soil over those recorded in plants raised on puddled soil with no standing water. In lentil, crops raised on puddled soil with 12 h of standing water showed significantly higher shoot length

Table 4.10 Effect of seed treatment and water regime & tillage at the time of sowing of different crops on shoot length (cm), 26 days after sowing (Net House Experiment No.1, 1984)

Soil/Water regime (W)	Seed treatment (S)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathy-rus (Nirmal)	Lathy-rus (local)	Mean
Unpuddled (tilled)	Treated	14.3	20.5	10.6	20.1	18.9	16.9
	Untreated	12.3	18.9	9.0	18.6	17.5	15.3
	Mean	13.3	19.7	9.8	19.4	18.2	16.1
Puddled (0 cm)	Treated	13.3	17.8	9.5	18.0	19.5	15.6
	Untreated	10.7	15.8	7.7	15.7	15.7	13.1
	Mean	12.0	16.8	8.6	16.9	17.6	14.4
Puddled (5 cm/12 h)	Treated	13.2	18.8	10.5	18.0	18.8	15.9
	Untreated	12.6	16.2	9.5	16.5	17.6	14.5
	Mean	12.9	17.5	10.0	17.3	18.2	15.2
Puddled (5 cm/24 h)	Treated	13.5	18.2	11.7	18.1	19.2	16.2
	Untreated	12.2	17.0	9.4	17.3	17.6	14.9
	Mean	12.8	17.6	10.6	17.7	18.4	15.6
Seed treatment (S)	Treated	13.6	18.8	10.6	18.5	19.1	16.1
	Untreated	11.9	17.0	8.9	17.0	17.1	14.4
Mean	Crops	12.8	17.9	9.8	17.8	18.1	

	C	W	S	CxW	CxS	WxS	CxWxS
S.Em ±	0.19	0.20	0.17	0.44	0.39	0.35	0.78
C.D. at 5%	0.62	0.57	0.49	1.26	N.S.	N.S.	N.S.

than those recorded in puddled soil with no standing water. In all crops except linseed greater shoot lengths were observed when plants were established on puddled soil with 24 h of standing water than those recorded in puddled soil with 12 h of standing water; the differences were, however, not significant. The plants raised from treated seeds had significantly higher shoot length than those raised from untreated seeds. Interaction between crops and seed treatments was not significant.

4.1.11 Root length at 26 days after sowing

Lathyrus (Nirmal) showed (Table 4.11) the maximum root length (12.1 cm) closely followed by *Lathyrus* (local) and peas (11.5). The root lengths of *Lathyrus* varieties and peas were significantly higher than lentil (9.6 cm) and linseed (10.1 cm). The lowest root length was recorded in lentil, however no significant difference was observed with linseed. The water regime & tillage treatments did not show significant difference in root length in plants established on different water regimes & tillage. Significantly longer roots were observed in plants raised from treated seeds than those recorded in plants raised from untreated seeds. Interaction between crops and seed treatments was not significant.

4.1.12 Shoot dry weight / plant at 26 days after sowing

The highest shoot dry weight / plant (116.0 mg) was recorded (Table 4.12) in peas which was significantly superior

Table 4.11 Effect of seed treatment and water regime & tillage at the time of sowing of different crops on root length (cm), 26 days after sowing (Net House Experiment No.1, 1984)

Soil/Water regime (W)	Seed treatment (S)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathyrus (Nirmal)	Lathyrus (local)	Mean
Unpuddled (tilled)	Treated	11.4	13.4	10.7	14.1	12.0	12.3
	Untreated	10.0	11.6	9.6	12.7	11.3	11.0
	Mean	10.7	12.5	10.2	13.4	11.7	11.7
Puddled (0 cm)	Treated	9.9	11.0	9.1	11.5	11.5	10.7
	Untreated	9.7	9.8	8.7	11.3	10.3	10.0
	Mean	9.8	10.4	8.9	11.4	10.9	10.4
Puddled (5 cm/12 h)	Treated	10.5	12.2	10.7	12.5	14.0	12.0
	Untreated	9.2	11.5	9.1	11.5	11.0	10.5
	Mean	9.9	11.9	9.7	12.0	12.5	11.3
Puddled (5 cm/24 h)	Treated	9.9	11.3	10.2	11.9	11.4	10.9
	Untreated	9.6	10.7	9.0	11.3	10.3	10.2
	Mean	9.8	11.0	9.6	11.6	10.9	10.6
Seed treatment (S)	Treated	10.4	12.0	10.1	12.5	12.2	11.4
	Untreated	9.8	10.9	9.1	11.7	10.7	10.4
Mean	Crops	10.1	11.5	9.6	12.1	11.5	
	C	W	S	CxW	CxS	WxS	CxWxS
S.Em ±	0.29	0.23	0.13	0.51	0.29	0.26	0.58
C.D. at 5%	0.95	N.S.	0.38	N.S.	N.S.	N.S.	N.S.

Table 4.12 Effect of seed treatment and water regime& tillage at the time of sowing of different crops on shoot dry weight / plant (mg), 26 days after sowing (Net House Experiment No.1, 1984)

Soil/Water regime (W)	Seed treatment (S)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathy-rus (Nirmal)	Lathy-rus (local)	Mean
Unpuddled (tilled)	Treated	32.5	129.0	43.9	112.9	128.0	89.3
	Untreated	30.0	119.5	35.2	107.0	124.0	83.1
	Mean	31.3	124.3	39.6	110.0	126.0	86.2
Puddled (0 cm)	Treated	29.4	104.1	36.5	107.5	97.4	75.0
	Untreated	22.4	100.7	36.2	100.1	88.9	69.7
	Mean	25.9	102.4	36.4	103.8	93.2	72.4
Puddled (5 cm/12 h)	Treated	28.7	134.0	39.2	109.6	123.6	87.0
	Untreated	28.1	104.9	38.0	108.8	112.0	78.4
	Mean	28.4	119.5	38.6	109.2	117.8	82.7
Puddled (5 cm/24 h)	Treated	27.7	119.5	41.0	111.2	115.1	82.9
	Untreated	26.9	116.2	36.4	108.7	113.1	80.3
	Mean	27.3	117.9	38.7	110.0	114.1	81.6
Seed treatment (S)	Treated	29.6	121.6	40.1	110.3	116.0	83.5
	Untreated	26.8	110.3	36.4	106.1	109.5	77.8
Mean	Crops	28.2	116.0	38.3	108.2	112.8	
	C	W	S	CxW	CxS	WxS	CxWxS
S.Em ±	0.71	0.63	0.80	1.44	1.79	1.60	3.58
C.D. at 5%	2.32	1.81	2.31	4.14	N.S.	N.S.	N.S.

to shoot dry weight recorded in other crops. Again the shoot dry weight of <u>Lathyrus</u> (local) was 112.8 mg and this was significantly superior to Nirmal variety of <u>Lathyrus</u> (108.2 mg). The lowest shoot dry weight (28.2 mg) was observed in linseed which was significantly lower than lentil. Significantly highest shoot dry weight / plant was recorded in plants raised on conventionally tilled soil. The lowest shoot dry weight / plant (72.4 mg) was observed in plants established on puddled soils with no standing water; this was significantly lower than shoot dry weight recorded in plants raised on puddled soil with 12 and 24 h of standing water. No significant difference was observed with regard to shoot dry weight accumulated between treatment with 12 and 24 h of submergences. The interaction between water regimes & tillage and crops was significant. Crops raised on puddled soil with no standing water showed adverse affect in shoot dry weight production except in linseed and lentil. Linseed recorded significantly higher shoot dry weight / plant (31.3 mg) when grown on conventionally tilled soil than those produced on puddled soil with no standing water. Shoot dry matter accumulation in linseed under different puddled soil conditions were not significantly different. In <u>Lathyrus</u> (local) and peas, the seeds sown on puddled soil with 24 h of submergence, showed lesser accumulation in shoot dry weight than those raised under 12 h of submergence; but this was not so in <u>Lathyrus</u> (Nirmal). Water regime & tillage treatments did not cause any significant variation in shoot dry weight in case of lentil. Plants raised from treated seeds produced more shoot dry weight / plant.

4.1.13 Root dry weight / plant at 26 days after sowing

Peas recorded (Table 4.13) the highest root dry weight / plant (37.8 mg), which was significantly higher than all other crops. _Lathyrus_ (local) showed the next highest root dry weight / plant (29.2 mg) followed by _Lathyrus_ (Nirmal) (26.9 mg) and the difference between these two was also significant. The lowest root dry weight / plant (3.0 mg) was recorded in linseed and it was significantly lower than lentil. Plants raised on conventionally tilled soil showed the highest root dry weight / plant (24.3 mg) closely followed by root dry weight / plant (23.5 mg) recorded in plants established on puddled soil with 12 h of standing water. The lowest root dry weight / plant was observed in plants established on puddled soil with no standing water; this was significantly lower than the root dry weights obtained in all other water regime & tillage treatments. Again root dry weight / plant recorded in plants established on puddled soil with 24 h of standing water was significantly lower than those raised in conventionally tilled and puddled soil with 12 h of standing water. The interaction between crops and water regimes & tillage was significant, indicating thereby that crops raised on puddled soil with no standing water had reduced root dry weight except in linseed and lentil. In lentil and Lathyrus (local), root dry weight / plant was adversely affected where the plants were raised on puddled soil with 24 h of standing water. No significant difference was observed in linseed due to water regime & tillage treatments. Plants raised from

Table 4.13 Effect of seed treatment and water regime & tillage at the time of sowing of different crops on root dry weight / plant (mg), 26 days after sowing (Net House Experiment No.1, 1984)

Soil/Water regime (W)	Seed treatment (S)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathy-rus (Nirmal)	Lathy-rus (local)	Mean
Unpuddled (tilled)	Treated	3.3	42.5	18.8	30.3	34.5	25.9
	Untreated	2.9	37.0	16.7	26.1	30.1	22.6
	Mean	3.1	39.8	17.8	28.2	32.3	24.3
Puddled (0 cm)	Treated	2.9	35.8	17.4	26.1	26.9	21.8
	Untreated	2.7	31.6	14.2	23.7	24.6	19.4
	Mean	2.8	33.7	15.8	24.9	25.8	20.6
Puddled (5 cm/12 h)	Treated	3.3	39.3	17.9	27.9	33.7	24.4
	Untreated	2.9	38.7	15.9	25.3	29.5	22.5
	Mean	3.1	39.0	16.9	26.6	31.6	23.5
Puddled (5 cm/24 h)	Treated	3.0	40.7	15.0	29.0	28.5	23.2
	Untreated	2.8	36.9	14.2	26.6	25.9	21.3
	Mean	2.9	38.8	14.6	27.8	27.2	22.3
Seed treatment (S)	Treated	3.1	39.6	17.3	28.3	30.9	23.8
	Untreated	2.8	36.0	15.3*	25.4	27.5	21.4
Mean	Crops	3.0	37.8	16.3	26.9	29.2	

	C	W	S	CxW	CxS	WxS	CxWxS
S.Em ±	0.39	0.36	0.16	0.82	0.37	0.33	0.74
C.D. at 5%	1.27	1.03	0.46	2.36	N.S.	N.S.	N.S.

treated seeds showed significantly higher root dry weight / plant than those from untreated seeds.

4.2 Net House Experiment No.2

The experiment was repeated with slight modification to confirm the variations in stand establishment and initial growth of winter crops under different water regime and tillage treatments, with treated and untreated seeds.

4.2.1 Stand establishment

It was observed (Table 4.14) that equal number of plants were established (9 out of 10 seeds sown in each) in linseed and *Lathyrus* varieties. Peas recorded the lowest stand establishment (6 out of 10 seeds) which was significantly lower than all other crops. Again, lentil showed (8 out of 10 seed) significantly lower stand establishment than linseed and *Lathyrus* varieties. Seeds sown in conventionally tilled soil recorded the highest stand establishment (9.2 out of 10 seeds) than all other regime & tillage treatments; this was significantly higher than others. Seeds sown on puddled soil with no standing water showed the lowest number of plants established than those recorded under all other water regime & tillage treatments; but this was at par with the stand establishment recorded on puddled soil with 12 and 36 h of standing water. No significant difference was, however, observed between 12 and 24 h of submergences. Interaction between the crops and water regimes & tillage was significant indicating the improved stand establishment when linseed was sown on puddled soil with 24 h of submergence.

Table 4.14 Effect of seed treatment and water regime & tillage at the time of sowing of different crops on stand establishment, 8 days after sowing (Net House Experiment No.2, 1984-85)

Soil/Water regime (W)	Seed treatment (S)	Winter crops (C)					
		Linseed	Peas	Lentil	Lathyrus (Nirmal)	Lathyrus (local)	Mean
Unpuddled (tilled)	Treated	7.0	8.4	8.0	10.0	10.0	8.7
	Untreated	9.6	10.0	10.0	9.0	10.0	9.7
	Mean	8.3	9.2	9.0	9.5	10.0	9.2
Puddled (0 cm)	Treated	8.4	4.4	9.0	9.0	9.0	8.0
	Untreated	8.4	4.0	8.6	9.0	6.0	7.2
	Mean	8.4	4.2	8.8	9.0	7.5	7.6
Puddled (5 cm/12 h)	Treated	8.0	5.6	9.6	9.0	8.6	8.2
	Untreated	8.4	5.6	8.4	8.6	9.0	8.0
	Mean	8.2	5.6	9.0	8.8	8.8	8.1
Puddled (5 cm/24 h)	Treated	10.0	5.0	8.6	9.0	9.6	8.4
	Untreated	9.6	5.6	9.0	8.0	10.0	8.4
	Mean	9.8	5.3	8.8	8.5	9.8	8.4
Puddled (5 cm/36 h)	Treated	9.6	5.0	7.0	9.4	9.0	8.0
	Untreated	8.6	6.0	5.4	9.0	9.0	7.6
	Mean	9.1	5.5	6.2	9.2	9.0	7.8
Seed treatment (S)	Treated	8.6	5.6	8.4	9.2	9.2	8.2
	Untreated	9.4	6.2	8.1	8.8	8.8	8.3
Mean	Crops	9.0	5.9	8.2	9.0	9.0	

	C	W	S	CxW	CxS	WxS	CxWxS
S.Em ±	0.14	0.22	0.12	0.48	0.28	0.28	0.64
C.D. at 5%	0.46	0.62	N.S.	1.36	N.S.	N.S.	N.S.

puddled soil with 36 h of submergence adversely affected the stand establishment of lentil. Peas sown on puddled soil with different periods of submergences had showed adverse affect on stand establishment. Stand establishment improved in *Lathyrus* (local) while after sowing of seeds submergences were maintained for 12 and 24 h. *Lathyrus* (Nirmal) showed no significant differences in stand establishment when raised on different water regime & tillage treatments. Seed treatments had no significant effect on stand establishment.

4.2.2 Shoot length at 18 days after sowing

Lathyrus (local) showed (Table 4.15) the longest shoot length (11.6 cm) and this was significantly higher than all other crops. The next longest mean shoot length (10.9 cm) recorded in *Lathyrus* (Nirmal) was followed by peas (8.3 cm); the difference between these two was also significant. The lowest shoot length (4.2 cm) was recorded in linseed which was significantly lower than lentil (5.3 cm). The shoot length of peas was significantly higher than lentil. Crops raised on puddled soil with 12 h of standing water showed the longest shoot length (9.0 cm) closely followed by the shoot length of plants established on conventionally tilled soil; these two shoot lengths were significantly superior to those raised under other water regimes & tillage. Plants established on puddled soil without stagnation of water recorded the lowest shoot length (7.0 cm) and this was at par with the shoot length (7.2 cm) of plants established on puddled soil with

Table 4.15 Effect of seed treatment and water regime & tillage at the time of sowing of different crops on shoot length (cm), 18 days after sowing (Net House Experiment No.2, 1984-85)

Soil/Water regime (W)	Seed treatment (S)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathyrus (Nirmal)	Lathyrus (local)	Mean
Unpuddled (tilled)	Treated	4.9	10.4	6.6	12.3	13.0	9.4
	Untreated	5.1	9.4	5.4	10.3	11.6	8.4
	Mean	5.0	9.9	6.0	11.3	12.3	8.9
Puddled (0 cm)	Treated	3.9	7.9	5.1	10.4	10.2	7.5
	Untreated	2.9	6.4	4.0	11.0	8.2	6.5
	Mean	3.4	7.2	4.6	10.7	9.2	7.0
Puddled (5 cm/12 h)	Treated	5.0	10.6	6.8	11.9	12.0	9.3
	Untreated	4.6	8.6	5.8	12.7	11.8	8.7
	Mean	4.8	9.6	6.3	12.3	11.9	9.0
Puddled (5 cm/24 h)	Treated	5.0	8.7	5.1	11.0	14.5	8.9
	Untreated	4.4	7.5	4.7	10.1	11.7	7.7
	Mean	4.7	8.1	4.9	10.6	13.1	8.3
Puddled (5 cm/36 h)	Treated	3.4	7.6	5.4	11.0	10.3	7.5
	Untreated	2.9	6.0	4.2	8.5	12.3	6.8
	Mean	3.2	6.6	4.8	9.8	11.3	7.2
Seed treatment (S)	Treated	4.4	8.9	5.8	11.3	12.0	8.5
	Untreated	4.0	7.6	4.8	10.5	11.2	7.6
Mean	Crops	4.2	8.3	5.3	10.9	11.6	

	C	W	S	CxW	CxS	WxS	CxWxS
S.Em ±	0.17	0.07	0.10	0.17	0.23	0.23	0.52
C.D. at 5%	0.55	0.20	0.30	0.48	N.S.	N.S.	N.S.

36 h of standing water. The shoot length (8.3 cm) of plants raised from seeds sown on puddled soil with 24 h of standing water was significantly higher than those raised on puddled soil without submergence and with submergence for 36 h. The interaction between crops and water regimes & tillage was significant. All crops raised on conventionally tilled soil showed significantly higher shoot length than those raised on puddled soil without any standing water. Stagnation of water upto 12 h increased the shoot length in linseed, lentil, peas and in Lathyrus (Nirmal); further increase in the duration of stagnation caused adverse affect on shoot length. Stagnation of water upto 24 h increased the shoot length in Lathyrus (local); but beyond this stagnation, shoot length was adversely affected. Plants raised from treated seeds showed significantly higher shoot length than those raised from untreated seeds. The interaction between crops and seed treatments was not significant.

4.2.3 Root length at 18 days after sowing

Highest root length (8.8 cm) was observed (Table 4.16) equally in peas and Lathyrus (local) followed by Lathyrus (Nirmal); root lengths of peas and Lathyrus (local) were significantly higher than lentil, linseed and Lathyrus (Nirmal). The lowest root length (6.4 cm) was recorded in lentil and this was significantly lower than linseed. Plants established on puddled soil with 24 h of standing water showed the highest root length (8.8 cm) closely followed by root length

Table 4.16 Effect of seed treatment and water regime & tillage at the time of sowing of different crops on root length (cm), 18 days after sowing (Net House Experiment No.2, 1984-85)

Soil/Water regime (W)	Seed treatment (S)	Winter crops (C)					
		Linseed	Peas	Lentil	Lathyrus (Nirmal)	Lathyrus (local)	Mean
Unpuddled (tilled)	Treated	8.6	9.3	8.0	9.2	10.2	9.1
	Untreated	7.0	8.7	7.0	8.2	9.6	8.1
	Mean	7.8	9.0	7.5	8.7	9.9	8.6
Puddled (0 cm)	Treated	6.3	7.2	4.7	7.5	7.1	6.6
	Untreated	5.3	6.2	5.2	5.9	5.5	5.6
	Mean	5.8	6.7	4.9	6.7	6.3	6.1
Puddled (5 cm/12 h)	Treated	7.6	10.5	5.9	10.2	9.5	8.7
	Untreated	7.4	8.5	6.1	8.6	8.3	7.8
	Mean	7.5	9.5	6.0	9.4	8.9	8.3
Puddled (5 cm/24 h)	Treated	8.3	11.3	7.7	9.4	11.1	9.6
	Untreated	5.9	9.1	6.5	9.0	9.6	8.0
	Mean	7.1	10.2	7.1	9.2	10.4	8.8
Puddled (5 cm/36 h)	Treated	7.9	9.4	6.4	9.0	10.2	8.6
	Untreated	6.0	7.7	6.6	8.0	7.0	7.2
	Mean	7.0	8.6	6.5	8.5	8.6	7.9
Seed treatment (S)	Treated	7.7	9.5	6.5	9.1	9.6	8.5
	Untreated	6.3	8.0	6.3	7.9	8.0	7.3
Mean	Crops	7.0	8.8	6.4	8.5	8.8	

	C	W	S	CxW	CxS	WxS	CxWxS
S.Em ±	0.09	0.08	0.12	0.19	0.26	0.26	0.58
C.D. at 5%	0.29	0.23	0.35	0.54	N.S.	N.S.	N.S.

recorded in plants raised on conventionally tilled soil; these were significantly higher than the root lengths observed in other water regime & tillage treatments. Plants established on puddled soil with no standing water recorded the lowest root length and this was significantly lower than the root length recorded on puddled soil with 36 h of standing water. Again root length recorded in plants established on puddled soil with 36 h submergence showed significantly lower root lengths than those recorded in plants raised on puddled soil with 12 h of standing water. Interaction between crops and water regime & tillage was significant indicating the adverse affect on root length when plants were raised on puddled soil without standing water in all crops. With the increase in the duration of stagnation of water from 12 to 24 h, root lengths increased in peas, lentil and Lathyrus (local) but in linseed and Lathyrus (Nirmal) stagnation of water upto 12 h showed increase in root length. Plants raised from treated seeds had higher root length than those from untreated seeds. The interaction between crops and seed treatments was not significant.

4.2.4 Shoot dry weight / plant at 18 days after sowing

Peas recorded the highest shoot dry weight (43.4 mg) closely followed by Lathyrus (local); this was significantly higher than rest of all other crops (Table 4.17). No significant difference was observed between the shoot dry weight of Lathyrus varieties. Linseed showed the lowest shoot dry weight which was significantly lower than lentil. Again lentil showed

Table 4.17 Effect of seed treatment and water regime & tillage at the time of sowing of different crops on shoot dry weight / plant (mg), 18 days after sowing (Net House Experiment No.2, 1984-85)

Soil/Water regime (W)	Seed treatment (S)	Winter crops (C) Lin-seed	Peas	Lentil	Lathy-rus (Nirmal)	Lathy-rus (local)	Mean
Unpuddled (tilled)	Treated	6.0	45.0	20.0	46.8	44.1	32.4
	Untreated	4.9	43.0	18.6	41.8	43.0	30.3
	Mean	5.5	44.0	19.3	44.3	43.6	31.4
Puddled (0 cm)	Treated	5.1	45.1	15.0	42.9	42.7	30.2
	Untreated	4.7	40.5	13.8	40.6	40.0	27.9
	Mean	4.9	42.8	14.4	41.7	41.4	29.1
Puddled (5 cm/12 h)	Treated	5.6	46.5	17.2	44.2	44.9	31.7
	Untreated	5.0	45.5	15.2	42.7	42.7	30.2
	Mean	5.3	46.0	16.2	43.4	43.8	30.9
Puddled (5 cm/24 h)	Treated	4.7	47.5	15.0	44.5	55.0	33.3
	Untreated	3.5	45.1	13.0	37.5	45.5	28.9
	Mean	4.1	46.3	14.0	41.0	50.5	31.1
Puddled (5 cm/36 h)	Treated	4.7	39.5	13.0	42.7	37.4	27.5
	Untreated	3.8	36.4	11.5	38.5	35.6	25.2
	Mean	4.3	37.9	12.3	40.6	36.5	26.4
Seed treatment (S)	Treated	5.2	44.7	16.0	44.2	44.8	31.0
	Untreated	4.4	42.1	14.4	40.2	41.4	28.5
Mean	Crops	4.8	43.4	15.2	42.2	43.1	

	C	W	S	CxW	CxS	WxS	CxWxS
S.Em ±	0.31	0.28	0.24	0.62	0.54	0.54	1.21
C.D. at 5%	1.01	0.79	0.70	1.75	N.S.	N.S.	N.S.

significantly lower shoot dry weight than *Lathyrus* (Nirmal). Plants raised on puddled soil with 36 h of standing water showed significantly lower shoot dry weight than all other water regimes & tillage. The highest shoot dry weight was recorded in plants raised on conventionally tilled soil closely followed by those recorded in plants raised on puddled soil with 12 and 24 h of standing water; these shoot dry weights were significantly higher than those recorded in plants raised on puddled soil with no standing water. Interaction between crops and water regimes & tillage was significant. Stagnation of water for 12 and 24 h showed progress in shoot dry weight accumulation in peas and *Lathyrus* (local). Lentil and *Lathyrus* (Nirmal) showed greater shoot dry weight in plants raised on puddled soil with 12 h of standing water. The adverse effect in shoot dry weight accumulation was observed in plants raised on puddled soil with 36 h of standing water in all the crops except linseed; water regime & tillage treatments did not cause any significant variation in shoot dry weight in case of linseed. Significantly higher shoot dry weight was observed in plants raised from treated seeds than those from untreated seeds. The interaction between crops and seed treatments was not significant.

4.2.5 Root dry weight / plant at 18 days after sowing

The highest root dry weight (17.9 mg) was recorded (Table 4.18) in *Lathyrus* (local) closely followed by peas (17.7 mg); these were significantly higher than rest of all

Table 4.18 Effect of seed treatment and water regime & tillage at the time of sowing of different crops on root dry weight/plant (mg), 18 days after sowing (Net House Experiment No.2, 1984-85)

Soil/Water regime (W)	Seed treatment (S)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathy-rus (Nirmal)	Lathy-rus (local)	Mean
Unpuddled (tilled)	Treated	1.6	19.7	6.6	18.5	19.0	13.1
	Untreated	1.4	17.6	5.2	16.5	17.7	11.7
	Mean	1.5	18.7	5.9	17.5	18.4	12.4
Puddled (0 cm)	Treated	1.4	18.0	6.6	17.5	18.7	12.4
	Untreated	1.2	16.4	5.3	16.0	14.8	10.7
	Mean	1.3	17.2	5.9	16.8	16.8	11.6
Puddled (5 cm/12 h)	Treated	1.5	18.3	7.7	17.0	19.5	12.8
	Untreated	1.4	16.7	6.0	15.2	17.5	11.4
	Mean	1.5	17.5	6.9	16.1	18.5	12.1
Puddled (5 cm/24 h)	Treated	1.5	20.0	6.5	18.5	20.5	13.4
	Untreated	1.3	18.0	5.5	15.5	17.2	11.5
	Mean	1.4	19.0	6.0	17.0	18.9	12.5
Puddled (5 cm/36 h)	Treated	1.5	17.5	5.5	17.1	17.7	11.9
	Untreated	1.3	14.5	5.5	15.2	16.7	10.6
	Mean	1.4	16.0	5.5	16.1	17.2	11.3
Seed treatment (S)	Treated	1.5	18.7	6.6	17.7	19.1	12.7
	Untreated	1.3	16.6	5.5	15.7	16.8	11.2
Mean	Crops	1.4	17.7	6.1	16.7	17.9	

	C	W	S	CxW	CxS	WxS	CxWxS
S.Em ±	0.10	0.14	0.19	0.30	0.43	0.43	0.95
C.D. at 5%	0.33	0.39	0.55	0.85	N.S.	N.S.	N.S.

other crops. *Lathyrus* (Nirmal) showed significantly higher root dry weight than lentil and linseed. The lowest root dry weight (1.4 mg) was recorded in linseed which was significantly lower than lentil. Establishment of plants on puddled soil with 24 h of standing water showed the highest root dry weight (12.5 mg) closely followed by the plants established on conventionally tilled soil; this was significantly higher than rest of all other water regime & tillage treatments. Again root length recorded in plants established on puddled soil with 12 h of standing water was significantly higher than the plants established on puddled soil with no standing water and submergence for 36 h. The lowest root dry weight was recorded in plants raised on puddled soil with 36 h of standing water showed no significant difference with the root dry weight recorded in plants established on puddled soil with no standing water. Interaction between the crops and water regimes & tillage was significant. In peas and *Lathyrus* (Nirmal) adverse affect on root dry matter accumulation was observed when plants were raised on puddled soil with 36 h of standing water. The highest root dry weight of peas was recorded in plants established on puddled soil with 24 h of standing water. Stagnation of water on puddled soil for 12 h increased the root dry weight in lentil while adverse affect on root dry matter accumulation was observed where the plants were established on puddled soil with 36 h of standing water. *Lathyrus* (Nirmal) raised on conventionally tilled soil showed the highest root dry weight though it was not significantly different than those recorded in plants raised on puddled soil without and with 24 h of standing water. Adverse affect in root dry matter accumulation in Lathyrus (local) was observed when the plants were raised on puddled soil without standing water; with the increase in stagnation of water for 12 and 24 h, root dry matter accumulation increased progressively on puddled soil; with 36 h of standing water dry matter production again declined. Water regime & tillage treatments could not create any significant variation in root dry weight in case of linseed. Plants from treated seeds showed significantly higher root dry weight than those from untreated seeds. The interaction between crops and seed treatments was not significant.

4.2.6 Shoot length at 25 days after sowing

Highest shoot length (14.1 cm) was recorded (Table 4.19) in Lathyrus varieties; these were significantly higher than all other crops. The lowest shoot length (7 cm) was recorded in linseed which was significantly lower than that of lentil. Peas showed the higher shoot length than lentil; the difference between these two was significant. The highest shoot length (12.0 cm) was observed in plants raised on conventionally tilled soil. Plants established on puddled soil with 12 h of standing water showed higher shoot length than those recorded in plants established on puddled soil with 24 h of standing water. Plants established on puddled soil without or with 36 h of standing water showed the lowest shoot length (9.9 cm in each case) and these were significantly lower than those

Table 4.19 Effect of seed treatment and water regime & tillage at the time of sowing of different crops on shoot length (cm), 25 days after sowing (Net House Experiment No.2, 1984-85)

Soil/Water regime (W)	Seed treatment (S)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathyrus (Nirmal)	Lathyrus (local)	Mean
Unpuddled (tilled)	Treated	9.2	13.3	8.1	15.2	15.0	12.2
	Untreated	9.7	12.7	7.7	14.0	14.7	11.8
	Mean	9.5	13.0	7.9	14.6	14.9	12.0
Puddled (0 cm)	Treated	7.6	10.3	6.0	13.5	14.2	10.3
	Untreated	6.6	10.3	6.2	12.0	12.6	9.5
	Mean	7.1	10.3	6.1	12.8	13.4	9.9
Puddled (5 cm/12 h)	Treated	7.3	14.7	8.9	15.8	14.2	12.2
	Untreated	6.8	11.1	7.0	15.0	13.9	10.8
	Mean	7.1	12.9	7.9	15.4	14.1	11.5
Puddled (5 cm/24 h)	Treated	6.7	11.8	8.7	14.2	15.5	11.4
	Untreated	5.7	11.2	6.3	12.4	13.4	9.8
	Mean	6.2	11.5	7.5	13.3	14.5	10.6
Puddled (5 cm/36 h)	Treated	6.0	11.0	8.5	13.1	13.0	10.3
	Untreated	4.4	9.7	6.4	12.4	14.2	9.4
	Mean	5.2	10.4	7.5	12.8	13.6	9.9
Seed treatment (S)	Treated	7.4	12.2	8.0	14.4	14.4	11.3
	Untreated	6.6	11.0	6.7	13.8	13.8	10.3
Mean	Crops	7.0	11.6	7.4	14.1	14.1	
	C	W	S	CxW	CxS	WxS	CxWxS
S.Em ±	0.06	0.11	0.14	0.25	0.30	0.30	0.68
C.D. at 5%	0.20	0.31	0.41	0.71	N.S.	N.S.	N.S.

plants established on puddled soil with 24 h of standing water. Interaction between the crops and water regimes & tillage was significant indicating the adverse affect on shoot length of linseed when established on puddled soil without or with different durations of standing water. Adverse affect on shoot length was observed in peas, lentil and Lathyrus varieties when the plants were established on puddled soil without standing water. Significant increase in shoot length was observed in peas, lentil and Lathyrus (Nirmal) when the plants were raised on puddled soil with 12 h of standing water; further stagnation of water for 24 h and 36 h caused gradual decrease in shoot length. With the increase in stagnation of water on puddled soil from 12 to 24 h, there was gradual increase in shoot length in Lathyrus (local) but when the seeds remained submerged for 36 h the rate of increase slowed down. Plants from treated seeds produced higher shoot length than those from untreated seeds. The interaction between crops and seed treatments was not significant.

4.2.7 Root length at 25 days after sowing

Root lengths recorded (Table 4.20) in Lathyrus (local), Lathyrus (Nirmal) and peas were 11.1 cm, 10.8 cm and 10.7 cm respectively, wherein no significant differences were observed between the varieties. The lowest root length (8.8 cm) was observed in linseed; it showed significant difference with the root length (9.3 cm) recorded in lentil. But both the root lengths of linseed and lentil were significantly lower than

Table 4.20 Effect of seed treatment and water regime & tillage at the time of sowing of different crops on root length (cm), 25 days after sowing (Net House Experiment No.2, 1984-85)

Soil/Water regime (W)	Seed treatment (S)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathy-rus (Nirmal)	Lathy-rus (local)	Mean
Unpuddled (tilled)	Treated	10.4	10.7	12.2	10.9	13.1	11.5
	Untreated	8.0	10.3	9.5	9.5	11.6	9.8
	Mean	9.2	10.5	10.9	10.2	12.4	10.7
Puddled (0 cm)	Treated	10.0	11.1	9.8	11.5	11.2	10.7
	Untreated	7.4	9.3	8.0	8.9	9.4	8.6
	Mean	8.7	10.2	8.9	10.2	10.3	9.7
Puddled (5 cm/12 h)	Treated	9.8	12.3	10.2	12.9	12.0	11.4
	Untreated	8.2	10.2	8.6	10.4	10.4	9.6
	Mean	9.0	11.3	9.4	11.7	11.2	10.5
Puddled (5 cm/24 h)	Treated	9.2	12.1	9.0	12.3	12.3	11.0
	Untreated	8.0	10.2	8.4	10.8	10.1	9.5
	Mean	8.6	11.2	8.7	11.6	11.2	10.3
Puddled (5 cm/36 h)	Treated	9.0	11.0	9.8	11.0	11.2	10.4
	Untreated	7.8	10.2	7.2	10.1	9.5	9.0
	Mean	8.4	10.6	8.5	10.6	10.4	9.7
Seed treatment (S)	Treated	9.7	11.4	10.2	11.7	12.0	11.0
	Untreated	7.9	10.0	8.3	9.9	10.2	9.3
Mean	Crops	8.8	10.7	9.3	10.8	11.1	
	C	W	S	CxW	CxS	WxS	CxWxS
S.Em ±	0.14	0.11	0.09	0.24	0.21	0.21	0.47
C.D. at 5%	0.46	0.31	0.26	0.68	N.S.	N.S.	N.S.

those recorded in rest of all crops. Plants raised on conventionally tilled soil showed the highest root length (10.7 cm) closely followed by the root length of plants established on puddled soil with 12 h of standing water. Root lengths recorded in plants established on puddled soil with 12 and 24 h of standing water showed no significant differences between themselves. Plants raised on puddled soil without and with 36 h of standing water showed equal root length (9.7 cm) which were significantly lower than root length recorded in plants raised on other water regime & tillage treatments. Interaction between the crops and water regime & tillage treatments was significant indicating the adverse affect on root growth in linseed, lentil and Lathyrus (local) when plants were raised on puddled soil with 36 h of standing water. Submergence for 12 h on puddled soil showed increase in root lengths in all crops. Further increase in stagnation of water for 24 h showed decrease in root length in all crops except Lathyrus (local). In lentil and Lathyrus (local) when plants were raised on puddled soil with no standing water showed significant reduction in root length as compared with conventionally tilled crops. Crops raised from treated seeds showed significantly higher root length than those from untreated seeds. Interaction between crops and seed treatments was not significant.

4.2.8 Shoot dry weight / plant at 25 days after sowing

The highest shoot dry weight (71.4 mg) was observed (Table 4.21) in peas; this was significantly higher than those recorded in other crops. Lathyrus (local) showed shoot dry

Table 4.21 Effect of seed treatment and water regime & tillage at the time of sowing of different crops on shoot dry weight / plant (mg), 25 days after sowing (Net House Experiment No.2, 1984-85)

Soil/Water regime (W)	Seed treatment ($)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathyrus (Nirmal)	Lathyrus (local)	Mean
Unpuddled (tilled)	Treated	15.2	84.7	25.2	67.7	70.0	52.6
	Untreated	12.5	75.5	22.2	62.8	67.5	48.1
	Mean	13.9	80.1	23.7	65.3	68.8	50.4
Puddled (0 cm)	Treated	12.2	73.1	25.7	67.0	65.7	48.7
	Untreated	10.0	67.5	20.1	61.7	60.0	43.9
	Mean	11.1	70.3	22.9	64.4	62.9	46.3
Puddled (5 cm/12 h)	Treated	11.5	78.5	24.7	70.7	67.7	50.6
	Untreated	10.7	72.2	20.1	64.0	62.0	45.8
	Mean	11.1	75.3	22.4	67.4	64.9	48.2
Puddled (5 cm/24 h)	Treated	10.6	69.5	23.2	62.0	68.8	46.8
	Untreated	8.2	63.7	19.2	56.5	62.5	42.0
	Mean	9.4	66.6	21.2	59.3	65.7	44.4
Puddled (5 cm/36 h)	Treated	9.2	68.5	22.4	65.2	66.5	46.4
	Untreated	8.0	60.2	19.5	60.0	62.5	42.0
	Mean	8.6	64.4	20.9	62.6	64.5	44.2
Seed treatment (S)	Treated	11.7	74.9	24.2	66.5	67.7	49.0
	Untreated	9.9	67.8	20.2	61.0	62.9	44.4
Mean	Crops	10.8	71.4	22.2	63.8	65.3	

	C	W	S	CxW	CxS	WxS	CxWxS
S.Em ±	0.39	0.29	0.33	0.65	0.73	0.73	1.64
C.D. at 5%	1.27	0.82	0.96	1.84	2.12	N.S.	N.S.

weight / plant (65.3 mg) significantly higher than *Lathyrus* (Nirmal) (63.8 mg / plant). The lowest shoot dry weight / plant was recorded in linseed which was significantly lower than that of lentil. Again lentil showed significantly lower shoot dry weight than *Lathyrus* (Nirmal). Crops raised on conventionally tilled soil showed the highest shoot dry weight / plant (50.4 mg) and this was significantly higher than those recorded in other water regime & tillage treatments. Puddled soil with 12 h of standing water showed the shoot dry weight / plant (48.2 mg) which was significantly higher than those observed in plants raised on other puddled soil without or with standing water. Puddled soil with 24 and 36 h of standing water showed almost equal shoot dry weights which were significantly lower than all other water regime & tillage treatments. Interaction between crops and water regime & tillage treatments was significant. In all crops, except the Nirmal variety of *Lathyrus* conventionally tilled soil condition favoured shoot dry weight accumulation over puddled soil without or with standing water. Amongst the crops, linseed and lentil showed progressive decline in shoot dry weight / plant with the increase in stagnation of water. But in peas and *Lathyrus* varieties with the increase in stagnation of water upto 12 h on puddled soil the increase in shoot dry weight / plant was found to be superior to other water regime & tillage treatments in puddled conditions. In Nirmal variety of *Lathyrus* water stagnation upto 12 h on puddled soil was even better than conventionally tilled soil. In local variety of *Lathyrus* shoot dry weight / plant did not significantly decline due to water stagnation even upto 36 h on puddled soil.

Crops raised from treated seeds showed significantly higher shoot dry weight than those from untreated seeds. Interaction between crops and seed treatment was also significant showing significant increase of shoot dry weight in all crops except linseed.

4.2.9 Root dry weight / plant at 25 days after sowing

As in shoot dry weight, the highest root dry weight / plant (27.9 mg) was recorded (Table 4.22) in peas and this was significantly higher than those recorded in other crops. In Lathyrus (local) root dry weight / plant observed (24.6 mg) was followed by Lathyrus (Nirmal); the difference of these two was significant. Here also as in shoot dry weight, the lowest root dry weight / plant (2.2 mg) was observed in linseed which was significantly lower than lentil (11.7 mg). The root dry weight of lentil was significantly lower than rest of all other crops. Crops raised on conventionally tilled soil showed the highest root dry weight / plant and this was significantly higher than those raised on puddled soil without or with standing water. Root dry weight recorded in plants raised on puddled soil with 24 h of standing water was significantly higher than those recorded in crops raised on puddled soil without or with standing water. Puddled soil having no standing water showed the lowest root dry weight / plant (16.8 mg) and this has no significant difference with the root dry weight recorded in plant established on puddled soil with 36 h of standing water. Interaction between crops and water regime & tillage treatments was significant. In puddled soil root dry weight increased with

Table 4.22 Effect of seed treatment and water regime & tillage at the time of sowing of different crops on root dry weight / plant (mg), 25 days after sowing (Net House Experiment No.2, 1984-85)

Soil/Water regime (W)	Seed treatment (S)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathy-rus (Nirmal)	Lathy-rus (local)	Mean
Unpuddled (Tilled)	Treated	2.8	33.0	13.3	25.3	30.5	21.0
	Untreated	2.5	28.0	12.5	23.5	25.3	18.4
	Mean	2.7	30.5	12.9	24.4	27.9	19.7
Puddled (0 cm)	Treated	2.5	27.0	12.3	26.0	25.2	18.6
	Untreated	1.9	22.0	10.1	20.0	21.0	15.0
	Mean	2.2	24.5	11.2	23.0	23.1	16.8
Puddled (5 cm/12 h)	Treated	2.8	30.5	13.5	25.5	24.8	19.4
	Untreated	1.8	24.3	11.7	21.5	20.2	15.9
	Mean	2.3	27.4	12.6	23.5	22.5	17.7
Puddled (5 cm/24 h)	Treated	1.8	34.0	12.8	24.8	27.0	20.1
	Untreated	1.6	28.5	10.0	21.8	22.6	16.9
	Mean	1.7	31.3	11.4	23.3	24.8	18.5
Puddled (5 cm/36 h)	Treated	1.9	29.5	11.8	25.3	26.8	19.1
	Untreated	1.5	22.3	9.0	21.0	22.0	15.2
	Mean	1.7	25.9	10.4	23.2	24.4	17.2
Seed treatment (S)	Treated	2.4	30.8	12.7	25.4	26.9	19.6
	Untreated	1.9	25.0	10.7	21.6	22.2	16.3
Mean	Crops	2.2	27.9	11.7	23.5	24.6	
	C	W	S	CxW	CxS	WxS	CxWxS
S.Em ±	0.19	0.21	0.15	0.47	0.33	0.33	0.73
C.D. at 5%	0.62	0.59	0.44	1.33	0.96	N.S.	N.S.

12 h of standing water in linseed, lentil and Lathyrus (Nirmal) but in peas and Lathyrus (local) root dry weight accumulation was in progress upto 24 h of standing water on puddled soil. There was a significant decline in root dry weight in peas and lentil when the plants were raised on puddled soil with 36 h of standing water. More root dry weight was recorded in plants raised from treated seeds than those from untreated seeds.

4.2.10 Shoot length at 32 days after sowing

Lathyrus (local) showed (Table 4.23) the highest shoot length (17.6 cm) closely followed by Lathyrus (Nirmal) and peas (17.5 cm); these shoot lengths were significantly higher than those recorded in linseed and lentil. The lowest shoot length (9.6 cm) was recorded in lentil which was significantly lower than those of linseed. Plants raised on conventionally tilled soil showed longer shoot (16.3 cm) closely followed by those recorded in plants raised on puddled soil with 12 h of standing water; these two shoot lengths were significantly superior to other water regime & tillage treatments in this regard. The lowest shoot length was observed in plants established on puddled soil with 36 h of standing water; however its difference with those recorded in puddled soil without standing water was not significant. Interaction between crops and water regime & tillage treatments was significant. Conventionally tilled soil showed longer shoot in all crops than those found in puddled soil with no standing water. Plants established on puddled soil with 12 h of standing water after sowing of seeds showed higher shoot length in all crops except linseed than

Table 4.23 Effect of seed treatment and water regime & tillage at the time of sowing of different crops on shoot length (cm), 32 days after sowing (Net House Experiment No.2, 1984-85)

Soil/Water regime (W)	Seed treatment (S)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathy-rus (Nirmal)	Lathy-rus (local)	Mean
Unpuddled (tilled)	Treated	15.0	23.4	10.6	18.5	19.5	17.4
	Untreated	14.2	17.8	9.2	16.0	18.7	15.1
	Mean	14.6	20.6	9.9	17.3	19.1	16.3
Puddled (0 cm)	Treated	14.9	18.3	9.1	17.4	16.5	15.2
	Untreated	10.5	14.1	8.5	15.2	16.0	12.9
	Mean	12.7	16.2	8.8	16.3	16.3	14.1
Puddled (5 cm/12 h)	Treated	13.1	20.5	10.6	19.3	19.5	16.6
	Untreated	11.5	16.2	10.5	18.5	18.3	15.0
	Mean	12.3	18.4	10.6	18.9	18.9	15.8
Puddled (5 cm/24 h)	Treated	11.0	17.2	10.2	19.0	18.0	15.1
	Untreated	8.8	16.0	8.2	17.8	16.2	13.4
	Mean	9.9	16.6	9.2	18.4	17.1	14.3
Puddled (5 cm/36 h)	Treated	10.8	16.6	10.0	16.8	17.1	14.3
	Untreated	9.6	15.2	8.6	16.2	16.5	13.2
	Mean	10.2	15.9	9.3	16.5	16.8	13.8
Seed treatment (S)	Treated	12.9	19.2	10.1	18.2	18.1	15.7
	Untreated	10.9	15.8	9.0	16.7	17.1	13.9
Mean	Crops	11.9	17.5	9.6	17.5	17.6	

	C	W	S	CxW	CxS	WxS	CxWxS
S.Em ±	0.20	0.28	0.18	0.62	0.40	0.40	0.90
C.D. at 5%	0.65	0.79	0.52	1.75	N.S.	N.S.	N.S.

those recorded in plants established on puddled soil without or with standing water for 24 or 36 h. Plants established from treated seeds showed superior shoot length to untreated seeds. Interaction between seed treatment and crops was not significant.

4.2.11 Root length at 32 days after sowing

Lathyrus (Nirmal) showed (Table 4.24) the highest root length (13.9 cm) which was significantly higher than the root length recorded in all other crops. The root length (13.3 cm) recorded in *Lathyrus* (local) was closely followed by peas (13.1 cm) and these two were significantly higher than lentil and linseed. Root length recorded in linseed was significantly lower than those recorded in lentil. The highest root length (14.0 cm) was observed in conventionally tilled soil; this was significantly higher than the root lengths recorded in plants raised on puddled soil without or with standing water. Plants raised on puddled soil with 12 and 24 h of standing water showed no significant differences in root length between them. The lowest root length was recorded in plants established on puddled soil without and with 36 h of standing water. Interaction between crops and water regimes & tillage was significant indicating the adverse affect in root length of linseed when plants were raised on puddled soil. In all crops long roots were observed when the plants were established on conventionally tilled soil. With the increase in stagnation of water from 12 h to 24 h, root length also increased in all crops except

Table 4.24 Effect of seed treatment and water regime & tillage at the time of sowing of different crops on root length (cm), 32 days after sowing (Net House Experiment No.2, 1984-85)

Soil/Water regime (W)	Seed treatment (S)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathyrus (Nirmal)	Lathyrus (local)	Mean
Unpuddled (tilled)	Treated	13.3	14.2	15.9	17.3	15.5	15.2
	Untreated	11.1	12.2	11.7	15.7	13.3	12.8
	Mean	12.2	13.2	13.8	16.5	14.4	14.0
Puddled (0 cm)	Treated	11.5	13.5	12.0	13.7	13.3	12.8
	Untreated	10.2	12.1	10.9	11.5	11.5	11.2
	Mean	10.9	12.8	11.5	12.6	12.4	12.0
Puddled (5 cm/12 h)	Treated	11.8	14.0	12.0	14.0	14.8	13.3
	Untreated	10.5	12.4	11.2	12.5	12.6	11.8
	Mean	11.2	13.2	11.6	13.3	13.7	12.6
Puddled (5 cm/24 h)	Treated	11.1	14.0	12.6	14.6	14.7	13.4
	Untreated	10.9	12.5	11.0	12.9	12.8	12.0
	Mean	11.0	13.3	11.8	13.8	13.8	12.7
Puddled (5 cm/36 h)	Treated	11.2	13.8	11.6	14.4	13.2	12.8
	Untreated	10.8	12.3	9.6	12.0	11.0	11.1
	Mean	11.0	13.1	10.6	13.2	12.1	12.0
Seed treatment (S)	Treated	11.8	13.9	12.8	14.8	14.3	13.5
	Untreated	10.7	12.3	10.9	12.9	12.2	11.8
Mean	Crops	11.3	13.1	11.9	13.9	13.3	
	C	W	S	CxW	CxS	WxS	CxWxS
S.Em ±	0.12	0.14	0.18	0.32	0.41	0.41	0.92
C.D. at 5%	0.39	0.39	0.52	0.91	N.S.	N.S.	N.S.

linseed; the difference was, however, not significant. Plants raised from treated seeds showed significantly longer root than those recorded in plants from untreated seeds. Interaction between crops and seed treatments was not significant.

4.2.12 Shoot dry weight / plant at 32 days after sowing

The highest shoot dry weight / plant (115.7 mg) was recorded (Table 4.25) in peas; this was significantly superior to all other crops. Shoot dry weight / plant recorded in Lathyrus-local (111.2 mg) was significantly higher than those observed in Lathyrus (Nirmal). The lowest shoot dry weight / plant (24.6 mg) was recorded in linseed and this was however significantly lower than lentil. Again, lentil showed significantly lower shoot dry weight than Lathyrus (Nirmal). Plants established on conventionally tilled soil showed the highest shoot dry weight / plant (88.9 mg) which was significantly higher than those recorded in all other water regime & tillage treatments. Plants raised on puddled soil with 12 h of standing water showed significantly higher shoot dry weight than all other treatments on puddled soil. Plants raised on puddled soil without standing water showed the lowest shoot dry weight and this however, did not differ significantly with plants raised on puddled soil having 36 h of standing water. Interaction between crops and water regime & tillage treatments was significant indicating that conventional tillage favoured in producing more shoot dry weight / plant over those produced in puddled soil with varying period of standing water. All crops except linseed when raised on puddled soil with 12 h of

Table 4.25 Effect of seed treatment and water regime & tillage at the time of sowing of different crops on shoot dry weight / plant (mg), 32 days after sowing (Net House Experiment No.2, 1984-85)

Soil/Water regime (W)	Seed treatment (S)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathy-rus (Nirmal)	Lathy-rus (local)	Mean
Unpuddled (tilled)	Treated	28.5	158.1	51.3	126.5	130.2	98.9
	Untreated	25.7	102.7	47.3	101.9	116.2	78.8
	Mean	27.1	130.4	49.3	114.2	123.2	88.9
Puddled (0 cm)	Treated	24.1	108.0	41.4	108.7	102.3	76.9
	Untreated	22.5	96.2	38.5	100.1	94.6	70.4
	Mean	23.3	102.1	39.9	104.4	98.5	73.7
Puddled (5 cm/12 h)	Treated	29.9	135.9	43.6	117.3	118.5	89.0
	Untreated	20.0	106.7	42.2	106.9	111.8	77.2
	Mean	25.0	121.3	42.9	112.1	115.2	83.1
Puddled (5 cm/24 h)	Treated	25.6	119.5	40.7	109.1	117.1	82.4
	Untreated	21.6	114.0	39.5	104.5	107.3	77.4
	Mean	23.6	117.0	40.1	106.8	112.2	79.9
Puddled (5 cm/36 h)	Treated	25.7	111.4	38.5	109.4	112.1	79.4
	Untreated	22.1	103.5	33.2	98.2	102.3	71.9
	Mean	23.9	107.5	35.9	103.8	107.2	75.7
Seed treatment	Treated	26.8	126.6	43.1	114.2	116.0	85.3
	Untreated	22.4	104.7	40.1	102.3	106.4	75.2
Mean	Crops	24.6	115.7	41.6	108.2	111.2	
	C	W	S	CxW	CxS	WxS	CxWxS
S.Em ±	0.32	0.44	0.46	0.98	1.04	1.04	2.33
C.D. at 5%	1.04	1.24	1.34	2.77	3.02	3.02	6.77

standing water produced significantly higher shoot dry weight / plant than when plants were raised on puddled soil without standing water. Shoot dry weight progressively declined when the plants were raised on puddled soil with more than 12 h of standing water. Plants raised from treated seeds produced significantly higher shoot dry weight than those raised from untreated seeds. Interaction between crops and seed treatments was significant; except in lentil in all crops significantly higher shoot dry weight / plant were observed in plants raised from treated seeds.

4.2.13 Root dry weight / plant at 32 days after sowing

Root dry weight / plant (39.3 mg) in peas was (Table 4.26) significantly more than those recorded in all other crops. Lathyrus (local) showed significantly higher root dry weight than that of Lathyrus (Nirmal). As like previous observations made here also linseed showed the lowest root dry weight / plant (2.8 mg) which was significantly lower than all other crops. Plants established on conventionally tilled soil showed significantly higher root dry weight / plant (26.4 mg) than those raised on puddled soil having different water regime & tillage. Puddled soil without standing water recorded the lowest root dry weight / plant (22.8 mg) which was significantly lower than all other water regime & tillage treatments. Significantly higher root dry weight was observed in plants established on puddled soil with 24 h of standing water than those recorded in plants established on puddled soil with 12 h of submergence. Increase in stagnation of water upto 36 h showed

Table 4.26 Effect of seed treatment and water regime & tillage at the time of sowing of different crops on root dry weight / plant (mg), 32 days after sowing (Net House Experiment No.2, 1984-85)

Soil/Water regime (W)	Seed treatment (S)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathy-rus (Nirmal)	Lathy-rus (local)	Mean
Unpuddled (tilled)	Treated	3.3	46.5	19.5	34.9	37.8	28.4
	Untreated	3.1	41.7	15.9	28.9	32.6	24.4
	Mean	3.2	44.1	17.7	31.9	35.2	26.4
Puddled (0 cm)	Treated	2.4	36.8	17.0	32.8	34.0	24.6
	Untreated	2.2	31.3	15.7	28.0	28.0	21.0
	Mean	2.3	34.1	16.3	30.4	31.0	22.8
Puddled (5 cm/12 h)	Treated	3.0	40.0	18.5	33.0	34.3	25.8
	Untreated	2.7	34.9	16.1	29.2	28.5	22.3
	Mean	2.9	37.5	17.3	31.1	31.4	24.1
Puddled (5 cm/24 h)	Treated	3.7	44.0	18.3	33.8	34.2	26.8
	Untreated	2.3	39.6	16.7	28.2	31.8	23.7
	Mean	3.0	41.8	17.5	31.0	33.0	25.3
Puddled (5 cm/36 h)	Treated	2.8	42.6	18.5	31.9	32.3	25.6
	Untreated	2.2	35.2	14.5	27.2	27.5	21.3
	Mean	2.5	38.9	16.5	29.6	29.9	23.5
Seed treatment (S)	Treated	3.0	42.0	18.4	33.3	34.5	26.2
	Untreated	2.5	36.5	15.8	28.3	29.7	22.6
Mean	Crops	2.8	39.3	17.1	30.8	32.1	

	C	W	S	CxW	CxS	WxS	CxWxS
S.Em ±	0.25	0.22	0.19	0.50	0.42	0.42	0.94
C.D. at 5%	0.82	0.62	0.55	1.41	1.22	N.S.	N.S.

singnificantly lower root dry weight than that of 12 h standing water. Interaction between crops and water regime & tillage treatments was significant. Peas and Lathyrus (local) showed significantly higher root dry weight in conventionally tilled soil than those observed in other water regime & tillage treatments. In other crops also high root dry weights were observed in plants sown in conventionally tilled soil. Puddled soil with no standing water showed lower root dry weight in all crops than when raised on with 12 and 24 h of standing water in all crops. Root dry weight increased in all crops except Lathyrus (Nirmal) when stagnation of water increased from 12 to 24 h. Plants raised from treated seeds showed significantly higher root dry weight than the plants, raised from untreated seeds. The interaction between seed treatments and crops was significant. Linseed showed the benefit of seed treatment less than other crops. In all crops except linseed, significantly higher root dry weight / plant were observed due to seed treatment.

4.3 Net House Experiment No.3

To analyse some treatment differences specially on stand establishment and shoot growth (length) in the field condition on puddled soil, this Net House Experiment was carried out in 1987.

4.3.1 Stand establishment

Lathyrus (local) showed (Table 4.27) higher stand establishment (out of 10 seeds 8.7 seeds could establish) closely

Table 4.27 Effect of water regime & tillage and shade at the time of sowing of different crops on stand establishment, 8 days after sowing (Net House Experiment No.3, 1987)

Soil/Water regime (W)	Shade treatment (S)	Winter crops (C)					
		Linseed	Peas	Lentil	Lathyrus (Nirmal)	Lathyrus (local)	Mean
Unpuddled (tilled)	Shade	8.8	10.0	8.3	8.5	10.0	9.1
	Without shade	7.8	9.5	9.0	8.3	9.0	8.7
	Mean	8.3	9.8	8.7	8.4	9.5	8.9
Puddled (0 cm)	Shade	9.5	9.0	4.8	8.0	7.5	7.8
	Without shade	7.8	3.3	4.5	7.3	8.8	6.3
	Mean	8.7	6.2	4.7	7.7	8.2	7.1
Puddled (5 cm/24 h)	Shade	5.8	8.3	6.3	9.0	9.3	7.7
	Without shade	9.0	6.3	5.0	7.8	8.3	7.3
	Mean	7.4	7.3	5.7	8.4	8.8	7.5
Puddled (5 cm/72 h)	Shade	6.8	8.3	5.5	8.3	8.8	7.5
	Without shade	5.3	6.5	5.0	7.5	7.3	6.3
	Mean	6.1	7.4	5.3	7.9	8.1	6.9
Shade treatment (S)	Shade	7.7	8.9	6.2	8.5	8.9	8.0
	Without shade	7.5	6.4	5.9	7.7	8.4	7.2
Mean	Crops	7.6	7.7	6.1	8.1	8.7	

	C	W	S	CxW	CxS	WxS	CxWxS
S.Em ±	0.20	0.19	0.11	0.42	0.25	0.23	0.51
C.D. at 5%	0.62	0.55	0.31	1.21	0.71	0.65	N.S.

followed by *Lathyrus* (Nirmal); this was significantly higher than those established in rest of the crops. However, amongst linseed, peas and *Lathyrus* (Nirmal) no significant difference was observed. Lentil showed the lowest stand establishment which was significantly lower than those recorded in all other crops. Satisfactory results in stand establishment was observed when the seeds were sown in conventionally tilled soil; 8.9 plants were established out of 10 seeds sown. This was significantly higher than those established on puddled soil with and without standing water. Stand establishment from sown seeds on puddled soil without or with 24 h of standing water did not differ significantly. The lowest stand establishment was recorded in puddled soil with 72 h standing water; however, the difference in stand establishment between this treatment and in the treatment where the seeds were sown on puddled soil with no standing water was not significant. Interaction between crops and water regimes & tillage treatments was significant. In peas and lentil adverse effect in stand establishment was recorded when seeds were sown on puddled soil without or with standing water for long duration. Linseeds showed lowest stand establishment when seeds were sown on puddled soil with 72 h of standing water and this was significantly lower than those recorded in other water regime & tillage treatments. In *Lathyrus* (Nirmal) stand establishment was equally good in conventionally tilled and puddled soil with or without standing water. *Lathyrus* (local) showed also good stand establishment in all water regime & tillage treatments. Plants established from seeds sown in shade were significantly higher in number than those established from seeds sown without shade. Interaction between crops and shade treatment was significant and all crops received the benefit of shade but significant differences were observed only in peas and Lathyrus (Nirmal).

4.3.2 Shoot length at 8 days after sowing

In all crops, shade produced longer shoots under all water regime & tillage treatments (Table 4.28).

The longest shoot (7.5 cm) was observed in Lathyrus (local) closely followed by Nirmal variety of Lathyrus (7.3 cm). The heights of plants of both the varieties of Lathyrus were significantly more than those recorded in rest of all crops. Again no significant difference in shoot length was observed between lentil and peas. Linseed showed the lowest shoot length which was significantly lower than all other crops. Crops raised on puddled soil with no standing water showed the longest shoot than those recorded in rest of all other water regime & tillage treatments; in this treatment plants were significantly longer than others. The lowest shoot length was recorded in crops raised on puddled soil with 72 h of standing water and this was significantly lower than all other water regime & tillage treatments. Interaction between crops and water regime & tillage treatments was significant indicating the lowest shoot length in all crops except linseed when plants were established on puddled soil with 72 h of submergence. In linseed and peas, crops raised on puddled

Table 4.28 Effect of water regime & tillage and shade at the time of sowing of different crops on shoot length (cm), 8 days after sowing (Net House Experiment No.3, 1987)

Soil/Water regime (W)	Shade treatment (S)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathy-rus (Nirmal)	Lathy-rus (local)	Mean
Unpuddled (tilled)	Shade	5.7	7.7	6.3	10.1	11.9	8.3
	Without shade	2.5	3.7	3.7	6.2	5.6	4.3
	Mean	4.1	5.7	5.0	8.2	8.8	6.3
Puddled (0 cm)	Shade	9.1	12.9	11.9	11.2	9.1	10.8
	Without shade	2.2	3.2	3.7	5.5	5.1	3.9
	Mean	5.7	8.1	7.8	8.4	7.1	7.4
Puddled (5 cm/24 h)	Shade	5.5	7.2	9.2	10.4	13.0	9.1
	Without shade	2.7	4.8	4.3	5.3	6.6	4.7
	Mean	4.1	6.0	6.8	7.9	9.8	6.9
Puddled (5 cm/72 h)	Shade	7.1	5.5	4.7	7.3	6.6	6.2
	Without shade	1.7	2.2	1.9	2.3	2.0	2.0
	Mean	4.4	3.9	3.3	4.8	4.3	4.1
Shade treatment (S)	Shade	6.9	8.3	8.0	9.8	10.2	8.6
	without shade	2.3	3.5	3.4	4.8	4.8	3.8
Mean	Crops	4.6	5.9	5.7	7.3	7.5	

	C	W	S	CxW	CxS	WxS	CxWxS
S.Em ±	0.18	0.15	0.09	0.35	0.20	0.18	0.41
C.D. at 5%	0.55	0.43	0.25	1.01	N.S.	0.51	N.S.

soil with no standing water at the time of sowing seeds, showed significantly longer shoots than those recorded in all other water regime & tillage treatments. Lentil and *Lathyrus* (Nirmal) showed also longer shoot in puddled soil with no standing water; the difference was significant when compared with conventional tillage and puddled with 72 h of submergence. Only in *Lathyrus* (local) the longest shoot length was recorded in plants raised on puddled soil with 24 h of standing water and this was significantly longer than the shoot lengths recorded in other water regime & tillage treatments except conventional tillage. Plants established from seeds sown under shade showed significantly longer shoots than those recorded in plants raised from seeds sown without shade.

4.4 Field Experiment No.1

Performance of winter crops established after conventional tillage following an early variety of rice and as paira crop following sole crop of a late variety and an intercrop of early + late variety of rice.

4.4.1 Productivity of rice

The experiment was carried out with the objective of assessing the productivity of winter crops following rice crop when established and managed differently.

The productivity of early (100 to 105 days) maturing rice variety 'MW 10' ranged from 3910 kg / ha in 1985-86 to 4078 kg / ha in 1986-87 (Table 4.29). On the other hand the productivity of late (143 to 150 days) maturing rice variety 'Swarna' ranged from 5546 kg / ha in 1986-87 to 6031 kg / ha in 1985-86 (Table 4.29). Where the early 'MW 10' and late 'Swarna' varieties were grown in alternate paired rows the yields were lower than 'Swarna' alone but higher than 'MW 10' and it ranged from 4803 kg / ha in 1985-86 to 5046 kg / ha in 1984-85 (Table 4.29). The difference in duration between the harvest of the early and late maturing varieties were 43 to 45 days, in different years. The land equivalent ratio of the inter-cropping of two varieties ranged from 0.97 to 1.05.

4.4.2 Productivity of winter crops

4.4.2.1 Stand establishment

The plant population / m^2 at 45 DAS and at harvest

Table 4.29 Yield of rice (in kg / ha) crop preceding the winter crops (Field Experiment No.1)

Year/crops grown	Yield of rice in kg/ha Swarna	MW 10	Total	S.Em ±	C.D. at 5 %	C.V. %
1984-85						
Sole crop of Swarna (S)	5654		5654 ±1339			
Sole crop of MW 10 (M)		4040	4040 ±1399			
Alternate paired rows (S+M)	2833	2213	5046 ± 778			
1985-86						
Sole crop of Swarna (S)	6031		6031	96.5	378.8	7.6
Sole crop of MW 10 (M)		3910	3910			
Alternate paired rows (S+M)	2883	1920	4803			
1986-87						
Sole crop of Swarna (S)	5546		5546	69.9	274.4	5.6
Sole crop of MW 10 (M)		4078	4078			
Alternate paired rows (S+M)	2844	2064	4908			

were recorded in three consecutive years of experimentation, the mean plant population / m^2 along with their statistical analysis have been presented in Tables 4.30a, 4.30b and 4.30c in 1984-85, 1985-86 and 1986-87, respectively.

In 1984-85, crops raised on conventionally tilled soil following the harvest of 'MW 10' as sole crop showed significantly higher plant population / m^2 (68) than those recorded under paira cropping at 45 DAS. However, no significant difference was observed between two treatments established by paira method (Plate 1). At harvest also similar trend of variation in results, was recorded. Higher plant population / m^2 under conventional tillage might be due to the placement of seeds to a favourable depth of soil for germination. Amongst winter crops, might be due to the differences in their seed sizes, significant differences in plant population between different crops were observed at 45 DAS and at harvest. The highest plant population / m^2 at 45 DAS was recorded in linseed (131) and the lowest in peas (31). No significant difference in plant population was observed between the two *Lathyrus* varieties. Similar was the trend of variation in results at harvest.

In 1985-86, no significant difference in plant population was found under different methods (Plate 2) of crop establishment at 45 DAS and at harvest. Amongst different winter crops, similar trend of variation in plant population was observed, as in 1984-85, both at 45 DAS and at harvest.

Table 4.30a Plant population / m^2 of winter crops under different methods of crop establishment and management at 45 DAS and at harvest, Field Experiment No.1 (1984-85)

Particulars of winter crops (C)	Previous crops (R)						Mean	
	Sole MW 10 (M) (Conventional tillage)		Sole Swarna (S) (Paira cropping)		Intercrop (S+M)			
	45 DAS	At harvest	45 DAS	At harvest	45 DAS	At harvest	45 DAS	At harvest
Linseed	136	133	130	128	126	125	131	129
Peas	33	32	29	28	30	29	31	30
Lentil	89	87	80	78	79	78	83	81
Lathyrus-N	41	39	36	34	37	36	38	36
Lathyrus-L	40	39	35	34	36	35	37	36
Mean	68	66	62	60	62	61		

		R	C	RxC
At 45 DAS	S.Em ±	1.0	0.8	1.5
	C.D. at 5%	3.9	2.3	N.S.
At harvest	S.Em ±	0.6	0.7	1.2
	C.D. at 5%	2.4	2.0	N.S.

Table 4.30b Plant population / m^2 of winter crops under different methods of crop establishment and management at 45 DAS and at harvest, Field Experiment No.1 (1985-86)

Particulars of winter crops (C)	Previous crops (R): Sole MW 10 (M) (Conventional tillage)		Sole Swarna (S) (Paira cropping)		Intercrop (S+M) (Paira cropping)		Mean	
	45 DAS	At harvest	45 DAS	At harvest	45 DAS	At harvest	45 DAS	At harvest
Linseed	138	137	135	130	127	126	133	131
Peas	34	33	31	29	29	28	31	30
Lentil	84	81	77	74	80	78	80	78
Lathyrus-N	37	36	33	33	35	33	35	34
Lathyrus-L	36	36	35	34	34	33	35	34
Mean	66	65	62	60	61	60		

		R	C	RxC
At 45 DAS	S.Em ±	2.1	1.5	2.6
	C.D. at 5%	N.S.	4.4	N.S.
At harvest	S.Em ±	1.4	1.2	2.1
	C.D. at 5%	N.S.	3.5	N.S.

Table 4.30c Plant population / m^2 of winter crops under different methods of crop establishment and management at 45 DAS and at harvest, Field Experiment No.1 (1986-87)

Particulars of winter crops (C)	Previous crops (R): Sole MW 10 (M) (Conventional tillage)		Sole Swarna (S) (Paira cropping)		Intercrop (S+M) (Paira cropping)		Mean	
	45 DAS	At harvest	45 DAS	At harvest	45 DAS	At harvest	45 DAS	At harvest
Linseed	151	147	142	138	147	141	147	142
Peas	35	33	28	27	29	28	31	29
Lentil	102	98	78	76	76	72	85	82
Lathyrus-N	42	40	37	37	39	38	39	38
Lathyrus-L	39	38	39	38	37	35	38	37
Mean	74	71	65	63	66	63		

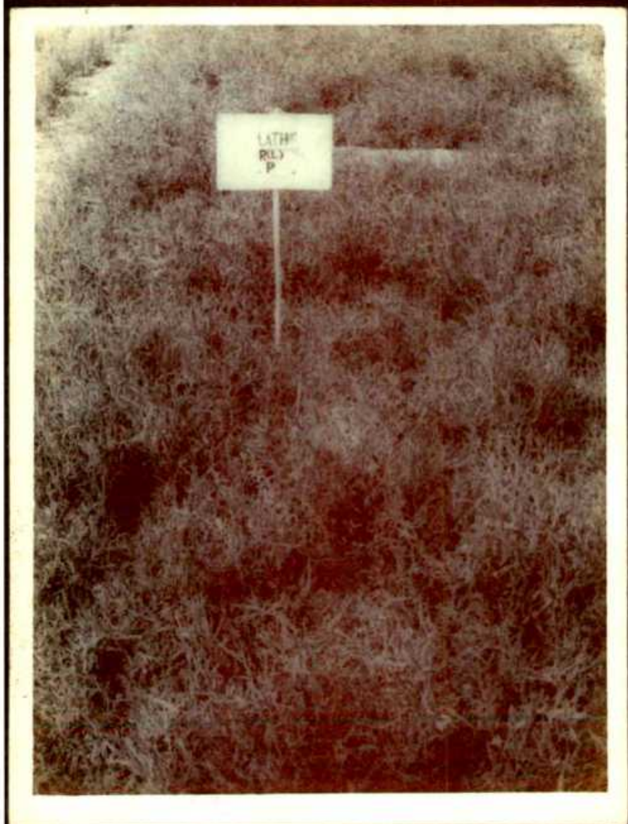
		R	C	RxC
At 45 DAS	S.Em $\pm$	0.8	1.1	2.0
	C.D. at 5%	3.1	3.2	5.8
At harvest	S.Em $\pm$	1.2	1.3	2.2
	C.D. at 5%	4.7	3.8	6.4

Plate 1. Photographs of lentil, 60
in vegetative stage in 198

A. Crop established under <u>pai</u>
relayed with 'Swarna' rice

B. Crop established under <u>pai</u>
relayed with 'Swarna'+MW10
alternate paired rows.

A



B

Plate 2. Photographs of Lathyrus (Nirmal) 65 days after sowing in vegetative stage in 1985-86

A. Crop established under conventional tillage.

B. Crop established under paira cropping relayed with 'Swarna' rice.

In 1986-87, the number of plants / m^2 were mo[r]
crop was established after conventional tillage than t[h]
established under *paira* cropping; the difference betwe[en]
two treatments (following sole and intercropping of ri[ce]
paira cropping was, however, not significant both at 4[5]
at harvest. The small seeded crops (linseed and lentil
significantly higher number of plants / m^2 than in othe
Linseed, peas and lentil showed better crop establishme
conventional tillage than when established as a *paira* c
Whereas *Lathyrus* did not show very wide differences bet
conventional and *paira* methods of crop establishment.

4.4.2.2 Shoot dry matter accumulation / m^2

Shoot dry matter accumulation / m^2 recorded at
in three consecutive years of experimentation have been
sented in Tables 4.31a, 4.31b and 4.31c in 1984-85, 198[5]
and 1986-87, respectively.

In 1984-85, the higher shoot dry matter accumu[lation /]
m^2 (655 g) was recorded in plants established under con[ventio]
nal method of cultivation, following the harvest of 'MW
rice than those recorded in other methods of stand esta[blish]
ment of *paira* croppings. The lowest shoot dry matter ac[cumu]
lation / m^2 (536 g) was recorded in crops raised in *pai[ra]*
of crop establishment followed in sole 'Swarna' rice as
to other methods of crop establishment. At 90 DAS, the
dry matter accumulation / m^2 ranged from 726 g in *Lathyr[us]*
(Nirmal) to 414 g in linseed (Plate 3). No significant

Plate 3. Photographs of linseed crop at flowering stage in 1984-85.

A. Crop established under conventional tillage.

B. Crop established with minimum tillage under <u>paira</u> cropping with late 'Swarna' variety of rice.

C. Crop established under <u>paira</u> cropping relayed with 'MW 10'+ 'Swarna' rice in alternate paired rows.

Table 4.31a Shoot dry matter accumulation (g / m^2) of winter crops under different methods of crop establishment and management at 90 DAS, Field Experiment No.1 (1984-85)

Particulars of winter crops (C)	Previous crops (R): Sole MW 10 (M) (Conventional tillage)	Sole Swarna (S) (Paira cropping)	Intercrop (S+M) (Paira cropping)	Mean
Linseed	487	341	414	414
Peas	696	578	633	636
Lentil	598	476	558	544
Lathyrus-N	777	688	714	726
Lathyrus-L	717	596	653	655
Mean	655	536	594	
		R	C	RxC
	S.Em ±	14.6	18.6	32.1
	C.D. at 5%	57.3	54.3	N.S.

Table 4.31b Shoot dry matter accumulation (g / m^2) of winter crops under different methods of crop establishment and managent at 90 DAS, Field Experiment No.1 (1985-86)

Particulars of winter crops (C)	Previous crops (R): Sole MW 10 (M) (Conventional tillage)	Sole Swarna (S) (Paira cropping)	Intercrop (S+M) (Paira cropping)	Mean
Linseed	469	306	409	395
Peas	756	717	728	734
Lentil	516	409	476	467
Lathyrus-N	737	653	714	701
Lathyrus-L	660	587	642	630
Mean	628	534	594	
		R	C	RxC
	S.Em ±	15.5	23.3	40.4
	C.D. at 5%	60.9	68.0	N.S.

Table 4.31c Shoot dry matter accumulation (g / m^2) of winter crops under different methods of crop establishment and management at 90 DAS, Field Experiment No.1 (1986-87)

Particulars of winter crops (C)	Previous crops (R)			Mean
	Sole MW 10 (M) (Conventional tillage)	Sole Swarna (S) (Paira cropping)	Intercrop (S+M) (Paira cropping)	
Linseed	401	344	375	373
Peas	626	519	582	576
Lentil	582	455	467	501
Lathyrus-N	708	588	694	663
Lathyrus-L	625	572	600	599
Mean	588	496	544	
		R	C	RxC
	S.Em ±	17.9	19.1	33.2
	C.D. at 5%	N.S.	55.8	N.S.

difference in shoot dry matter accumulation / m^2 was recorded between peas (Plate 4) and *Lathyrus* (local).

In 1985-86, plants raised under conventional method of crop establishment, showed higher shoot dry matter accumulation / m^2 (628 g) than those recorded by *paira* method of crop establishment. Crops established by *paira* method in sole 'Swarna' rice plots showed significantly lesser dry matter accumulation than those recorded in crops established conventionally. Again no significant difference in shoot dry matter accumulation / m^2 was observed between two treatments under *paira* method of crop establishment. Significantly higher shoot dry matter accumulation / m^2 (734 g) was recorded in peas than those recorded in other crops except *Lathyrus* (Nirmal) and the lowest dry matter accumulation / m^2 (395 g) was recorded in linseed which was significantly lower than those recorded in other crops. Interaction between the methods of crop establishment and the winter crops was not found significant.

In 1986-87, the effect of previous cropping on growth of winter crop was not significant. Amongst winter crops, highest shoot dry matter accumulation / m^2 (663 g) was recorded in *Lathyrus* (Nirmal) and it was significantly superior to *Lathyrus* (local). The lowest shoot dry matter accumulation / m^2 (373 g) was recorded in linseed, which was significantly lower than those recorded in other crops. No significant differences in shoot dry matter accumulation / m^2 was recorded between peas

A

B

Plate 4. Photographs of peas crop at pod forming stage in 1984-85.

A. Crop established with conventional tillage.

B. Crop established under <u>paira</u> cropping relayed with 'Swarna' rice crop.

and *Lathyrus* (local). The interaction between the effects of previous cropping with the growth of winter crops was not significant.

4.4.2.3 Root dry weight / core sample (i.e. in 578 c.c. of soil core)

Root dry weights per core sample were determined at four soil depths at intervals of 15 cm, at 60 and 105 DAS in 1984-85 and 1985-86.

In 1984-85, at 0 - 15 cm soil depth the highest root dry weight (158.1 and 187.9 mg / 578 c.c. of soil core on 60 and 105 DAS, respectively) was recorded in crops established after conventional tillage. The lowest root dry weight (144.1 and 173.3 mg / 578 c.c. of soil core on 60 and 105 DAS, respectively) was recorded under *paira* method of crop establishment following sole crop of 'Swarna' rice. Peas recorded the highest root dry weight (159.7 mg / 578 c.c. of soil core) closely followed by *Lathyrus* varieties and the lowest (135.8 mg / 578 c.c. of soil core) was recorded in linseed at 60 DAS. At 105 DAS also, peas showed the highest root dry weight (195 mg / 578 c.c. of soil core) closely followed by *Lathyrus* (Nirmal) and the lowest (160.2 mg / 578 c.c. of soil core) was recorded in linseed also. Interaction between crops and methods of crop establishment was found significant at 60 DAS. In all crops higher root dry weights were recorded under conventional tillage than those recorded in *paira* cropping and the differences were significant in all crops.

Again, all crops raised in the treatment under paira cropping following intercrop of rice ('Swarna' +'MW 10') showed higher root dry weight than those recorded in treatment under paira cropping following sole crop of 'Swarna' rice but the differences were not significant (Table 4.32a) in linseed and Lathyrus (Nirmal).

In 1985-86, at 0 - 15 cm soil depth under conventional method of crop establishment crops showed significantly higher root dry weight (176 mg / 578 c.c. of soil core) than those established under paira cropping and the lowest (148.5 mg / 578 c.c. of soil core) was recorded under paira cropping following sole crop of 'Swarna' rice at 60 DAS. At 105 DAS, plants raised under conventional method of crop establishment showed the highest root dry weight (198.9 mg / 578 c.c. of soil core). The difference in root dry weight between the winter crops established by paira method following sole and mixed culture of rice, was not significant. Peas recorded the highest root dry weight (187.7 mg / 578 c.c. of soil core) and the lowest was recorded in lentil (140.9 mg / 578 c.c. of soil core). No significant difference was observed between linseed and lentil and also between Lathyrus varieties at 60 DAS. At 105 DAS, peas also recorded the highest root dry weight (208.9 mg / 578 c.c. of soil core) which was significantly more than those recorded in other crops. The lowest root dry weight was recorded in lentil (163.0 mg / 578 c.c. of soil core) which was significantly lower than those recorded in all other crops (Table 4.32b).

Table 4.32a Root dry weight per core sample (578 c.c. of soil) in winter crops under different methods of crop establishment and management at 0 - 15 cm depth on 60 and 105 DAS in mg, Field Experiment No.1 (1984-85)

Particulars of winter crops (C)	Previous crops (R)						Mean	
	Sole MW 10 (M)		Sole Swarna (S)		Intercrop (S+M)			
	(Conventional tillage)		(Paira cropping)					
	60 DAS	105 DAS	60 DAS	105 DAS	60 DAS	105 DAS	60 DAS	105 DAS
Linseed	140.7	169.2	131.8	151.5	134.9	159.8	135.8	160.2
Peas	167.4	202.0	151.3	188.8	160.4	194.3	159.7	195.0
Lentil	148.9	178.4	136.1	160.8	142.2	171.7	142.4	170.3
Lathyrus-N	169.2	198.3	152.1	186.2	156.4	193.8	159.2	192.8
Lathyrus-L	164.5	191.4	149.4	179.1	156.8	184.6	156.9	185.0
Mean	158.1	187.9	144.1	173.3	150.1	180.8		

		R	C	RxC
At 60 DAS	S.Em ±	0.81	1.16	2.01
	C.D. at 5%	3.18	3.39	5.87
At 105 DAS	S.Em ±	1.41	1.71	2.96
	C.D. at 5%	5.54	4.99	N.S.

Table 4.32b Root dry weight per core sample (578 c.c. of soil) in winter crops under different methods of crop establishment and management at 0 - 15 cm depth on 60 and 105 DAS in mg, Field Experiment No.1 (1985-86)

Particulars of winter crops (C)	Previous crops (R)						Mean	
	Sole MW 10 (M) (Conventional tillage)		Sole Swarna (S) (Paira cropping)		Intercrop (S+M) (Paira cropping)			
	60 DAS	105 DAS	60 DAS	105 DAS	60 DAS	105 DAS	60 DAS	105 DAS
Linseed	167.5	186.6	114.9	162.2	104.3	163.2	140.9	170.7
Peas	198.1	232.0	174.2	194.8	190.7	199.9	187.7	208.9
Lentil	150.3	177.2	132.0	150.1	138.8	161.6	140.4	163.0
Lathyrus-N	180.7	188.2	155.7	167.1	174.4	194.5	170.3	183.3
Lathyrus-L	183.6	210.6	165.8	190.4	158.9	173.2	169.4	191.4
Mean	176.0	198.9	148.5	172.9	160.6	178.5		

		R	C	RxC
At 60 DAS	S.Em ±	1.85	3.89	6.73
	C.D. at 5%	7.26	11.35	N.S.
At 105 DAS	S.Em ±	3.05	2.03	3.52
	C.D. at 5%	11.97	5.93	N.S.

In 1984-85, at 15 - 30 cm soil depth, crops established under conventional method of crop establishment, at 60 DAS, showed significantly higher root dry weight (41.8 mg / 578 c.c. of soil core) than those recorded in treatment under paira cropping following sole crop of 'Swarna' rice. No significant difference was observed at 60 DAS between two treatments under paira method of crop establishment. At 105 DAS, conventional method of crop establishment showed significantly the higher root dry weight (53.5 mg / 578 c.c. of soil core) than those recorded under paira method of crop establishment and the difference between the two treatments (established under paira cropping) was also significant. Amongst crops, peas recorded the highest root dry weight (48.8 mg / 578 c.c. of soil core) and it was significantly higher than rest of the crops. The lowest root dry weight (30 mg / 578 c.c. of soil core) was recorded in linseed which was significantly lower than all other crops at 60 DAS. At 105 DAS, similar was the trend of variation except that the difference in root dry weight between two varieties of *Lathyrus*, was not significant. Interaction (Table 4.33a) between methods of crop establishment and crops, was also significant at 105 DAS. This indicated thereby that the root dry weights of all crops, were higher under conventional method of crop establishment than those observed under paira method of crop establishment; the differences were, however, not significant in linseed lentil and *Lathyrus* (Nirmal). Again, higher root dry weights were observed in all crops established under paira cropping following intercrop of two

Table 4.33a Root dry weight per core sample (578 c.c. of soil) in winter crops under different methods of crop establishment and management at 15 - 30 cm depth on 60 and 105 DAS in mg - Field Experiment No.1 (1984-85)

Particulars of winter crops (C)	Previous crops (R)						Mean	
	Sole MW 10 (M)		Sole Swarna (S)		Intercrop (S+M)			
	(Conventional tillage)		(Paira cropping)					
	60 DAS	105 DAS	60 DAS	105 DAS	60 DAS	105 DAS	60 DAS	105 DAS
Linseed	31.4	37.6	28.7	34.4	30.0	35.1	30.0	35.7
Peas	52.2	67.7	44.3	58.2	49.9	62.7	48.8	62.9
Lentil	35.9	45.1	31.0	40.6	31.3	42.6	32.7	42.8
Lathyrus-N	42.1	56.9	37.6	47.8	40.5	53.5	40.1	52.7
Lathyrus-L	47.5	60.1	41.4	47.2	44.1	48.3	44.3	51.9
Mean	41.8	53.5	36.6	45.6	39.2	48.4		

		R	C	RxC
At 60 DAS	S.Em ±	0.83	0.88	1.52
	C.D. at 5%	3.26	2.57	N.S.
At 105 DAS	S.Em ±	0.64	0.86	1.48
	C.D. at 5%	2.51	2.51	4.32

rice varieties (Swarna + MW 10) than those under paira cropping following sole crop of 'Swarna' rice; the differences were, however, significant only in case of peas and Lathyrus (Nirmal).

In 1985-86, at 15 - 30 cm soil depth, the highest root dry weight (42.9 mg / 578 c.c. of soil core) was recorded in crops established under conventional method of crop establishment. No significant difference in root dry weight was observed between the two treatments established under paira method of crop establishment at 60 DAS. At 105 DAS, crops raised under conventional method showed significantly higher root dry weight (53.5 mg / 578 c.c. of soil core) than the crops raised under paira method of crop establishment (46.9 mg / 578 c.c. of soil core). No significant difference was observed between two treatments established under paira cropping. Amongst crops, peas showed significantly the highest root dry weight (51 mg / 578 c.c. of soil core) and the lowest 31.4 mg / 578 c.c. of soil core) was recorded in lentil but the difference between lentil and linseed, at 60 DAS was not significant. At 105 DAS, similar was the trend of variation between the crops (Table 4.33b).

In 1984-85, at 30 - 45 cm soil depth, crops established under conventional method of crop establishment recorded the highest root dry weight (22.2 and 32.1 mg / 578 c.c. of soil core at 60 and 105 DAS, respectively)and the lowest (18.5 and 28 mg / 578 c.c. of soil core at 60 and 105 DAS, respectively) was recorded in crops established through paira cropping

Table 4.33b Root dry weight per core sample (578 c.c. of soil) in winter crops under different methods of crop establishment and management at 15 - 30 cm depth on 60 and 105 DAS in mg - Field Experiment No.1 (1985-86)

Particulars of winter crops (C)	Previous crops (R): Sole MW 10 (M) (Conventional tillage)		Sole Swarna (S) (Paira cropping)		Intercrop (S+M) (Paira cropping)		Mean	
	60 DAS	105 DAS	60 DAS	105 DAS	60 DAS	105 DAS	60 DAS	105 DAS
Linseed	41.1	45.1	28.2	33.2	32.0	43.5	33.8	40.6
Peas	50.3	65.9	52.5	62.0	50.2	62.7	51.0	63.5
Lentil	33.5	41.9	31.3	37.9	29.3	39.8	31.4	39.9
Lathyrus-N	46.3	58.6	43.4	54.4	44.7	57.0	44.8	56.7
Lathyrus-L	43.2	54.7	35.5	46.8	36.2	48.1	38.2	49.9
Mean	42.9	53.2	38.2	46.9	38.5	50.2		

		R	C	RxC
At 60 DAS	S.Em ±	0.90	1.22	2.11
	C.D. at 5%	3.53	3.56	N.S.
At 105 DAS	S.Em ±	0.89	1.44	2.49
	C.D. at 5%	3.49	4.20	N.S.

after the sole crop of the late variety of rice 'Swarna'. The differences in root dry weights observed between two treatments of *paira* cropping, were significant both at 60 and 105 DAS. At 60 DAS, peas recorded the highest root dry weight (24.2 mg / 578 c.c. of soil core) and the lowest (13.8 mg / 578 c.c. of soil core) was recorded in linseed which was significantly lower than those recorded in all other crops. No significant difference was observed in root dry weights between *Lathyrus* varieties at 60 DAS. At 105 DAS, the highest root dry weight (37.5 mg / 578 c.c. of soil core) was recorded in peas and the lowest (24.9 mg / 578 c.c. of soil core) was recorded in linseed. No significant differences in root dry weights were observed amongst lentil and *Lathyrus* varieties (Table 4.34a).

In 1985-86, at 30 - 45 cm soil depth, conventional method of crop establishment showed the highest root dry weight (27.3 mg / 578 c.c. of soil core) than those recorded in crops established under *paira* cropping at 60 DAS. But this difference was not significant at 105 DAS. At 60 DAS, peas recorded the highest root dry weight (31.9 mg / 578 c.c. of soil core) and the lowest (17 mg / 578 c.c. of soil core) was recorded in lentil which was significantly lower than those recorded in rest of the crops. No significant difference in root dry weights was observed between *Lathyrus* varietiesat 60 DAS. At 105 DAS, the trend of variation was very similar to those recorded at 60 DAS (Table 4.34b).

Table 4.34a Root dry weight per core sample (578 c.c. of soil) in winter crops under different methods of crop establishment and management at 30 - 45 cm depth, on 60 and 105 DAS in mg, Field Experiment No.1, (1984-85)

Particulars of winter crops (C)	Previous crops (R)						Mean	
	Sole MW 10 (M) (Conventional tillage)		Sole Swarna (S) (Paira cropping)		Intercrop (S+M) (Paira cropping)			
	60 DAS	105 DAS	60 DAS	105 DAS	60 DAS	105 DAS	60 DAS	105 DAS
Linseed	15.8	27.1	12.6	23.7	13.0	24.0	13.8	24.9
Peas	26.9	39.5	21.7	35.5	23.9	37.5	24.2	37.5
Lentil	19.3	30.4	17.1	25.9	18.3	28.9	18.2	28.4
Lathyrus-N	24.6	32.0	20.2	27.3	22.1	30.1	22.3	29.8
Lathyrus-L	24.6	31.6	20.8	27.5	23.4	28.1	22.9	29.1
Mean	22.2	32.1	18.5	28.0	20.1	29.7		

		R	C	RxC
At 60 DAS	S.Em ±	0.31	0.40	0.69
	C.D. at 5%	1.22	1.17	N.S.
At 105 DAS	S.Em ±	0.24	0.62	1.07
	C.D. at 5%	0.94	1.81	N.S.

Table 4.34b Root dry weight per core sample (578 c.c. of soil) in winter crops under different methods of crop establishment and management at 30 - 45 cm depth, on 60 and 105 DAS in mg, Field Experiment No.1 (1985-86)

Particulars of winter crops (C)	Previous crops (R): Sole MW 10 (M) (Conventional tillage)		Sole Swarna (S) (Paira cropping)		Intercrop (S+M) (Paira cropping)		Mean	
	60 DAS	105 DAS	60 DAS	105 DAS	60 DAS	105 DAS	60 DAS	105 DAS
Linseed	24.8	30.8	21.9	26.2	22.9	30.2	23.2	29.1
Peas	34.9	39.0	29.4	34.2	31.3	35.3	31.9	36.2
Lentil	18.0	26.0	15.2	23.6	17.7	25.7	17.0	25.1
Lathyrus-N	28.0	35.3	23.4	28.4	25.6	32.4	25.7	32.0
Lathyrus-L	30.7	35.9	24.5	30.5	26.9	33.0	27.4	33.1
Mean	27.3	33.4	22.9	28.6	24.9	31.3		

		R	C	RxC
At 60 DAS	S.Em ±	0.59	0.95	1.64
	C.D. at 5%	2.32	2.77	N.S.
At 105 DAS	S.Em ±	1.32	0.93	1.61
	C.D. at 5%	N.S.	2.71	N.S.

In 1984-85, at 45 - 60 cm soil depth, crops established under conventional method of stand establishment showed higher root dry weights (11 and 19.8 mg / 578 c.c. of soil core at 60 and 105 DAS, respectively) than those established under *paira* croppings. The lowest root dry weights (8.4 and 13.3 mg / 578 c.c. of soil core at 60 and 105 DAS, respectively) were recorded in winter crops established under *paira* cropping following sole crop of 'Swarna' rice; these yields were significantly lower than the crop that followed mixed culture of two varieties of rice. At 60 DAS, peas recorded higher root dry weight (10.9 mg / 578 c.c. of soil core) than those recorded in *Lathyrus* varieties. The lowest root dry weight (7.8 mg / 578 c.c. of soil core) was recorded in linseed. At 105 DAS, the highest root dry weight (20 mg / 578 c.c. of soil core) was recorded in peas and the lowest (12.5 mg / 578 c.c. of soil core) was recorded in linseed which was significantly lower than the root dry weights recorded in all other crops. The difference in root dry weight between *Lathyrus* varieties was statistically at par. Interaction between crops and methods of crop establishment was found significant only at 105 DAS. In all the crops higher root dry weights were observed under conventional method of crop establishment than those under *paira* cropping and the differences were significant except in linseed (Table 4.35a).

In 1985-86, at 45 - 60 cm soil depth, no significant difference in root dry weight was observed under different methods of crop establishment at 60 DAS. Amongst crops,

Table 4.35a Root dry weight per core sample (578 c.c. of soil) in winter crops under different methods of crop establishment and management at 45 - 60 cm depth on 60 and 105 DAS in mg, Field Experiment No. 1 (1984-85)

Particulars of winter crops (C)	Previous crops (R): Sole MW 10 (M) (Conventional tillage)		Sole Swarna (S) (Paira cropping)		Intercrop (S+M) (Paira cropping)		Mean	
	60 DAS	105 DAS	60 DAS	105 DAS	60 DAS	105 DAS	60 DAS	105 DAS
Linseed	8.5	14.2	7.0	10.6	8.0	12.7	7.8	12.5
Peas	13.0	25.4	9.4	16.3	10.2	18.3	10.9	20.0
Lentil	10.4	16.9	7.8	12.1	9.1	13.0	9.1	14.0
Lathyrus-N	11.5	21.8	8.3	14.5	10.5	16.8	10.1	17.7
Lathyrus-L	11.7	20.7	9.6	13.0	10.8	15.5	10.7	16.4
Mean	11.0	19.8	8.4	13.3	9.7	15.3		

		R	C	RxC
At 60 DAS	S.Em ±	0.22	0.32	0.56
	C.D. at 5%	0.86	0.93	N.S.
At 105 DAS	S.Em ±	0.40	0.47	0.82
	C.D. at 5%	1.57	1.37	2.39

peas recorded the highest root dry weight (14 mg / 578 c.c. of soil core) closely followed by Lathyrus varieties. Although lentil recorded the lowest root dry weight (10.1 mg / 578 c.c. of soil core) still it did not differ with that recorded in linseed, at 60 DAS. Again, no significant difference was observed amongst linseed and Lathyrus varieties. At 105 DAS, conventional method of crop establishment showed the highest root dry weight (18.3 mg / 578 c.c. of soil core) which was significantly higher than those recorded in paira cropping (16.6 mg / 578 c.c. of soil core) following intercrop of two rice varieties ('Swarna' +'MW 10'). Again no significant difference was observed in root dry weight between two treatments under paira method of stand establishment. Peas recorded significantly higher root dry weight (23.5 mg / 578 c.c. of soil core) and the lowest (14.2 mg / 578 c.c. of soil core) was recorded in lentil; but no significant difference was observed between lentil and linseed. Again, no significant difference in root dry weight was observed between linseed and Lathyrus varieties (Table 4.35b).

4.4.2.4 Number of nodules / plant

Number of nodules / plant was counted at 60 DAS, from a depth of 0 - 25 cm soil in 1985-86 and 1986-87.

In 1985-86, no significant difference in number of nodules / plant under different methods of crop establishment was observed. Amongst crops, Lathyrus (Nirmal) had significantly higher number of nodules (236 / plant) than peas

Table 4.35b Root dry weight per core sample (578 c.c. of soil) in winter crops under different methods of crop establishment and management at 45 - 60 cm depth, on 60 and 105 DAS in mg, Field Experiment No. 1 (1985-86)

Particulars of winter crops (C)	Previous crops (R): Sole MW 10 (M) (Conventional tillage)		Sole Swarna (S) (Paira cropping)		Intercrop (S+M) (Paira cropping)		Mean	
	60 DAS	105 DAS	60 DAS	105 DAS	60 DAS	105 DAS	60 DAS	105 DAS
Linseed	12.6	15.5	12.0	16.0	10.7	15.2	11.8	15.6
Peas	14.8	22.1	12.9	28.2	14.2	20.2	14.0	23.5
Lentil	11.1	16.3	9.1	10.6	10.2	15.6	10.1	14.2
Lathyrus-N	13.1	19.2	14.6	17.0	11.9	15.8	13.2	17.3
Lathyrus-L	15.5	18.4	12.2	15.2	13.1	16.2	13.6	16.6
Mean	13.4	18.3	12.2	17.4	12.0	16.6		

		R	C	RxC
At 60 DAS	S.Em $\pm$	0.44	0.71	1.23
	C.D. at 5%	N.S.	2.07	N.S.
At 105 DAS	S.Em $\pm$	0.23	0.71	1.23
	C.D. at 5%	0.90	2.07	N.S.

(188 / plant) and lentil (87 / plant). The number of nodules / plant in local variety of Lathyrus was statistically at par with peas and also with Latyyrus (Nirmal). The interaction between crops and methods of crop establishment was significant. Lathyrus (local) under conventional method of crop establishment showed higher number of nodules / plant than those recorded under paira cropping. Again, peas under two treatments established as paira method of crop establishment following the sole crop of 'Swarna' rice and also following the inter-cropped of two rice varieties showed significantly higher number of nodules / plant than the number of nodules / plant recorded under conventional method of crop establishment (Table 4.36a).

In 1986-87, conventional method of winter crop establishment recorded significantly higher number of nodules / plant (145 / plant) than those recorded in other two treatments established as paira crop. Paira method of crop establishment following sole crop of 'Swarna' rice and intercropped ('Swarna' + 'MW 10') rice recorded equal number of nodules / plant. Amongst crops, Lathyrus (Nirmal) recorded significantly higher number of nodules / plant (152 / plant) closely followed by Lathyrus (local) than peas (117 / plant) and lentil (91 / plant). The number of nodules / plant recorded in lentil (117 / plant) and peas (91 / plant) were statistically at par. The interaction between crops and methods of establishment was not significant (Table 4.36b).

Table 4.36a Number of nodules / plant of winter crops under different methods of crop establishment and management at 60 DAS, Field Experiment No.1 (1985-86)

Particulars of winter crops (C)	Previous crops (R)			Mean
	Sole MW 10 (M) (Conventional tillage)	Sole Swarna (S) (Paira cropping)	Intercrop (S+M) (Paira cropping)	
Peas	115	249	202	189
Lentil	105	75	81	87
Lathyrus-N	240	236	231	236
Lathyrus-L	286	186	198	223
Mean	187	187	178	
		R	C	RxC
	S.Em ±	14.1	13.0	22.5
	C.D. at 5%	N.S.	37.9	65.7

Table 4.36b Number of nodules / plant of winter crops under different methods of crop establishment and management at 60 DAS, Field Experiment No.1 (1986-87)

Particulars of winter crops (C)	Previous crops (R)			
	Sole MW 10 (M) (Conventional tillage)	Sole Swarna (S) (Paira cropping)	Intercrop (S+M) (Paira cropping)	
Peas	141	109	101	117
Lentil	100	85	89	91
Lathyrus-N	176	148	132	152
Lathyrus-L	161	132	154	149
Mean	145	119	119	
		R	C	RxC
	S.Em ±	4.7	9.3	16.2
	C.D. at 5%	18.5	27.1	N.S.

4.4.2.5 Yield components

4.4.2.5.1 Number of pods or capsules / m^2

The number of pods or capsules / m^2 were counted in all the three years of experimentation at harvest and have been summarised in Tables 4.37a, 4.37b and 4.37c, as recorded in 1984-85, 1985-86 and 1986-87, respectively.

In 1984-85, under conventional method of crop establishment the number of pods in case of legumes and number of capsules in case of linseed per square metre (i.e. m^2) were more than in two treatments under paira method of crop establishment. No significant difference in number of pods or capsules / m^2 was observed between two treatments under paira cropping. Amongst crops, lentil showed significantly the highest number of pods / m^2 (7954) and the lowest (904) number was recorded in peas which was significantly lower than those recorded in all other crops. No significant difference in number of pods / m^2 was observed between two varieties of *Lathyrus*. The interaction between winter crops and methods of crop establishment was significant. Lentil recorded significantly higher number of pods / m^2 under conventional tillage than those in crops established under paira cropping. Under paira cropping the lentil crop following intercrop of 'Swarna' + 'MW 10' recorded again higher number of pods / m^2 than those recorded in plots that followed sole crop of 'Swarna'. Similar was the trend of difference in linseed but the difference between two treatments under paira

Table 4.37a Number of pods or capsules / m^2, at harvest, of water crops under different methods of crop establishment and management, Field Experiment No.1 (1984-85)

Particulars of winter crops (C)	Previous crops (R): Sole MW 10 (M) (Conventional tillage)	Sole Swarna (S) (Paira cropping)	Intercrop (S+M) (Paira cropping)	Mean
Linseed	4637	4010	4342	4330
Peas	968	816	927	904
Lentil	9086	6741	8035	7954
Lathyrus-N	1896	1546	1628	1690
Lathyrus-L	1774	1495	1693	1654
Mean	3672	2922	3325	
		R	C	RxC
	S.Em ±	107.2	106.7	184.8
	C.D. at 5%	420.8	311.5	539.4

Table 4.37b Number of pods or capsules / m^2, at harvest, of winter crops under different methods of crop establishment and management, Field Experiment No.1 (1985-86)

Particulars of winter crops (C)	Previous crops (R): Sole MW 10 (M) (Conventional tillage)	Sole Swarna (S) (Paira cropping)	Intercrop (S+M) (Paira cropping)	Mean
Linseed	4385	3313	3683	3794
Peas	1098	995	1006	1033
Lentil	7173	5255	6073	6167
Lathyrus-N	1692	1440	1554	1562
Lathyrus-L	1448	1390	1471	1436
Mean	3159	2479	2757	
		R	C	RxC
	S.Em ±	162.9	155.7	269.6
	C.D. at 5%	N.S.	454.5	N.S.

cropping was not significant. In other crops differences between the methods of crop establishment were not statistically significant.

In 1985-86, no significant difference between the methods of crop establishment in respect of number of pods or capsules / m^2 was observed. Amongst crops, lentil showed significantly higher number of pods / m^2 (6167) than those recorded in rest of other crops. The lowest number of pods / m^2 (1033) was recorded in peas, as in the previous year, which was significantly lower than those recorded in rest of the other crops except *Lathyrus* (local). No significant differences was observed in number of pods / m^2 between two varieties of *Lathyrus*. The interaction between crops and methods of crop establishment was not significant.

In 1986-87 also no significant difference in number of pods or capsules / m^2 was observed amongst methods of crop establishment. As in the previous years lentil showed significantly the highest number of pods / m^2 (5974) and the lowest number of pods / m^2 was recorded in peas which was significantly lower than those recorded in rest of the other crops. No significant difference in number of pods / m^2 was observed between *Lathyrus* varieties. The interaction between crops and methods of crop establishment was found to be significant. As was observed in the year 1984-85, the number of pods / m^2 was significantly lower in lentil when it was established under *paira* cropping than when it followed 'MW 10' after conventional tillage; the difference between two treatments established

Table 4.37c Number of pods of capsules / m^2, at harvest, of winter crops under different methods of crop establishment and management, Field Experiment No.1 (1986-87)

Particulars of winter crops (C)	Previous crops (R)			Mean
	Sole MW 10 (M) (Conventional tillage)	Sole Swarna (S) (Paira cropping)	Intercrop (S+M)	
Linseed	3786	3419	3648	3618
Peas	1006	804	943	918
Lentil	6991	5367	5563	5974
Lathyrus-N	1535	1361	1563	1486
Lathyrus-L	1469	1335	1502	1435
Mean	2957	2457	2644	
		R	C	RxC
	S.Em ±	162.4	106.3	184.1
	C.D. at 5%	N.S.	310.3	537.4

under *paira* cropping was however not significant. In other crops these differences were not wide and significant.

4.4.2.5.2 Number of seeds / pod or capsule

The number of seeds / pod or capsule were recorded in all the crops in all the three years of experimentation and have been presented in Tables 4.38a, 4.38b and 4.38c in 1984-85, 1985-86 and 1986-87, respectively.

The number of seeds / pod or capsule being mainly a genetical character was least affected due to the differences in the methods of establishment. As usual the crops differed widely and significantly between themselves.

4.4.2.5.3 Test weight

Test weights or 100 seeds weights of all the crops in all the three years of experimentation have been summarised in Tables 4.39a, 4.39b and 4.39c in 1984-85, 1985-86 and 1986-87, respectively.

Test weight differences being mainly governed by genetical factors, environmental differences provided to the crops at the time of establishment did not cause any significant difference in any of the crops.

4.4.2.6 Grain yield of crops

Grain yields in kg / ha recorded in three consecutive years have been presented in Tables 4.40a, 4.40b and 4.40c for 1984-85, 1985-86 and 1986-87 seasons, respectively.

Table 4.38a Number of seeds / pod or capsule of winter crops under different methods of crop establishment and management, Field Experiment No.1 (1984-85)

Particulars of winter crops (C)	Previous crops (R)			Mean
	Sole MW 10 (M)	Sole Swarna (S)	Intercrop (S+M)	
	(Conventional tillage)	(Paira cropping)		
Linseed	9.0	8.9	8.9	8.9
Peas	5.5	5.5	5.7	5.6
Lentil	1.9	1.9	1.9	1.9
Lathyrus-N	3.6	3.7	3.5	3.6
Lathyrus-L	3.6	3.5	3.6	3.6
Mean	4.7	4.7	4.7	
		R	C	RxC
	S.Em ±	0.06	0.08	0.13
	C.D. at 5%	N.S.	0.23	N.S.

Table 4.38b Number of seeds / pod or capsule of winter crops under different methods of crop establishment and management, Field Experiment No.1 (1985-86)

Particulars of winter crops (C)	Previous crops (R)			Mean
	Sole MW 10 (M)	Sole Swarna (S)	Intercrop (S+M)	
	(Conventional tillage)	(Paira cropping)		
Linseed	8.6	8.1	8.1	8.3
Peas	5.8	5.9	5.8	5.8
Lentil	1.9	1.9	1.9	1.9
Lathyrus-N	3.6	3.8	3.7	3.7
Lathyrus-L	3.7	3.6	3.6	3.6
Mean	4.7	4.7	4.6	
		R	C	RxC
	S.Em ±	0.04	0.07	0.12
	C.D. at 5%	N.S.	0.20	N.S.

Table 4.38c Number of seeds / pod or capsule of winter crops under different methods of crop establishment and management, Field Experiment No.1 (1986-87)

Particulars of winter crops (C)	Previous crops (R)			Mean
	Sole MW 10 (M) (Conventional tillage)	Sole Swarna (S) (Paira cropping)	Intercrop (S+M) (Paira cropping)	
Linseed	8.5	7.8	8.0	8.1
Peas	5.1	5.7	5.5	5.4
Lentil	1.8	1.9	1.8	1.8
Lathyrus-N	3.6	3.7	3.8	3.7
Lathyrus-L	3.6	3.6	3.7	3.6
Mean	4.5	4.5	4.6	
		R	C	RxC
	S.Em ±	0.05	0.09	0.16
	C.D. at 5%	N.S.	0.26	N.S.

Table 4.39a Test weight of seeds (in g of 100 seeds) of winter crops under different methods of crop establishment and management, Field Experiment No.1 (1984-85)

Particulars of winter crops (C)	Previous crops (R)			Mean
	Sole MW 10 (M) (Conventional tillage)	Sole Swarna (S) (Paira cropping)	Intercrop (S+M) (Paira cropping)	
Linseed	0.51	0.53	0.53	0.52
Peas	7.13	7.57	7.56	7.42
Lentil	1.70	1.65	1.86	1.74
Lathyrus-N	5.85	5.70	5.66	5.74
Lathyrus-L	5.53	5.37	5.77	5.56
Mean	4.14	4.16	4.28	
		R	C	RxC
	S.Em ±	0.10	0.15	0.27
	C.D. at 5%	N.S.	0.44	N.S.

Table 4.39b Test weight of seeds (in g of 100 seeds) of winter crops under different methods of crop establishment and management, Field Experiment No.1 (1985-86)

Particulars of winter crops (C)	Previous crops (R)			Mean
	Sole MW 10 (M) (Conventional tillage)	Sole Swarna (S) (Paira cropping)	Intercrop (S+M) (Paira cropping)	
Linseed	0.51	0.50	0.52	0.51
Peas	7.04	7.08	7.22	7.11
Lentil	1.71	1.68	1.68	1.69
Lathyrus-N	5.76	5.56	5.70	5.67
Lathyrus-L	5.54	5.36	5.76	5.55
Mean	4.11	4.04	4.18	
		R	C	RxC
	S.Em ±	0.90	0.19	0.34
	C.D. at 5%	N.S.	0.55	N.S.

Table 4.39c Test weight of seeds (in g of 100 seeds) of winter crops under different methods of crop establishment and management at harvest, Field Experiment No.1 (1986-87)

Particulars of winter crops (C)	Previous crops (R)			Mean
	Sole MW 10 (M) (Conventional tillage)	Sole Swarna (S) (Paira cropping)	Intercrop (S+M) (Paira cropping)	
Linseed	0.54	0.52	0.51	0.52
Peas	7.21	7.32	7.18	7.24
Lentil	1.71	1.64	1.68	1.68
Lathyrus-N	5.67	5.78	5.53	5.66
Lathyrus-L	5.67	5.59	5.62	5.63
Mean	4.16	4.17	4.10	
		R	C	RxC
	S.Em ±	0.07	0.06	0.10
	C.D. at 5%	N.S.	0.18	N.S.

In 1984-85, crops established under conventional method recorded significantly higher grain yield (1824 kg / ha) than under *paira* cropping, following intercropped rice (1625 kg / ha). The later treatment on the other hand, provided significantly higher grain yield than those recorded under *paira* cropping following the sole crop of 'Swarna' rice. Different crops followed similar type of variation and so the interaction between crops and methods of establishment was not significant. Nirmal variety of *Lathyrus* recorded the highest grain yield (2028 kg / ha) closely followed by *Lathyrus* (local). The lowest grain yield (1170 kg / ha) was recorded in linseed but it's difference with lentil was not significant.

In 1985-86 also similar trend of variations between treatments was recorded, although the differences due to the variations in methods of crop establishment were not significant. Nirmal variety of *Lathyrus* which matured 10 days later, yielded the maximum (1956 kg / ha) and it was significantly more than the local variety (1718 kg / ha). But there was no significant difference in grain yield between peas and *Lathyrus* (local). Although, the lowest grain yield was recorded in linseed (1003 kg / ha) but its difference with lentil (1086 kg / ha) was not significant.

In 1986-87, the trend of variation in results were very similar to that of 1984-85; conventional method of crop establishment showed the maximum yield, closely followed by the treatment where the crops were established after *paira*

Table 4.40a Productivity of winter crops under different methods of crop establishment and management in kg / ha, Field Experiment No.1 (1984-85)

Particulars of winter crops (C)	Previous crops (R) Sole MW 10 (M) (Conventional tillage)	Sole Swarna (S) (Paira cropping)	Intercrop (S+M)	Mean
Linseed	1354	1004	1151	1170
Peas	1739	1497	1678	1638
Lentil	1504	1121	1347	1324
Lathyrus-N	2305	1858	1922	2028
Lathyrus-L	2217	1738	2028	1994
Mean	1824	1444	1625	
		R	C	RxC
	S.Em ±	38.5	80.9	140.2
	C.D. at 5%	151.1	236.1	N.S.
	C.V. %	9.2	14.9	

Table 4.40b Productivity of winter crops under different methods of crop establishment and management in kg / ha, Field Experiment No.1 (1985-86)

Particulars of winter crops (C)	Previous crops (R) Sole MW 10 (M) (Conventional tillage)	Sole Swarna (S) (Paira cropping)	Intercrop (S+M)	Mean
Linseed	1226	853	929	1003
Peas	1928	1837	1852	1872
Lentil	1209	962	1087	1086
Lathyrus-N	2173	1787	1908	1956
Lathyrus-L	1724	1692	1737	1718
Mean	1652	1426	1503	
		R	C	RxC
	S.Em ±	83.2	54.0	93.5
	C.D. at 5%	N.S.	157.6	N.S.
	C.V. %	21.1	10.6	

Table 4.40c Productivity of winter crops under different methods of crop establishment and management in kg / ha, Field Experiment No.1 (1986-87)

Particulars of winter crops (C)	Previous crops (R)			Mean
	Sole MW 10 (M) (Conventional tillage)	Sole Swarna (S) (Paira cropping)	Intercrop (S+M) (Paira cropping)	
Linseed	1088	870	948	969
Peas	1706	1428	1684	1606
Lentil	1173	946	950	1023
Lathyrus-N	1850	1702	1883	1812
Lathyrus-L	1814	1613	1831	1753
Mean	1526	1312	1459	

	R	C	RxC
S.Em ±	29.4	52.8	91.5
C.D. at 5%	115.4	154.1	N.S.
C.V. %	8.0	11.1	

cropping following intercropped rice. The crop established after *paira* cropping following the sole crop of 'Swarna' gave the lowest yield. Nirmal variety of *Lathyrus* gave significantly the highest grain yield (1812 kg / ha) closely followed by local variety of *Lathyrus* (1753 kg / ha). But no significant difference in grain yield was observed between peas (1606 kg / ha) and *Lathyrus* (local). Though the lowest grain yield (969 kg / ha) was recorded in linseed but it did not differ significantly with lentil yield (1023 kg / ha). The interaction between different methods of crop establishment and crops was not significant, indicating thereby that all the crops behaved similarly when established differently.

4.4.2.7 Monetary evaluation of productivity in Rs / ha

The monetary values of the productivity of different crops were calculated and their valuation in terms of Rs / ha have been summarised in Tables 4.41a, 4.41b and 4.41c in 1984-85, 1985-86 and 1986-87, respectively.

In 1984-85, under conventional method of crop establishment the highest valuation in Rs / ha (Rs.6182) was recorded. The lowest productivity in Rs / ha (Rs.4885) was recorded under *paira* cropping following sole crop of 'Swarna' rice and it was significantly lower than the crops established under *paira* cropping following the 'intercropped rice'. Amongst crops, significantly the highest valuation in Rs / ha (Rs.6964) was recorded in peas and the lowest (Rs.4886 / ha) was recorded in local variety of *Lathyrus*. The difference in the valuation

Table 4.41a Evaluation of winter crops under different methods of crop establishment and management in Rs / ha, Field Experiment No.1 (1984-85)

Particulars of winter crops (C)	Previous crops (R)			Mean
	Sole MW 10 (M) (Conventional tillage)	Sole Swarna (S) (Paira cropping)	Intercrop (S+M)	
Linseed	6497	4820	5527	5615
Peas	7393	6365	7134	6964
Lentil	5943	4429	5322	5231
Lathyrus-N	5647	4553	4708	4969
Lathyrus-L	5432	4258	4969	4886
Mean	6182	4885	5532	
		R	C	RxC
	S.Em ±	133.9	143.0	247.7
	C.D. at 5%	525.5	417.5	N.S.
	C.V. %	9.4	7.8	

Table 4.41b Evaluation of winter crops under different methods of crop establishment and management in Rs / ha, Field Experiment No.1 (1985-86)

Particulars of winter crops (C)	Previous crops (R)			Mean
	Sole MW 10 (M) (Conventional tillage)	Sole Swarna (S) (Paira cropping)	Intercrop (S+M)	
Linseed	5884	4093	4455	4811
Peas	8195	7807	7872	7958
Lentil	4775	3799	4292	4289
Lathyrus-N	5324	4377	4674	4792
Lathyrus-L	4224	4146	4254	4208
Mean	5680	4844	5109	
		R	C	RxC
	S.Em ±	313.3	203.2	351.9
	C.D. at 5%	N.S.	593.1	N.S.
	C.V. %	23.3	11.7	

of the productivity of two varieties of *Lathyrus* was not significant. The valuation of linseed and lentil was statistically at par. The interaction between different methods of crop establishment and crops was not significant.

In 1985-86, variations in the valuation of the crop yield followed similar trend as in 1984-85, although the differences due to methods of establishment were not significant. Peas, as in the previous year recorded the maximum valuation. The valuation of the produce in Rs / ha (Rs.4208) from *Lathyrus* (local) was as good as lentil and *Lathyrus* (Nirmal). Again, no significant difference in valuation of crop yield was observed amongst linseed, lentil and *Lathyrus* (Nirmal). Interaction between different methods of establishment and crops was not significant.

In 1986-87, conventional method of crop establishment as in previous years recorded the highest valuation of productivity in Rs / ha (Rs.5217) which was significantly superior to the valuation of the productivity in Rs / ha (Rs.4422) recorded in *paira* method of crop establishment following sole 'Swarna' rice but not with *paira* method of crop establishment followed in intercropped rice plots. Again, the difference in the valuation of productivity in Rs / ha was not significant between two treatments under *paira* method of crop establishment. Amongst crops, significantly the highest valuation of productivity in Rs / ha (Rs.6827) was obtained in peas. Though the lowest productivity in Rs / ha (Rs.4042) was recorded in lentil

Table 4.41c Evaluation of winter crops under different methods of crop establishment and management in Rs / ha, Field Experiment No. 1 (1986-87)

Particulars of winter crops (C)	Previous crops (R)			Mean
	Sole MW 10 (M) (Conventional tillage)	Sole Swarna (S) (Paira cropping)	Intercrop (S+M)	
Linseed	5221	4177	4549	4649
Peas	7251	6071	7159	6827
Lentil	4635	3737	3754	4042
Lathyrus-N	4533	4171	4613	4439
Lathyrus-L	4445	3952	4486	4294
Mean	5217	4422	4912	

	R	C	RxC
S.Em ±	126.8	110.8	191.9
C.D. at 5%	497.8	323.4	N.S.
C.V. %	10.1	6.9	

but it did not differ significantly with Lathyrus (local). Again no significant difference was observed between linseed and Lathyrus (Nirmal) and between Lathyrus varieties. The interaction between different methods of crop establishment and crops was also not significant.

4.4.2.8 Evaluation of productivity in terms of Energy output MJ / ha

Grain yields in kg / ha of different crops were converted into energy output in terms of MJ / ha by multiplying the energy unit equivalent to each kg of seeds of respective crops and have been presented in Tables 4.42a, 4.42b and 4.42c for the years 1984-85, 1985-86 and 1986-87, respectively.

In 1984-85, crops raised under conventional method of crop establishment showed the highest productivity in terms of energy output in MJ / ha (MJ 29603) than those recorded in two treatments under paira cropping and the lowest (MJ 23295 / ha) was recorded in treatment under paira cropping following sole crop of late maturing 'Swarna' rice. Though the highest productivity in terms of energy output in MJ / ha (MJ 29821) was recorded in Nirmal variety of Lathyrus but the differences amongst Lathyrus varieties and linseed were statistically at par. Lentil recorded significantly the lowest productivity in terms of energy output in MJ / ha (MJ 19469) than rest of the crops. Interaction between crops and methods of crop establishment was significant. In all the crops, under conventional method of crop establishment only, higher productivity in terms of energy was observed than those under *paira* cropping but the differences in all the crops were significant only when compared with the *paira* cropping following sole crop of 'Swarna' rice and in case of linseed and *Lathyrus* (Nirmal) when compared with the *paira* cropping following intercrop of rice varieties. Again, higher productivity in terms of energy output were observed in all the crops, raised under *paira* cropping following the intercrop of rice varieties than those observed in *paira* cropping following 'Swarna' rice but no significant differences were observed in case of peas and *Lathyrus* (Nirmal).

In 1985-86, methods of crop establishment and interaction between methods of crop establishment and crops showed no significant difference in productivity in energy output in MJ / ha. Amongst crops, *Lathyrus* (Nirmal) recorded significantly the highest productivity in terms of energy MJ / ha (MJ 28753) output closely followed by peas; no significant difference was observed amongst linseed, peas and *Lathyrus* (local). The lowest productivity in energy output in MJ / ha (MJ 15962) was recorded in lentil which was significantly lower than those recorded in rest of the other crops.

In 1986-87, conventional method of crop establishment showed significantly higher productivity in terms of energy output in MJ / ha (MJ 24677) than those recorded under *paira* cropping following the intercrop of rice varieties. The later treatment in turn provided significantly higher

Table 4.42a Evaluation of winter crops under different methods of crop establishment and management in Energy (MJ) / ha, Field Experiment No.1 (1984-85)

Particulars of winter crops (C)	Previous crops (R) Sole MW 10 (M) (Conventional tillage)	Sole Swarna (S)M (Paira cropping)	Intercrop (S+M)	Mean
Linseed	33841	25108	28791	29247
Peas	25573	22016	24676	24088
Lentil	22118	16483	19806	19469
Lathyrus-N	33888	27322	28253	29821
Lathyrus-L	32594	25548	29816	29319
Mean	29603	23295	26268	
		R	C	RxC
	S.Em ±	678.0	640.1	1109.3
	C.D. at 5%	2661.7	1868.4	3237.9
	C.V. %	10.0	7.3	

Table 4.42b Evaluation of winter crops under different methods of crop establishment and management in Energy (MJ)/ ha, Field Experiment No.1 (1985-86)

Particulars of winter crops (C)	Previous crops (R) Sole MW 10 (M) (Conventional tillage)	Sole Swarna (S) (Paira cropping)	Intercrop (S+M)	Mean
Linseed	30650	21316	23208	25058
Peas	28347	27004	27229	27527
Lentil	17772	14141	15974	15962
Lathyrus-N	31948	26269	28042	28753
Lathyrus-L	25343	24877	25529	25250
Mean	26812	22721	23996	
		R	C	RxC
	S.Em ±	1412.0	892.1	1546.0
	C.D. at 5%	N.S.	2603.9	N.S.
	C.V. %	22.3	10.9	

Table 4.42c Evaluation of winter crops under different methods of crop establishment and management in Energy (MJ) / ha, Field Experiment No.1 (1986-87)

Particulars of winter crops (C)	Previous crops (R) Sole MW 10 (M) (Conventional tillage)	Sole Swarna (S) (Paira cropping)	Intercrop (S+M)	Mean
Linseed	27192	21758	23692	24214
Peas	25079	20997	24694	23590
Lentil	17248	13906	13970	15041
Lathyrus-N	27195	25024	27680	26633
Lathyrus-L	26671	23711	26916	25766
Mean	24677	21079	23390	
		R	C	RxC
	S.Em ±	550.1	563.7	976.3
	C.D. at 5%	2159.6	1645.4	N.S.
	C.V. %	9.2	7.3	

productivity in terms of energy than those recorded under paira cropping following sole crop of 'Swarna' rice.

Amongst crops, the highest productivity in terms of energy output in MJ / ha (MJ 26633) was recorded in Lathyrus (Nirmal) but it did not differ significantly with Lathyrus (local). The lowest productivity in terms of energy output was recorded in lentil. No significant difference in energy output was observed between linseed and peas and between linseed and Lathyrus (local).

4.4.2.9 Loss of soil moisture through winter crops established under different methods

It may be recapitulated that in this experiment crops were established through conventional tillage after harvesting of short duration rice 'MW 10' and under paira method of crop establishment following late maturing sole crop 'Swarna' rice and in intercropped 'Swarna' + 'MW 10' rice. Under paira method, seeds were sown in standing water and then 24 h after sowing, the water was drained out. At this time the soil was saturated and the loss of moisture consisted of percolation loss, evaporational loss through soil surface and transpirational loss both from standing rice (10 - 12 days before harvest) and the newly emerged winter crops.

In 1984-85, upto 60 DAS, crops raised under two treatments under paira cropping system, following sole crop of rice 'Swarna' and intercropped rice 'Swarna + MW 10', showed higher loss of soil moisture than those recorded in crops raised under conventional method (98 mm) of crop establishment (Table 4.43a). The highest loss of soil moisture (684 mm) was recorded in treatment under paira cropping following intercropped rice and it was significantly higher than those (673 mm) recorded under paira cropping following sole crop of 'Swarna' rice upto 60 DAS. Upto 105 DAS, similar was the trend of variation in loss of soil moisture under different methods of crop establishment.

Amongst crops, peas caused the highest loss of soil moisture closely followed by Lathyrus (Nirmal) both upto 60 and 105 DAS. Although the lowest amount of loss of soil moisture was recorded in linseed (472 mm) but it has not significantly different from lentil (474 mm) upto 60 DAS; the loss of soil moisture in Lathyrus varieties were statistically at par. Upto 105 DAS, the lowest amount of evapotranspiration loss of soil moisture was recorded in lentil (559 mm). No significant difference was observed between linseed and Lathyrus (local). Interaction between crops and methods of crop establishment was not significant (Table 4.43a).

In 1985-86 also, similar was the trend of variation with respect to loss of soil moisture under different methods of crop establishment as was observed (Table 4.43b) in 1984-85; only the loss of moisture in two treatments under paira cropping showed no significant difference upto 60 DAS.

Table 4.43a Loss of soil moisture (mm) in winter crops under different methods of crop establishment and management at 0 - 60 cm soil depth upto 60 and 105 DAS, Field Experiment No. 1(1984-85)

Particulars of winter crops (C)	Previous crops (R): Sole MW 10 (M) (Conventional tillage)		Sole Swarna (S) (Paira cropping)		Intercrop (S+M) (Paira cropping)		Mean	
	60 DAS	105 DAS	60 DAS	105 DAS	60 DAS	105 DAS	60 DAS	105 DAS
Linseed	92	181	658	743	666	768	472	564
Peas	114	194	692	796	697	798	501	596
Lentil	90	178	662	738	670	761	474	559
Lathyrus-N	104	190	686	791	694	797	495	593
Lathyrus-L	92	185	668	747	694	781	485	571
Mean	98	186	673	763	684	781		

		R	C	RxC
At 60 DAS	S.Em ±	2.6	3.6	6.2
	C.D. at 5%	10.2	10.5	N.S.
At 105 DAS	S.Em ±	3.3	4.5	7.8
	C.D. at 5%	13.0	13.1	N.S.

Table 4.43b Loss of soil moisture (mm) in winter crops under different methods of crop establishment and management at 0 - 60 cm soil depth upto 60 and 105 DAS, Field Experiment No. 1 (1985-86)

Particulars of winter crops (C)	Previous crops (R): Sole MW 10 (M) (Conventional tillage)		Sole Swarna (S) (Paira cropping)		Intercrop (S+M) (Paira cropping)		Mean	
	60 DAS	105 DAS	60 DAS	105 DAS	60 DAS	105 DAS	60 DAS	105 DAS
Linseed	89	170	673	749	690	761	484	560
Peas	108	188	702	787	730	788	513	588
Lentil	93	168	684	744	694	761	490	557
Lathyrus-N	101	177	699	768	705	783	502	576
Lathyrus-L	98	173	692	759	695	774	495	568
Mean	98	175	690	762	703	773		

		R	C	RxC
At 60 DAS	S.Em ±	4.8	7.1	12.3
	C.D. at 5%	18.8	N.S.	N.S.
At 105 DAS	S.Em ±	1.4	3.3	5.6
	C.D. at 5%	5.5	9.6	N.S.

Crops showed no significant difference amongst them in loss of moisture upto 60 DAS; interaction between treatments was also not significant upto 105 DAS; peas recorded the highest amount of soil moisture loss (588 mm) and the lowest was recorded in lentil (557 mm). Between linseed and *Lathyrus* (local) and between two *Lathyrus* varieties, no significant differences in evapotranspiration loss of soil moisture were observed upto 105 DAS. Interaction between crops and methods of crop establishment was not significant.

4.4.2.10 Water use efficiency (kg / mm / ha) of winter crops

As discussed earlier in the material and method, the soil moisture status were determined at the time of sowing, at 60 and 105 DAS, gravimetrically. In case of *paira* cropping seeds were sown 10 - 12 days before the harvest of rice, and the water was drained out 24 h after sowing. About 60 % of the total rainfall (34.3 mm in 1984-85 and 15.3 mm in 1985-86) received during the growth period, was added to soil moisture loss, also. As such, the water present in the soil at the time of sowing can be classified as moisture at saturated level, which might have been lost through percolation, transpiration from the rice crop (10 - 12 days before harvest) and from the seedlings of winter crops, in addition to the loss of moisture from soil surface through evaporation. In case of establishment of crop under conventional tillage, the sowing was done when the soil moisture status was near 'field capacity'.

As reported in the earlier chapter the soil water loss through crops was appreciably higher under paira cropping than those established under conventional tillage. Even when the crop was established as a paira crop, the soil moisture loss was more (Table 4.44) in the crops following mixed crop 'Swarna + MW 10' of rice than those following the sole crop of 'Swarna' rice. Quite possible blank spaces left after the harvesting of early maturing variety (MW 10), aggravated evaporational loss.

The water use efficiency calculated on the basis of loss of soil moisture recorded upto 105 DAS, was appreciably high where the crop was established under conventional tillage. This indicated that the moisture conserved in the soil profile, through the light soil mulch spread over (under conventional tillage mulch) was best utilized for crop production. On the other hand, under paira cropping, without mulch the water use efficiency was much lower than that was recorded under conventional tillage; this might be due to the fact that the loss of soil moisture under paira cropping was much higher than conventional tillage.

Peas and *Lathyrus* varieties because of their quick ground coverage, high yield and high soil moisture utilisation, showed high water use efficiency both under paira cropping as well as under conventional tillage. *Lathyrus* always showed an edge over peas which on the other hand showed better soil moisture utilization for productive purpose than lentil and linseed (Table 4.44).

Table 4.44 Water use efficiency (kg / mm / ha) of winter crops under different methods of crop establishment and management calculated from the loss of soil moisture recorded upto 105 DAS, Field Experiment No.1 (1984-85 and 1985-86)

Particulars of winter crops (C)	Previous crops (R)								
	Sole MW 10 (M)			Sole Swarna (S)			Intercrop (S+M)		
	(Conventional tillage)			(Paira cropping)					
	1984 -85	1985 -86	Mean	1984 -85	1985 -86	Mean	1984 -85	1985 -86	Mean
Linseed	7.48	7.21	7.35	1.35	1.14	1.25	1.50	1.22	1.36
Peas	8.96	10.26	9.61	1.88	2.33	2.11	2.10	2.35	2.23
Lentil	8.45	7.20	7.83	1.52	1.29	1.41	1.77	1.43	1.60
Lathyrus-N	12.13	12.28	12.21	2.35	2.33	2.34	2.41	2.44	2.43
Lathyrus-L	11.98	9.97	10.98	2.33	2.23	2.28	2.60	2.24	2.42

4.5 Field Experiment No.2

Studies on the performance of winter crops established as *paira* crop with and without pre-sowing treated seeds and fertilizer, following a late maturing variety of rice.

The experiment was carried out with the objective of assessing the productivity of winter crops after rice crop under different doses of fertilizer and seed treatments.

4.5.1 Productivity of rice

The productivity of rice variety 'Swarna' ranged (Table 4.45) from 5057 to 5473 kg / ha in 1984-85. The productivity of rice, which was adequately fertilized, and followed different winter crops managed differently in subsequent years (1985-86 and 1986-87), did not differ significantly and the yields ranged from 4871 to 5373 kg / ha in 1985-86 and from 5283 to 5405 kg / ha in 1986-87.

4.5.2 Productivity of winter crops

4.5.2.1 Stand establishment

The plant population / m^2 of winter crops, at 45 DAS and at harvest were recorded in all the three years of experimentation. The mean number of plant population / m^2 along with their statistical analysis have been summarised in Table 4.46a, 4.46b and 4.46c in 1984-85, 1985-86 and 1986-87, respectively.

As usual in 1984-85, significant differences in plant population / m^2 at harvest were observed, only amongst crops, may be because of their differences in seed sizes. This

Table 4.45 The productivity of rice (in kg / ha) in plots to be sown under *paira* cropping with winter crops, Field Experiment No.2.

Particulars of main plots to be sown with winter crops	Yields (kg / ha)		
	1984-85	1985-86	1986-87
1. To be relayed with Linseed	5057 ±2923	4871	5300
2. To be relayed with peas	5268 ±3043	5373	5361
3. To be relayed with lentil	5473 ±2450	5078	5326
4. To be relayed with *Lathyrus* (Nirmal)	5306 ±2373	5044	5405
5. To be relayed with *Lathyrus* (local)	5159 ±2309	4968	5283
S.Em ±		143.1	78.2
C.D. at 5 %		N.S.	N.S.
C.V. %		9.78	5.07

difference was also significant at 45 DAS. Linseed recorded the highest number of plant population / m^2 (137 and 133 at 45 DAS and at harvest, respectively) and the lowest (28 and 27 at 45 DAS and at harvest, respectively) was recorded in peas. No significant difference was observed in between *Lathyrus* varieties. With regard to seed treatment no significant difference was observed at 45 DAS and at harvest in the stand establishment. Only at 45 DAS mean effect of the application of fertilizer (top dressing) showed very narrow but significantly higher plant population / m^2 (64) than those recorded in plots raised without top dressing (63). The interaction between crops and seed treatment was not significant. The interaction between crops and fertilizer application was significant only at 45 DAS; so was the case of interaction between seed treatment and fertilizer application. The interaction between crops, seed treatment and fertilizer application was also significant at 45 DAS but not at harvest. Top dressing of fertilizer slightly depressed population / m^2 in peas but not in others. The differences were however, very small and at the time of harvest none of the differences were statistically significant.

In 1985-86 also, the differences in plant population / m^2 were significant only between crops both at 45 DAS as well as at harvest. The small seeded crop, linseed recorded the highest number of plants per unit area (136 / m^2 at harvest) as against only 34 plants / m^2 in case of *Lathyrus* varieties.

In 1986-87, like previous years plant population / m^2 amongst different crops showed significant difference and the

Table 4.46a Effect of seed treatment and fertilizer application on plant population / m^2 of winter crops, established as paira crop at 45 DAS and at harvest, Field Experiment No.2 (1984-85)

Winter crops (C)	Fertilizer level (F)	Seed treatment (S): Treated 45 DAS	Treated At harvest	Untreated 45 DAS	Untreated At harvest	Mean 45 DAS	Mean At harvest
Linseed	F_0	132	130	136	132	134	131
	$F_{20}+F_{40}$	140	135	138	134	139	135
	Mean	136	133	137	133	137	133
Peas	F_0	26	26	29	27	28	27
	$F_{20}+F_{40}$	28	27	26	26	27	27
	Mean	27	27	28	27	28	27
Lentil	F_0	77	75	78	74	77	75
	$F_{20}+F_{40}$	84	78	81	73	83	76
	Mean	81	77	80	74	80	76
Lathyrus-N	F_0	36	33	36	34	36	34
	$F_{20}+F_{40}$	36	35	37	35	37	35
	Mean	36	34	37	35	37	35
Lathyrus-L	F_0	38	37	37	36	38	37
	$F_{20}+F_{40}$	37	34	35	34	36	34
	Mean	38	36	36	35	37	36
Fertilizer	F_0	62	60	63	61	63	61
	$F_{20}+F_{40}$	65	62	63	60	64	61
Grand mean		64	61	63	61		

	C	S	F	CxS	CxF	SxF	CxSxF
At 45 DAS							
S.Em ±	0.9	2.1	0.3	4.8	0.6	0.4	0.8
C.D. at 5%	2.9	N.S.	0.9	N.S.	1.7	1.2	2.3
At harvest							
S.Em ±	0.9	1.1	0.5	2.5	1.0	0.6	1.4
C.D. at 5%	2.9	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 4.46b Effect of seed treatment and fertilizer application on plant population / m^2 of winter crops, established as paira crop at 45 DAS and at harvest, Field Experiment No.2 (1985-86)

Winter crops (C)	Fertilizer level (F)	Seed treatment (S)					
		Treated		Untreated		Mean	
		45 DAS	At harvest	45 DAS	At harvest	45 DAS	At harvest
Linseed	F_0	142	136	141	138	142	137
	$F_{20}+F_{40}$	150	143	131	127	141	135
	Mean	146	140	136	133	142	136
Peas	F_0	29	26	28	26	29	26
	$F_{20}+F_{40}$	28	25	31	27	30	26
	Mean	29	26	30	27	30	26
Lentil	F_0	78	75	78	77	78	76
	$F_{20}+F_{40}$	79	77	73	72	76	75
	Mean	79	76	76	75	77	76
Lathyrus-N	F_0	37	35	37	33	37	34
	$F_{20}+F_{40}$	35	34	34	31	35	33
	Mean	36	35	36	32	36	34
Lathyrus-L	F_0	33	33	35	35	34	34
	$F_{20}+F_{40}$	34	33	38	35	36	34
	Mean	34	33	37	35	35	34
Fertilizer	F_0	64	61	64	62	64	62
	$F_{20}+F_{40}$	65	62	61	58	63	60
Grand mean		65	62	63	60		

	C	S	F	CxS	CxF	SxF	CxSxF
At 45 DAS							
S.Em ±	1.4	1.2	0.6	2.6	1.4	0.9	2.0
C.D. at 5%	4.6	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
At harvest							
S.Em ±	1.3	0.8	0.7	1.8	1.6	1.0	2.3
C.D. at 5%	4.2	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

significantly highest plant population / m^2 (137 and 134 / m^2 at 45 DAS and at harvest, respectively) was observed in linseed and the lowest (27 and 26/m^2 at 45 DAS and at harvest, respectively) was recorded in peas (Plate 5). Seed treatment adversely affected the stand establishment of linseed but in other crops it slightly improved, particularly lentil and peas; the interaction between crops and seed treatment was significant. Similarly, fertilizer application slightly increased the number of plants per unit area in case of linseed but in other cases it caused bit of reduction.

Thus, from the three years data it appears that seed treatment and fertilizer application did not cause any major effect on the stand establishment of the crops.

4.5.2.2 Shoot dry matter accumulation / m^2

Shoot dry matter accumulation / m^2 recorded in three consecutive years of experimentation at 90 DAS have been summarised in Tables 4.47a, 4.47b and 4.47c in 1984-85, 1985-86 and 1986-87, respectively.

In 1984-85, peas recorded the highest shoot dry matter accumulation / m^2 (706 g) than all other crops. The lowest shoot dry matter accumulation / m^2 (297 g) was recorded in linseed which was significantly lower than other crops. Again no significant difference was observed in between Lathyrus varieties. Application of fertilizer as top dressing produced significantly higher shoot dry matter accumulation / m^2 (596 g) in crops than those (512 g) grown without fertilizer top

Table 4.46c Effect of seed treatment and fertilizer application on plant population / m^2 in winter crops, established as paira crop at 45 DAS and at harvest, Field Experiment No.2 (1986-87)

Winter crops (C) Fertilizer level (F)		Seed treatment (S)					
		Treated		Untreated		Mean	
		45 DAS	At harvest	45 DAS	At harvest	45 DAS	At harvest
Linseed	F_0	128	124	138	134	133	129
	$F_{20}+F_{40}$	129	126	153	150	141	138
	Mean	129	125	146	142	137	134
Peas	F_0	30	28	22	21	26	25
	$F_{20}+F_{40}$	28	27	27	25	28	26
	Mean	29	28	25	23	27	26
Lentil	F_0	77	75	67	64	72	70
	$F_{20}+F_{40}$	81	78	64	63	73	71
	Mean	79	77	66	64	73	71
Lathyrus-N	F_0	37	36	36	35	37	36
	$F_{20}+F_{40}$	33	32	34	33	34	33
	Mean	35	34	35	34	36	35
Lathyrus-L	F_0	38	37	35	33	37	35
	$F_{20}+F_{40}$	33	32	32	31	33	32
	Mean	36	35	34	32	35	34
Fertilizer	F_0	62	60	60	57	61	59
	$F_{20}+F_{40}$	61	59	62	60	62	60
Grand mean		62	60	61	59		

	C	S	F	CxS	CxF	SxF	CxSxF
At 45 DAS							
S.Em ±	1.3	1.1	0.9	2.5	2.1	1.3	2.9
C.D. at 5%	4.2	N.S.	N.S.	9.8	N.S.	N.S.	N.S.
At harvest							
S.Em ±	1.3	1.0	1.0	2.3	2.2	1.4	3.1
C.D. at 5%	4.2	N.S.	N.S.	9.0	6.4	N.S.	N.S.

Table 4.47a Effect of seed treatment and fertilizer application on shoot dry matter accumulation (g / m^2) of inter-crops, established as *paira* crop following rice at 90 DAS, Field Experiment No.2 (1984-85)

Seed treatment (S)	Fertilizer level (F)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathy-rus-N	Lathy-rus-L	Mean
Seeds treated	F_0	254	682	502	622	620	536
	$F_{20}+F_{40}$	367	771	578	749	678	629
	Mean	311	727	540	686	649	583
Seeds untreated	F_0	235	650	434	614	509	488
	$F_{20}+F_{40}$	328	719	494	639	631	562
	Mean	282	685	464	627	570	525
Fertilizer (Mean)	F_0	245	666	468	618	565	512
	$F_{20}+F_{40}$	348	745	536	694	655	596
Grand mean		297	706	502	657	610	

	C	S	F	CxS	CxF	SxF	CxSxF
S.Em ±	14.4	16.3	8.0	36.5	17.8	11.3	25.2
C.D. at 5%	47.0	N.S.	23.3	N.S.	N.S.	N.S.	N.S.

Plate 5. Seeds of peas failed because the radicles of pea seeds could not anchor well, wherever the soil surface became hard for want of shade from the companion crop in 1986-87.

dressing (Plate 6). Seed treatment and all other interactions did not show any significant difference between treatments.

In 1985-86, the highest shoot dry matter accumulation / m^2 (817 g) was recorded in peas and the lowest shoot dry matter accumulation / m^2 (316 g) was recorded in linseed which was significantly lower than all other crops. Crops raised from treated seeds significantly increased the dry matter accumulation / m^2 to the tune of 19.5 % than those from untreated seeds. Top dressing with fertilizer also produced significantly higher shoot dry matter accumulation / m^2 (619 g) than those recorded in crops raised with no top dressing (496 g). This amounted to 25 % increase in shoot dry weight. Maximum increase (about 33 %) was recorded in linseed. None of the interactions was significant. In 1986-87, similar was the trend of variation amongst different crops in respect of shoot dry matter accumulation / m^2 as was observed in 1985-86. Highest shoot dry matter accumulation / m^2 (631 g) was recorded in peas closely followed (599 g / m^2) by _Lathyrus_ (Nirmal) and the lowest (272 g) was recorded in linseed which was significantly lower than the rest of the crops. Again, no significant difference in shoot dry matter accumulation / m^2 was observed between _Lathyrus_ varieties. Significantly higher shoot dry matter / m^2 (523 g) was recorded in crops raised from treated seeds than those (462g)from untreated seeds. Similarly, crops top dressed with fertilizer showed significantly higher dry matter accumulation / m^2 (548 g) than those (437 g) raised without top

Table 4.47b Effect of seed treatment and fertilizer application on shoot dry matter accumulation (g / m^2) of winter crops, established as paira crop following rice at 90 DAS, Field Experiment No.2 (1985-86)

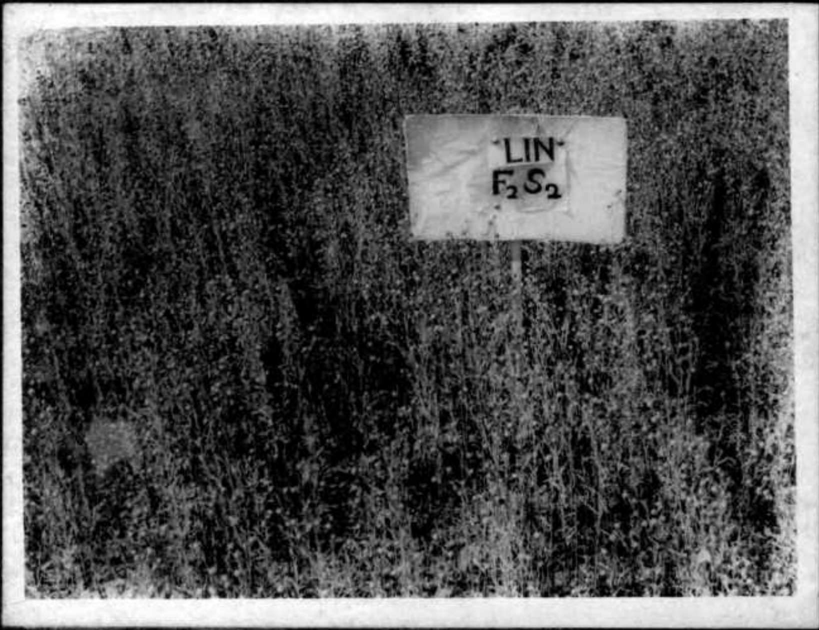
Seed treatment (S)	Fertilizer level (F)	Winter crops (C)					
		Linseed	Peas	Lentil	Lathyrus-N	Lathyrus-L	Mean
Seeds treated	F_0	280	820	485	568	572	545
	$F_{20}+F_{40}$	410	987	591	701	649	668
	Mean	345	904	538	635	611	607
Seeds untreated	F_0	239	627	403	480	483	446
	$F_{20}+F_{40}$	333	830	490	576	617	569
	Mean	286	729	447	528	550	508
Fertilizer (mean)	F_0	260	724	444	524	528	496
	$F_{20}+F_{40}$	372	909	541	639	633	619
Grand mean		316	817	493	582	581	

	C	S	F	CxS	CxF	SxF	CxSxF
S.Em ±	36.2	19.7	12.5	44.2	28.0	17.7	39.6
C.D. at 5%	118.1	77.3	36.3	N.S.	N.S.	N.S.	N.S.

Table 4.47c Effect of seed treatment and fe
on shoot dry matter accumulatic
crops, established as *paira* crc
90 DAS, Field Experiment No.2 (

Seed treatment (S) Fertilizer level (F)		Winter cr		
		Lin-seed	Peas	Lentil
Seeds treated	F_0	230	611	383
	$F_{20}+F_{40}$	333	721	516
	Mean	282	666	450
Seeds untreated	F_0	205	554	310
	$F_{20}+F_{40}$	318	635	441
	Mean	262	595	376
Fertilizer (Mean)	F_0	218	583	347
	$F_{20}+F_{40}$	326	678	479
Grand mean		272	631	413

	C	S	F	CxS
S.Em ±	19.2	15.4	8.9	34.4
C.D. at 5%	62.6	60.5	25.9	N.S.



B

A

Plate 6. Photographs of Peas crop at pod forming and linseed crop at flowering stage under <u>paira</u> method in 1984-85.

A. Peas crop raised from pre-sowing chemically treated seeds with fertilizers top dressing.

B. Linseed crop raised from pre-sowing chemically treated seeds with fertilizer top dressing.

dressing of fertilizer. The mean increments due to seed treatment and fertilizer application were 13 and 25 per cent respectively; linseed showed the maximum advantage.

4.5.2.3 Root dry weight / core sampler (i.e. in 578 c.c. of soil)

Root dry weights per core sample in mg were determined from four soil depths at intervals of 15 cm, on 60 and 105 DAS in 1984-85 and 1985-86.

In 1984-85, at 0 - 15 cm soil depth, the highest root dry weight (149.5 and 186.8 mg / 578 c.c. of soil core at 60 and 105 DAS, respectively) was observed in peas. At 60 DAS, however, there was no significant difference between the root dry weights of two Lathyrus varieties. The lowest root dry weights (108.5 and 149.6 mg / 578 c.c. of soil core at 60 and 105 DAS, respectively) were recorded in linseed both on 60 and 105 DAS. Crops raised from treated seeds showed significantly higher root dry weights than those recorded in crops raised from untreated seeds both at 60 and 105 DAS. The mean increments ranged from 5 to 8.7 % . Top dressing of fertilizer also increased root dry weight and the mean increments were 14 % at 60 DAS and 8.9 % at 105 DAS. As usual, the increase due to top dressing of fertilizer was more in linseed than in other leguminous crops (56 and 11 % increase at 60 and 105 DAS, respectively). The interactions between different factors were, however, not significant (Table 4.48a).

Table 4.48a Effect of seed treatment and fertilizer application on root dry matter production in 578 c.c. of soil in winter crops, established as paira crop at 0 - 15 cm depth on 60 and 105 DAS in mg, Field Experiment No.2 (1984-85)

Winter crops (C) / Fertilizer level (F)		Seed treatment (S) Treated 60 DAS	Treated 105 DAS	Untreated 60 DAS	Untreated 105 DAS	Mean 60 DAS	Mean 105 DAS
Linseed	F_0	91.8	146.2	77.5	137.3	84.7	141.8
	$F_{20}+F_{40}$	133.7	158.4	130.7	156.4	132.2	157.4
	Mean	112.8	152.3	104.1	146.9	108.5	149.6
Peas	F_0	152.3	184.7	138.4	172.0	145.4	178.4
	$F_{20}+F_{40}$	157.2	201.3	149.9	188.8	153.6	195.1
	Mean	154.8	193.0	144.2	180.4	149.5	186.8
Lentil	F_0	132.2	165.2	108.2	161.8	120.2	163.5
	$F_{20}+F_{40}$	140.0	176.0	130.6	171.9	135.3	174.0
	Mean	136.1	170.6	119.4	166.9	127.8	168.8
Lathyrus-N	F_0	142.3	176.6	131.0	166.5	136.7	171.5
	$F_{20}+F_{40}$	156.0	191.5	140.4	182.5	148.2	187.0
	Mean	149.2	184.1	135.7	174.5	142.5	179.3
Lathyrus-L	F_0	145.8	172.4	138.8	159.5	142.3	166.0
	$F_{20}+F_{40}$	152.5	185.3	146.0	177.5	149.3	181.4
	Mean	149.2	178.9	142.4	168.5	145.8	173.7
Fertilizer	F_0	132.9	169.0	118.8	159.4	125.9	164.3
	$F_{20}+F_{40}$	147.9	182.5	139.5	175.4	143.7	179.0
Grand mean		140.4	175.8	129.2	167.4		

	C	S	F	CxS	CxF	SxF	CxSxF
At 60 DAS							
S.Em ±	2.27	2.08	1.40	4.65	2.23	1.40	2.23
C.D. at 5%	7.40	8.17	4.07	N.S.	N.S.	N.S.	N.S.
At 105 DAS							
S.Em ±	1.97	1.99	1.03	4.47	2.30	1.45	3.25
C.D. at 5%	6.42	7.81	2.99	N.S.	N.S.	N.S.	N.S.

In 1985-86 also, at 0 - 15 cm soil depth, peas showed the highest root dry weight (162.8 and 185.9 mg / 578 c.c. of soil core at 60 and 105 DAS, respectively) and the lowest (114.8 and 144.9 mg / 578 c.c. of soil core at 60 and 105 DAS, respectively) was also, recorded in linseed. At 105 DAS, no significant difference was observed between linseed and lentil. Seed treatment and top dressing of the crops with fertilizer also increased root dry weights similar to observation recorded in 1984-85. Interaction between crops and fertilizer was significant at 60 DAS. As usual linseed responded to top dressing of fertilizer more than the other crops, particularly when sampled at 60 DAS. The increase in linseed root weight, due to fertilizer application, sampled at 60 DAS was to the tune of 37.6 % (Table 4.48b).

In 1984-85, at 15 - 30 cm soil depth also peas recorded the highest root dry weight (43.7 and 59.2 mg / 578 c.c. of soil core on 60 and 105 DAS, respectively). The lowest root dry weight (31.5 mg / 578 c.c. of soil core) at 60 DAS was recorded in linseed but it did not differ significantly with that of lentil. Again no significant difference was observed between <u>Lathyrus</u> varieties at 60 DAS. At 105 DAS also linseed showed the lowest root dry weight (39.1 mg / 578 c.c. of soil core) which was significantly lower than those recorded in all other crops. No significant difference was observed between <u>Lathyrus</u> varieties at 105 DAS. Seed treatment and top dressing of fertilizer significantly increased root dry weights in all the

Table 4.48b Effect of seed treatment and fertilizer application on root dry matter production in 578 c.c. of soil in winter crops, established as paira crop at 0 - 15 cm depth on 60 and 105 DAS in mg, Field Experiment No.2 (1985-86)

Winter crops (C) Fertilizer level (F)		Seed treatment (S) Treated 60 DAS	Treated 105 DAS	Untreated 60 DAS	Untreated 105 DAS	Mean 60 DAS	Mean 105 DAS
Linseed	F_0	97.3	139.5	95.9	131.3	96.6	135.4
	$F_{20}+F_{40}$	136.7	162.3	129.0	146.5	132.9	154.4
	Mean	117.0	150.9	112.5	138.9	114.8	144.9
Peas	F_0	169.5	187.3	123.0	162.7	146.3	175.0
	$F_{20}+F_{40}$	193.5	207.8	165.0	185.5	179.3	196.7
	Mean	181.5	197.6	144.0	174.1	162.8	185.9
Lentil	F_0	112.4	151.1	87.4	131.0	99.9	141.1
	$F_{20}+F_{40}$	125.7	160.3	90.8	156.8	108.3	158.6
	Mean	119.1	155.7	89.1	143.9	104.1	149.9
Lathyrus-N	F_0	150.5	167.5	128.5	155.2	139.5	161.4
	$F_{20}+F_{40}$	164.3	177.1	153.1	166.0	158.7	171.6
	Mean	157.4	172.3	140.8	160.6	149.1	166.5
Lathyrus-L	F_0	144.0	157.6	114.1	147.5	129.1	152.6
	$F_{20}+F_{40}$	155.0	171.6	121.4	161.8	138.2	166.7
	Mean	150.0	164.6	117.8	154.7	133.7	159.7
Fertilizer	F_0	134.7	160.6	109.8	145.5	122.3	153.1
	$F_{20}+F_{40}$	155.0	175.8	131.9	163.3	143.5	169.6
Grand mean		144.9	168.2	120.9	154.4		

	C	S	F	CxS	CxF	SxF	CxSxF
At 60 DAS							
S.Em ±	3.56	4.20	1.73	9.39	3.88	2.45	5.48
C.D. at 5%	11.61	16.49	5.03	N.S.	11.28	N.S.	N.S.
At 105 DAS							
S.Em ±	1.86	2.50	1.24	5.60	2.77	1.75	3.92
C.D. at 5%	6.07	9.81	3.61	N.S.	N.S.	N.S.	N.S.

Table 4.49a Effect of seed treatment and fertilizer application on root dry matter production in 578 c.c. of soil in winter crops, established as paira crop at 15 - 30 cm depth on 60 and 105 DAS mg, Field Experiment No.2 (1984-85)

Winter crops (C) / Fertilizer level (F)		Seed treatment (S)					
		Treated		Untreated		Mean	
		60 DAS	105 DAS	60 DAS	105 DAS	60 DAS	105 DAS
Linseed	F_0	30.8	39.8	27.3	31.9	29.1	35.9
	$F_{20}+F_{40}$	34.4	44.0	33.1	40.5	33.8	42.3
	Mean	32.6	41.9	30.2	36.2	31.5	39.1
Peas	F_0	42.3	57.3	38.8	54.4	40.6	55.8
	$F_{20}+F_{40}$	47.7	63.9	45.7	61.0	46.7	62.5
	Mean	45.0	60.6	42.3	57.7	43.7	59.2
Lentil	F_0	34.0	43.8	30.7	39.7	32.4	41.8
	$F_{20}+F_{40}$	36.5	46.1	33.5	44.5	35.0	45.3
	Mean	35.3	44.9	32.1	42.1	33.7	43.6
Lathyrus-N	F_0	37.1	52.9	30.7	47.3	33.9	50.1
	$F_{20}+F_{40}$	43.4	54.2	39.0	48.3	41.2	51.3
	Mean	40.3	53.6	34.9	47.8	37.6	50.7
Lathyrus-L	F_0	39.7	50.5	34.7	42.2	37.2	46.4
	$F_{20}+F_{40}$	44.1	53.0	42.3	52.2	43.2	52.6
	Mean	41.9	51.8	38.5	47.2	40.2	49.5
Fertilizer	F_0	36.8	48.9	32.4	43.1	34.6	46.0
	$F_{20}+F_{40}$	41.2	52.2	38.7	49.3	40.0	50.8
Grand mean		39.0	50.6	35.6	46.2		

	C	S	F	CxS	CxF	SxF	CxSxF
At 60 DAS							
S.Em ±	1.05	0.45	0.44	1.02	0.99	0.63	1.40
C.D. at 5%	3.42	1.77	1.28	N.S.	N.S.	N.S.	N.S.
At 105 DAS							
S.Em ±	0.99	0.64	0.60	1.43	1.34	0.85	1.90
C.D. at 5%	3.23	2.51	1.74	N.S.	N.S.	N.S.	N.S.

crops. None of the interactions between crops, seed treatment and top dressing of fertilizer were significant (Table 4.49a).

In 1985-86, at 15 - 30 cm soil depth, the highest root dry weight (46.2 and 55.6 mg / 578 c.c. of soil core on 60 and 105 DAS, respectively) was recorded in peas closely followed by Nirmal variety of Lathyrus. The lowest root dry weight (28 and 33.9 mg / 578 c.c. of soil core on 60 and 105 DAS, respectively) was recorded in linseed but it did not differ significantly from lentil, both at 60 and 105 DAS. No significant difference was observed in root dry weight between Lathyrus varieties at 60 DAS. Both seed treatment and top dressing of fertilizer significantly increased the root dry weights of the crops as was recorded in previous year. Interactions between different factors were, however, not significant (Table 4.49b).

In 1984-85, at 30 - 45 cm soil depth, significant differences in root dry weights were observed amongst different crops at 60 and 105 DAS. At 60 DAS, the higher root dry weight (28.1 mg / 578 c.c. of soil core) was observed in Lathyrus (Nirmal) than those recorded in all other crops. The lowest root dry weight was observed in linseed but it did not differ significantly from those of lentil and Lathyrus (local). At 105 DAS, Lathyrus (Nirmal) continued to record the highest root dry weight (37.3 mg / 578 c.c. of soil core) closely followed by peas (35.6 mg / 578 c.c. of soil core). The lowest root dry weight (25.1 mg / 578 c.c. of soil core) was recorded in linseed which was significantly lower than the root dry

Table 4.49b Effect of seed treatment and fertilizer application on root dry matter production in 578 c.c. of soil in winter crops, established as paira crop at 15 - 30 cm depth on 60 and 105 DAS in mg, Field Experiment No. 2 (1985-86)

Winter crops (C)	Fertilizer level (F)	Treated 60 DAS	Treated 105 DAS	Untreated 60 DAS	Untreated 105 DAS	Mean 60 DAS	Mean 105 DAS
Linseed	F_0	25.2	32.0	18.6	25.5	21.9	28.8
	$F_{20}+F_{40}$	35.5	44.0	32.5	34.0	34.0	39.0
	Mean	30.4	38.0	25.6	29.8	28.0	33.9
Peas	F_0	45.0	59.8	40.7	46.7	42.9	53.3
	$F_{20}+F_{40}$	51.0	61.8	47.9	54.0	49.5	57.9
	Mean	48.0	60.8	44.3	50.4	46.2	55.6
Lentil	F_0	26.8	35.4	24.8	32.1	25.8	33.8
	$F_{20}+F_{40}$	34.6	43.5	27.1	36.0	30.9	39.8
	Mean	30.7	39.5	25.9	34.1	28.4	36.8
Lathyrus-N	F_0	44.0	58.0	32.4	48.0	38.2	53.0
	$F_{20}+F_{40}$	48.5	61.3	42.3	54.5	45.4	57.9
	Mean	46.3	59.7	37.4	51.3	41.8	55.5
Lathyrus-L	F_0	40.3	47.1	36.2	41.5	38.3	44.3
	$F_{20}+F_{40}$	46.3	52.0	39.2	46.8	42.8	49.4
	Mean	43.3	49.6	37.7	44.2	40.6	46.9
Fertilizer	F_0	36.2	46.4	30.5	38.8	33.4	42.6
	$F_{20}+F_{40}$	43.2	52.5	37.8	45.1	40.5	48.8
Grand mean		39.7	49.5	34.2	42.0		

	C	S	F	CxS	CxF	SxF	CxSxF
At 60 DAS							
S.Em ±	1.66	1.26	0.87	2.81	1.95	1.24	2.76
C.D. at 5%	5.41	4.95	2.53	N.S.	N.S.	N.S.	N.S.
At 105 DAS							
S.Em ±	1.00	1.18	0.75	2.64	1.67	1.06	2.36
C.D. at 5%	3.26	4.63	2.18	N.S.	N.S.	N.S.	N.S.

weights recorded in all other crops; no significant difference was observed between lentil and *Lathyrus* (local). Top dressing of fertilizer significantly increased root dry weight both at 60 and 105 DAS 15.7 and 16.4 per cent respectively. Crops raised from pre-sowing treated seeds, showed increased amount of root dry weight even at 30 - 45 cm soil depth by 7.9 to 13.7 % ; the treatment differences were, however, not significant. None of the interactions between different factors were found significant (Table 4.50a).

In 1985-86, at 30 - 45 cm soil depth, peas recorded the highest root dry weight (28.3 mg / 578 c.c. of soil core at 60 and 40.6 mg / 578 c.c. of soil core at 105 DAS). It's differences with *Lathyrus* (Nirmal) were, however, significant at 105 DAS but not at 60 DAS. At 60 DAS, the lowest root dry weight (18.9 / 578 c.c. of soil core) was recorded in linseed but it did not differ significantly with lentil and *Lathyrus* (local). Although, Nirmal variety of *Lathyrus* recorded higher root dry weight than the local variety of *Lathyrus*, the differences between them was, however, not significant. Seed treatment and top dressing of fertilizer increased root dry weights significantly both at 60 and at 105 DAS. On an average due to pre-sowing seed treatment, the increments in root dry weights ranged from 19.9 to 35.6 % . Top dressing of fertilizer caused 12.3 to 23.4 % increases in dry weight of roots even at 30 - 45 cm depth. None of the interactions between different growth factors were significant (Table 4.50b).

Table 4.50a Effect of seed treatment and fertilizer application on root dry matter production in 578 c.c. of soil in winter crops, established as paira crop at 30 - 45 cm depth on 60 and 105 DAS in mg, Field Experiment No.2 (1984-85)

Winter crops (C) / Fertilizer level (F)		Seed treatment (S) Treated 60 DAS	Treated 105 DAS	Untreated 60 DAS	Untreated 105 DAS	Mean 60 DAS	Mean 105 DAS
Linseed	F_0	21.4	24.5	19.2	22.1	20.3	23.3
	$F_{20}+F_{40}$	24.7	27.5	23.9	26.4	24.3	26.9
	Mean	23.1	26.0	21.6	24.3	22.3	25.1
Peas	F_0	25.0	34.4	18.8	30.9	21.9	32.7
	$F_{20}+F_{40}$	28.7	39.4	24.2	37.6	26.5	38.5
	Mean	26.9	36.9	21.5	34.3	24.2	35.6
Lentil	F_0	22.3	28.0	15.4	25.0	18.9	26.5
	$F_{20}+F_{40}$	23.2	32.5	19.3	30.6	21.3	31.6
	Mean	22.8	30.3	17.4	27.8	20.1	29.1
Lathyrus-N	F_0	27.1	36.0	25.8	33.5	26.5	34.8
	$F_{20}+F_{40}$	30.3	40.7	28.9	38.6	29.6	39.7
	Mean	28.7	38.4	27.4	36.1	28.1	37.3
Lathyrus-L	F_0	21.3	30.7	20.9	27.7	21.1	29.2
	$F_{20}+F_{40}$	24.9	34.8	22.8	32.7	23.9	33.8
	Mean	23.1	32.8	21.9	30.2	22.5	31.5
Fertilizer	F_0	23.4	30.7	20.0	27.8	21.7	29.3
	$F_{20}+F_{40}$	26.4	35.0	23.8	33.2	25.1	34.1
Grand mean		24.9	32.9	21.9	30.5		

	C	S	F	CxS	CxF	SxF	CxSxF
At 60 DAS							
S.Em ±	0.74	0.80	0.34	1.80	0.75	0.48	1.06
C.D. at 5%	2.41	N.S.	0.99	N.S.	N.S.	N.S.	N.S.
At 105 DAS							
S.Em ±	0.91	0.77	0.36	1.72	0.80	0.50	1.13
C.D. at 5%	2.97	N.S.	1.05	N.S.	N.S.	N.S.	N.S.

Table 4.50b Effect of seed treatment and fertilizer application on root dry matter production in 578 c.c. of soil in winter crops, established as paira crop at 30 - 45 cm depth on 60 and 105 DAS in mg, Field Experiment No. 2 (1985-86)

Winter crops (C)	Fertilizer level (F)	Seed treatment (S): Treated 60 DAS	Treated 105 DAS	Untreated 60 DAS	Untreated 105 DAS	Mean 60 DAS	Mean 105 DAS
Linseed	F_0	21.1	30.5	14.0	24.5	17.6	27.5
	$F_{20}+F_{40}$	22.9	35.1	17.4	28.0	20.2	31.6
	Mean	22.0	32.8	15.7	26.3	18.9	29.6
Peas	F_0	29.0	41.0	21.3	36.1	25.2	38.6
	$F_{20}+F_{40}$	35.7	46.7	26.9	38.5	31.3	42.6
	Mean	32.4	43.9	24.1	37.3	28.3	40.6
Lentil	F_0	16.7	25.0	14.0	22.5	15.4	23.8
	$F_{20}+F_{40}$	24.6	32.5	18.8	25.5	21.7	29.0
	Mean	20.7	28.8	16.4	24.0	18.6	26.4
Lathyrus-N	F_0	26.4	34.8	19.7	30.5	23.1	32.7
	$F_{20}+F_{40}$	31.3	37.6	23.4	32.0	27.4	34.8
	Mean	28.9	36.2	21.6	31.3	25.3	33.8
Lathyrus-L	F_0	26.6	32.5	16.1	24.7	21.4	28.6
	$F_{20}+F_{40}$	28.6	33.5	22.7	29.0	25.7	31.3
	Mean	27.6	33.0	19.4	26.9	23.6	30.0
Fertilizer	F_0	24.0	32.8	17.0	27.7	20.5	30.2
	$F_{20}+F_{40}$	28.6	37.1	21.8	30.6	25.3	33.9
Grand mean		26.3	35.0	19.4	29.2		

	C	S	F	CxS	CxF	SxF	CxSxF
At 60 DAS							
S.Em ±	1.70	1.62	0.79	3.62	1.77	1.12	2.50
C.D. at 5%	5.54	6.36	2.30	N.S.	N.S.	N.S.	N.S.
At 105 DAS							
S.Em ±	1.25	0.75	0.56	1.67	1.25	0.79	1.76
C.D. at 5%	4.08	2.94	1.63	N.S.	N.S.	N.S.	N.S.

In 1984-85, at 45 - 60 cm soil depth, although Lathyrus (Nirmal) showed the highest root dry weight (12.6 mg / 578 c.c. of soil core) yet it's difference with peas was not significant at 60 DAS. But at 105 DAS, peas recorded significantly higher dry weight of roots then in Nirmal variety of Lathyrus. The difference between two varieties of Lathyrus was not significant both at 60 and 105 DAS. Linseed and lentil continued to accumulate less dry weights in roots than other crops. Crops raised from pre-sowing treated seeds produced significantly higher root dry weight (11.1 mg / 578 c.c. of soil core) than that was recorded in crops raised from untreated seeds at 60 DAS (9.5 mg / 578 c.c. of soil core). At 105 DAS, no significant difference in root dry weight production was recorded between the two pre-sowing seed treatments. Crops top dressed with fertilizer showed significantly higher root dry weight (11.1 mg / 578 c.c. of soil core at 60 DAS and at 105 DAS, 17.6 mg / 578 c.c. of soil core) than the crops raised without top dressing of fertilizer. Interactions between the growth factors were not significant (Table 4.51a).

In 1985-86, at 45 - 60 cm soil depth, at 60 DAS the highest root dry weight (16.7 mg / 578 c.c. of soil core) was recorded in peas and was significantly more than those recorded in lentil but not in other crops. At 105 DAS, Lathyrus (Nirmal) showed the highest root dry weight (21.6 mg / 578 c.c. of soil core) but it was not significantly more than those recorded in peas and Lathyrus (local); the lowest root dry weight

Table 4.51a Effect of seed treatment and fertilizer application on root dry matter production in 578 c.c. of soil in winter crops, established as <u>paira</u> crop at 45 - 60 cm depth on 60 and 105 DAS in mg, Field Experiment No. 2 (1984-85)

Winter crops (C)	Fertilizer level (F)	Seed treatment (S) Treated 60 DAS	Treated 105 DAS	Untreated 60 DAS	Untreated 105 DAS	Mean 60 DAS	Mean 105 DAS
Linseed	F_0	8.0	12.4	6.8	11.3	7.4	11.9
	$F_{20}+F_{40}$	9.3	16.3	8.2	15.9	8.8	16.1
	Mean	8.7	14.4	7.5	13.6	8.1	14.0
Peas	F_0	12.3	16.0	9.5	15.2	10.9	15.6
	$F_{20}+F_{40}$	14.4	22.9	12.1	19.5	13.3	21.2
	Mean	13.4	19.5	10.8	17.4	12.1	18.4
Lentil	F_0	7.5	14.6	6.8	11.1	7.2	12.9
	$F_{20}+F_{40}$	9.3	16.1	7.1	14.3	8.2	15.2
	Mean	8.4	15.4	6.9	12.7	7.7	14.1
Lathyrus-N	F_0	12.9	16.1	10.0	14.3	11.5	15.2
	$F_{20}+F_{40}$	14.4	19.1	12.7	17.0	13.6	18.1
	Mean	13.7	17.6	11.4	15.7	12.6	16.7
Lathyrus-L	F_0	11.0	15.2	10.7	14.7	10.9	15.0
	$F_{20}+F_{40}$	12.3	18.2	10.9	16.1	11.6	17.2
	Mean	11.7	16.7	10.8	15.4	11.3	16.1
Fertilizer	F_0	10.3	14.9	8.8	13.3	9.6	14.1
	$F_{20}+F_{40}$	11.9	18.5	10.2	16.6	11.1	17.6
Grand mean		11.1	16.7	9.5	15.0		

	C	S	F	CxS	CxF	SxF	CxSxF
At 60 DAS							
S.Em ±	0.49	0.33	0.18	0.75	0.40	0.25	0.57
C.D. at 5%	1.60	1.30	0.52	N.S.	N.S.	N.S.	N.S.
At 105 DAS							
S.Em ±	0.49	0.83	0.29	1.85	0.64	0.41	0.91
C.D. at 5%	1.60	N.S.	0.84	N.S.	1.86	N.S.	N.S.

(12.6 mg / 578 c.c. of soil core) was recorded in lentil, which was significantly lower than those recorded in linseed and other crops. Although plants raised from pre-sowing treated seeds had higher root dry weights than those raised from untreated seeds yet the difference between the seed treatments was not significant. Crops top dressed with fertilizer showed significantly higher root dry weights (14.7 and 19.2 mg / 578 c.c. of soil core at 60 and 105 DAS, respectively) than those recorded in crops without fertilizer (13.1 and 16.9 mg / 578 c.c. of soil core at 60 and 105 DAS, respectively). Interactions between the growth factors were not significant (Table 4.51b).

4.5.2.4 Number of nodules / plant

Number of nodules per plant were counted at 60 DAS, upto a depth of 0 - 25 cm soil in 1985-86 and 1986-87.

In 1985-86, the highest number of nodules / plant (174) was recorded in Lathyrus (Nirmal) which was significantly higher than those recorded in lentil and Lathyrus (local), but statistically at par with peas. The lowest number of nodules / plant (91) was recorded in lentil which was significantly lower than those recorded in other crops. Although both pre-sowing seed treatment and top dressing of fertilizer, slightly increased the number of nodules / plant, the treatment differences were not significant (Table 4.52a).

In 1986-87, Lathyrus (local) showed the highest number of nodules / plant (136) very closely followed by Nirmal variety

Table 4.51b Effect of seed treatment and fertilizer application on root dry matter production in 578 c.c. of soil in winter crops, established as *paira* crop at 45 - 60 cm depth on 60 and 105 DAS in mg, Field Experiment No. 2 (1985-86)

Winter crops (C)	Fertilizer level (F)	Seed treatment (S) Treated 60 DAS	Treated 105 DAS	Untreated 60 DAS	Untreated 105 DAS	Mean 60 DAS	Mean 105 DAS
Linseed	F_0	12.4	14.5	11.8	13.5	12.1	14.0
	$F_{20}+F_{40}$	13.9	17.6	13.7	16.2	13.8	16.9
	Mean	13.2	16.1	12.8	14.9	12.9	15.5
Peas	F_0	16.8	21.1	14.1	17.0	15.5	19.1
	$F_{20}+F_{40}$	18.8	23.0	16.8	22.9	17.8	23.0
	Mean	17.8	22.1	15.5	20.0	16.7	21.1
Lentil	F_0	7.2	12.4	8.0	11.1	7.6	11.8
	$F_{20}+F_{40}$	9.5	14.1	8.1	12.5	8.8	13.3
	Mean	8.4	13.3	8.1	11.8	8.2	12.6
Lathyrus-N	F_0	18.9	23.0	12.1	18.0	15.5	20.5
	$F_{20}+F_{40}$	17.8	24.0	16.6	21.1	17.2	22.6
	Mean	18.4	23.5	14.4	19.6	16.4	21.6
Lathyrus-L	F_0	16.1	20.8	13.5	17.8	14.8	19.3
	$F_{20}+F_{40}$	16.7	21.0	15.3	20.0	16.0	20.5
	Mean	16.4	20.9	14.4	18.9	15.4	19.9
Fertilizer	F_0	14.3	18.4	11.9	15.5	13.1	16.9
	$F_{20}+F_{40}$	15.3	19.9	14.1	18.5	14.7	19.2
Grand mean		14.8	19.2	13.0	17.0		

	C	S	F	CxS	CxF	SxF	CxSxF
At 60 DAS							
S.Em ±	1.23	1.17	0.45	2.61	1.01	0.64	1.43
C.D. at 5%	4.01	N.S.	1.31	N.S.	N.S.	N.S.	N.S.
At 105 DAS							
S.Em ±	0.63	0.65	0.32	1.45	0.72	0.46	1.02
C.D. at 5%	2.05	N.S.	0.93	N.S.	N.S.	N.S.	N.S.

Table 4.52a Effect of seed treatment and fertilizer application on number of nodules / plant of winter grain legumes, established as paira crop following rice at 60 DAS, Field Experiment No.2 (1985-86)

Seed treatment (S)	Fertilizer level (F)	Winter grain legumes (C) Peas	Lentil	Lathyrus-N	Lathyrus-L	Mean
Seeds treated	F_0	189	97	197	122	151
	$F_{20}+F_{40}$	165	95	256	144	165
	Mean	177	96	227	133	158
Seeds untreated	F_0	114	92	121	149	119
	$F_{20}+F_{40}$	156	79	120	138	123
	Mean	135	86	121	144	121
Fertilizer (Mean)	F_0	152	95	159	136	136
	$F_{20}+F_{40}$	161	87	188	141	144
Grand mean		156	91	174	139	

	C	S	F	CxS	CxF	SxF	CxSxF
S.Em ±	8.3	10.2	16.3	20.3	32.6	23.0	46.1
C.D. at 5%	28.7	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

of *Lathyrus* (128). This year number of nodules / plant in peas was low. The lowest number of nodules / plant (86) was recorded in lentil which was significantly lower than others. Effect of pre-sowing seed treatment and top dressing of fertilizer showed no significant differences between the treatments. Interaction between crops and top dressing of fertilizer was significant, indicating higher number of nodules / plant (146) in *Lathyrus* (local) where crop was top dressed with fertilizer. Other interactions were not found significant (Table 4.52b).

4.5.2.5 Yield components

4.5.2.5.1 Number of pods or capsules / m^2

Pods or capsules / m^2 were counted in all the three years of experimentation at harvest and these have been presented in Tables 4.53a, 4.53b and 4.53c in 1984-85, 1985-86 and 1986-87, respectively.

In 1984-85, as expected the differences in the number of pods or capsules / m^2 were significant amongst the crops. The highest number of pods / m^2 (6371) was recorded in lentil followed by number of capsules / m^2 in linseed (2922) and the lowest number of pods / m^2 (822) was recorded in peas which was significantly lower than those recorded in rest of the crops. No significant difference in number of pods / m^2 was observed between *Lathyrus* varieties. Crops raised from treated seeds produced significantly higher number of pods / m^2 (2784) than those recorded in crops raised from untreated seeds (2512 / m^2). Similarly, crops top dressed with fertilizer, produced

Table 4.52b Effect of seed treatment and fertilizer application on number of nodules / plant of winter grain legumes, established as paira crop following rice at 60 DAS, Field Experiment No.2 (1986-87)

Seed treatment (S)	Fertilizer level (F)	Winter grain legumes (C) Peas	Lentil	Lathyrus-N	Lathyrus-L	Mean
Seeds treated	F_0	147	77	163	108	124
	$F_{20}+F_{40}$	104	87	151	144	122
	Mean	126	82	157	126	123
Seeds untreated	F_0	97	101	92	141	108
	$F_{20}+F_{40}$	113	79	103	148	111
	Mean	105	90	98	145	110
Fertilizer (Mean)	F_0	122	89	128	125	116
	$F_{20}+F_{40}$	109	83	127	146	116
Grand mean		116	86	128	136	

	C	S	F	CxS	CxF	SxF	CxSxF
S.Em ±	4.80	5.73	2.75	11.47	5.51	3.89	7.79
C.D. at 5%	16.61	N.S.	N.S.	N.S.	16.21	N.S.	N.S.

Table 4.53a Effect of seed treatment and fertilizer application on number of pods or capsules / m^2 of winter crops, established as paira crop following rice at harvest, Field Experiment No. 2 (1984-85)

Seed treatment (S)	Fertilizer level (F)	Winter crops (C) Lin-seed	Peas	Lentil	Lathy-rus-N	Lathy-rus-L	Mean
Seeds treated	F_0	2604	803	6481	1604	1527	2604
	$F_{20}+F_{40}$	3494	935	7043	1667	1680	2964
	Mean	3049	869	6762	1636	1604	2784
Seeds untreated	F_0	2190	682	5459	1448	1481	2252
	$F_{20}+F_{40}$	3397	865	6498	1522	1579	2772
	Mean	2794	774	5979	1485	1530	2512
Fertilizer (Mean)	F_0	2397	743	5970	1526	1504	2428
	$F_{20}+F_{40}$	3446	900	6771	1595	1630	2868
Grand mean		2922	822	6371	1561	1567	

	C	S	F	CxS	CxF	SxF	CxSxF
S.Em ±	62.6	44.9	39.3	100.4	87.8	55.6	124.3
C.D. at 5%	204.1	176.3	114.2	N.S.	255.3	N.S.	N.S.

significantly higher number of pods / m^2 (2868) than those recorded in crops raised without fertilizer top dressing. Interaction effect between crops and fertilizer was significant. Lentil and linseed produced significantly higher number of pods or capsules with fertilizer top dressing than those recorded in the same crops without fertilizer top dressing. Other interactions were not significant.

In 1985-86, similar trend of variation in number of pods or capsules was observed in different crops as was observed in 1984-85. Seed treatment and fertilizer top dressing also showed similar type of variation as was observed in 1984-85. Interaction between crops and fertilizer top dressing was found to be significant. Top dressing of fertilizer caused greater increase in number of pods or capsules / m^2 in linseed and lentil than in other crops.

In 1986-87, the highest number of pods / m^2 (4759) was observed in lentil and the lowest (688) was recorded in peas which was significantly lower than in others. Seed treatment and top dressing of fertilizer showed similar effect as was observed in previous two years of experimentation. Interaction between crops and seed treatment was significant, indicating thereby that the pre-sowing seed treatment increased number of pods or capsules / m^2 more in linseed (8.7 %) and lentil (18.4 %) than in *Lathyrus* (7.2 to 13.5 %) and peas (9 %). Similarly, the interaction between fertilizer and crops being significant, it indicated, as in earlier years that top dressing

Table 4.53b Effect of seed treatment and fertilizer application on number of pods or capsules / m^2 of winter crops, established as paira crop following rice at harvest, Field Experiment No.2 (1985-86)

Seed treatment (S)	Fertilizer level (F)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathy-rus-N	Lathy-rus-L	Mean
Seeds treated	F_0	2215	931	4826	1300	1224	2099
	$F_{20}+F_{40}$	3541	1173	5892	1395	1368	2674
	Mean	2878	1052	5359	1348	1296	2387
Seeds untreated	F_0	2022	721	4156	1214	1137	1850
	$F_{20}+F_{40}$	3202	1038	4935	1279	1259	2343
	Mean	2612	880	4546	1247	1198	2097
Fertilizer (Mean)	F_0	2119	826	4491	1257	1181	1975
	$F_{20}+F_{40}$	3372	1106	5414	1337	1314	2509
Grand mean		2745	966	4953	1298	1247	

	C	S	F	CxS	CxF	SxF	CxSxF
S.Em ±	54.8	38.5	22.7	86.2	50.7	32.0	71.7
C.D. at 5%	178.7	151.3	66.0	N.S.	147.4	N.S.	N.S.

Table 4.53c Effect of seed treatment and fertilizer application on number of pods or capsules / m^2 of winter crops, established as <u>paira</u> crop following rice, at harvest, Field Experiment No.2 (1986-87)

Seed treatment (S)	Fertilizer level (F)	Winter crops (C) Linseed	Peas	Lentil	Lathyrus-N	Lathyrus-L	Mean
Seeds treated	F_0	2175	652	4212	1405	1162	1921
	$F_{20}+F_{40}$	3174	782	6105	1592	1576	2646
	Mean	2675	717	5159	1499	1369	2284
Seeds untreated	F_0	1822	628	3487	1306	1095	1668
	$F_{20}+F_{40}$	3102	687	5231	1489	1316	2365
	Mean	2462	658	4359	1398	1206	2017
Fertilizer (Mean)	F_0	1999	640	3850	1356	1129	1795
	$F_{20}+F_{40}$	3138	735	5668	1541	1446	2506
Grand mean		2569	688	4759	1449	1288	

	C	S	F	CxS	CxF	SxF	CxSxF
S.Em $\pm$	15.3	21.9	6.1	49.0	13.5	8.6	19.2
C.D. at 5%	49.9	86.0	17.7	192.4	39.3	N.S.	55.8

caused greater increase in pods or capsules / m^2 in linseed (57 %), lentil (47 %) and local variety of Lathyrus (28 %) than in peas (14.8 %) and Nirmal variety of Lathyrus (13.6 %). The interaction amongst crops, seed treatment and fertilizer application was also significant and this indicated some of the crops e.g. linseed and lentil gave the best performance through seed treatment and fertilizer application than others e.g. Lathyrus.

4.5.2.5.2 Number of seeds / pod or capsule

The number of seeds / pod or capsule were recorded in different crops in all the three years of experimentation which have been summarised in Tables 4.54a, 4.54b and 4.54c in 1984-85, 1985-86 and 1986-87, respectively.

In all the three years of experimentation, as expected due to various nature and genetical characters of the crops, significant differences in number of seeds / pod or capsule were observed amongst the crops. The highest number of seeds / capsule was observed in linseed and the lowest number of seeds / pod was observed in lentil which was significantly lower than those recorded in other crops. No significant difference in number of seeds / pod was observed between Lathyrus varieties in all the three years of experimentation. Effects of seed treatment and fertilizer top dressing and the interactions between different growth factors were not significant in all the three years of experimentation except in 1984-85 where the

Table 4.54a Effect of seed treatment and fertilizer application on number of seeds / pod or capsule of winter crops, established as *paira* crop following rice at harvest, Field Experiment No. 2 (1984-85)

Seed treatment (S) / Fertilizer level (F)		Winter crops (C)					
		Linseed	Peas	Lentil	Lathyrus-N	Lathyrus-L	Mean
Seeds treated	F_0	8.0	5.3	1.9	3.4	3.6	4.4
	$F_{20}+F_{40}$	8.3	5.6	1.9	3.5	3.6	4.6
	Mean	8.2	5.5	1.9	3.5	3.6	4.5
Seeds untreated	F_0	7.6	5.4	1.8	3.3	3.5	4.3
	$F_{20}+F_{40}$	8.1	5.5	1.9	3.4	3.2	4.4
	Mean	7.9	5.5	1.9	3.4	3.4	4.4
Fertilizer (Mean)	F_0	7.8	5.4	1.9	3.4	3.6	4.4
	$F_{20}+F_{40}$	8.2	5.6	1.9	3.5	3.4	4.5
Grand mean		8.1	5.5	1.9	3.5	3.5	

	C	S	F	CxS	CxF	SxF	CxSxF
S.Em ±	0.08	0.07	0.03	0.15	0.05	0.04	0.09
C.D. at 5%	0.26	N.S.	0.09	N.S.	0.15	N.S.	N.S.

Table 4.54b Effect of seed treatment and fertilizer application on number of seeds / pod or capsule of winter crops, established as paira crop following rice - Field Expreiment No.2 (1985-86)

Seed treatment (S)	Fertilizer level (F)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathy-rus-N	Lathy-rus-L	Mean
Seeds treated	F_0	8.8	5.5	1.9	3.6	3.6	4.7
	$F_{20}+F_{40}$	8.8	5.5	1.9	3.7	3.5	4.7
	Mean	8.8	5.5	1.9	3.7	3.6	4.7
Seeds untreated	F_0	8.3	5.4	1.7	3.5	3.5	4.5
	$F_{20}+F_{40}$	8.7	5.3	1.8	3.3	3.5	4.5
	Mean	8.5	5.4	1.8	3.4	3.5	4.5
Fertilizer (Mean)	F_0	8.6	5.5	1.8	3.6	3.6	4.6
	$F_{20}+F_{40}$	8.8	5.4	1.9	3.5	3.5	4.6
Grand mean		8.7	5.5	1.9	3.6	3.6	

	C	S	F	CxS	CxF	SxF	CxSxF
S.Em $\pm$	0.07	0.09	0.04	0.20	0.08	0.05	0.12
C.D. at 5%	0.23	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 4.54c Effect of seed treatment and fertilizer application on number of seeds / pod or capsule of winter crops, established as paira crop following rice - Field Experiment No.2 (1986-87)

Seed treatment (S)	Fertilizer level (F)	Winter crops (C) Linseed	Peas	Lentil	Lathyrus-N	Lathyrus-L	Mean
Seeds treated	F_0	9.1	5.1	2.0	3.5	3.7	4.7
	$F_{20}+F_{40}$	9.0	5.2	2.0	3.8	3.7	4.7
	Mean	9.1	5.2	2.0	3.7	3.7	4.7
Seeds untreated	F_0	9.0	5.3	1.9	3.5	3.5	4.6
	$F_{20}+F_{40}$	8.8	5.4	1.9	3.6	3.6	4.7
	Mean	8.9	5.4	1.9	3.6	3.6	4.7
Fertilizer (Mean)	F_0	9.1	5.2	2.0	3.5	3.6	4.7
	$F_{20}+F_{40}$	8.9	5.3	2.0	3.7	3.7	4.7
Grand mean		9.0	5.3	2.0	3.7	3.7	

	C	S	F	CxS	CxF	SxF	CxSxF
S.Em ±	0.08	0.08	0.03	0.19	0.07	0.04	0.10
C.D. at 5%	0.26	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

crops top dressed with fertilizer showed slightly greater number of seeds / pod or capsule, more particularly in linseed.

4.5.2.5.3 Test weight

Test weights or 100 seeds weight of all the crops in all the three years of experimentation were recorded and summarised in Tables 4.55a, 4.55b and 4.55c in 1984-85, 1985-86 and 1986-87, respectively.

In all the three years, peas showed the highest test weight of grains (7.32 g / 100 seeds) than those recorded in all other crops. The lowest test weight was observed in linseed which was significantly lower than the others in all the three years of experimentation. Lathyrus varieties showed no significant difference in test weight in all the three years. Crops top dressed with fertilizer showed significantly higher (2 to 3.7 %) test weight in 1984-85 and 1986-87 than the test weights recorded in crops raised without top dressing. Significant increase in test weights (3.5 - 4.2 %) due to interaction between crops and fertilizer top dressing was observed particularly in peas and Lathyrus (Nirmal) in 1986-87 only.

4.5.2.6 Grain yield of crops

Grain yields in kg / ha of all the crops were recorded in all the three years and have been summarised in Tables 4.56a, 4.56b and 4.56c in 1984-85, 1985-86 and 1986-87, respectively.

In 1984-85, Lathyrus (Nirmal) recorded the highest grain yield (1927 kg / ha) but it did not differ significantly

Table 4.55a Effect of seed treatment and fertilizer application on test (in g of 100 seeds) weight of winter crops, established as *paira* crop following rice, Field Experiment No.2 (1984-85)

Seed treatment (S) Fertilizer level (F)		Winter crops (C) Linseed	Peas	Lentil	Lathyrus-N	Lathyrus-L	Mean
Seeds treated	F_0	0.51	7.12	1.72	5.58	5.29	4.04
	$F_{20}+F_{40}$	0.52	7.75	1.75	5.79	5.68	4.30
	Mean	0.52	7.44	1.74	5.69	5.49	4.17
Seeds untreated	F_0	0.51	7.45	1.61	5.46	5.19	4.04
	$F_{20}+F_{40}$	0.51	7.25	1.76	5.51	5.42	4.09
	Mean	0.51	7.35	1.69	5.49	5.31	4.07
Fertilizer (Mean)	F_0	0.51	7.29	1.67	5.52	5.24	4.05
	$F_{20}+F_{40}$	0.52	7.50	1.76	5.65	5.55	4.20
Grand mean		0.52	7.40	1.72	5.59	5.40	

	C	S	F	CxS	CxF	SxF	CxSxF
S.Em ±	0.06	0.09	0.01	0.22	0.02	0.01	0.03
C.D. at 5%	0.02	N.S.	0.03	N.S.	N.S.	N.S.	N.S.

Table 4.55b Effect of seed treatment and fertilizer application on test (in g of 100 seeds) weight of winter crops, established as *paira* crop following rice, Field Experiment No.2 (1985-86)

Seed treatment (S)	Fertilizer level (F)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathy-rus-N	Lathy-rus-L	Mean
Seeds treated	F_0	0.52	7.22	1.68	5.48	5.39	4.06
	$F_{20}+F_{40}$	0.50	7.36	1.71	5.65	5.33	4.11
	Mean	0.51	7.29	1.70	5.57	5.36	4.09
Seeds untreated	F_0	0.51	7.21	1.60	5.41	5.37	4.02
	$F_{20}+F_{40}$	0.51	7.14	1.69	5.36	5.45	4.03
	Mean	0.51	7.18	1.65	5.39	5.41	4.03
Fertilizer (Mean)	F_0	0.52	7.22	1.64	5.45	5.38	4.04
	$F_{20}+F_{40}$	0.51	7.25	1.70	5.51	5.39	4.07
Grand mean		0.51	7.24	1.68	5.48	5.39	

	C	S	F	CxS	CxF	SxF	CxSxF
S.Em ±	0.03	0.09	0.02	0.22	0.04	0.02	0.05
C.D. at 5%	0.10	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 4.55c Effect of seed treatment and fertilizer application on test (in g of 100 seeds) weight of winter crops, established as paira crop following rice, Field Experiment No.2 (1986-87)

Seed treatment (S)	Fertilizer level (F)	Winter crops (C) Lin-seed	Peas	Lentil	Lathy-rus-N	Lathy-rus-L	Mean
Seeds treated	F_0	0.50	7.14	1.74	5.57	5.68	4.13
	$F_{20}+F_{40}$	0.53	7.58	1.73	5.70	5.48	4.20
	Mean	0.52	7.36	1.74	5.64	5.58	4.17
Seeds untreated	F_0	0.52	7.22	1.65	5.42	5.41	4.04
	$F_{20}+F_{40}$	0.51	7.37	1.67	5.67	5.47	4.14
	Mean	0.52	7.30	1.66	5.55	5.44	4.09
Fertilizer (Mean)	F_0	0.51	7.18	1.70	5.50	5.55	4.09
	$F_{20}+F_{40}$	0.52	7.48	1.70	5.69	5.48	4.17
Grand mean		0.52	7.33	1.70	5.60	5.51	

	C	S	F	CxS	CxF	SxF	CxSxF
S.Em ±	0.03	0.09	0.02	0.20	0.03	0.02	0.05
C.D. at 5%	0.10	N.S.	0.06	N.S.	0.09	N.S.	N.S.

with *Lathyrus* (local) (1890 kg / ha) and these two grain yields were significantly higher than those recorded in rest of the other crops. The lowest grain yield (778 kg / ha) was recorded in linseed which was significantly lower than all others. Seed treatment did not cause significant difference. Crops top dressed with fertilizer gave significantly higher grain yields (1606 kg / ha) than those (1420 kg / ha) raised without fertilizer top dressing. Interaction between different factors was not significant. Seed treatment increased yields very slightly but significantly (9 %) and it ranged from 12 % in lentil to 6 % in peas. The mean grain yields also increased significantly due to top dressing of fertilizer (13 %), ranging from 49 % in linseed to 9 % in *Lathyrus* (local).

In 1985-86, the highest grain yield was recorded in peas (1968 kg / ha) and the lowest (741 kg / ha) in linseed which was significantly lower than those, recorded in other crops. No significant difference in grain yield was observed between *Lathyrus* varieties. Crops raised from treated seeds and also the crops top dressed with fertilizer showed significantly higher grain yields than those recorded in crops raised from untreated seeds and without top dressing of fertilizer. The interaction between crops and fertilizer was significant. Productivity of linseed increased due to top dressing of fertilizer to the extent of 69 % ; the corresponding increase in peas, lentil, *Lathyrus* (Nirmal) and *Lathyrus* (local) were 24, 14, 12 and 16 per cent, respectively.

Table 4.56a Effect of seed treatment and fertilizer application on the productivity of winter crops, established as paira crop following rice in kg / ha, Field Experiment No. 2 (1984-85)

Seed treatment (S) Fertilizer level (F)		Winter crops (C) Lin-seed	Peas	Lentil	Lathy-rus-N	Lathy-rus-L	Mean
Seeds treated	F_0	654	1619	1357	1931	1885	1489
	$F_{20}+F_{40}$	955	1809	1402	2109	2046	1664
	Mean	805	1714	1380	2020	1966	1577
Seeds untreated	F_0	597	1561	1101	1773	1725	1351
	$F_{20}+F_{40}$	905	1667	1368	1895	1902	1547
	Mean	751	1614	1235	1834	1814	1449
Fertilizer (Mean)	F_0	626	1590	1229	1852	1805	1420
	$F_{20}+F_{40}$	930	1738	1385	2002	1974	1606
Grand mean		778	1664	1307	1927	1890	

	C	S	F	CxS	CxF	SxF	CxSxF
S.Em ±	40.1	42.7	21.6	95.5	48.3	30.6	68.3
C.D. at 5%	130.8	N.S.	62.8	N.S.	N.S.	N.S.	N.S.
C.V. %	9.18	15.46	7.82				

Table 4.56b Effect of seed treatment and fertilizer application on the productivity of winter crops, established as *paira* crop following rice in kg / ha, Field Experiment No.2 (1985-86)

Seed treatment (S)	Fertilizer level (F)	Winter crops (C)					
		Linseed	Peas	Lentil	Lathyrus-N	Lathyrus-L	Mean
Seeds treated	F_0	573	1919	933	1507	1553	1297
	$F_{20}+F_{40}$	1011	2283	1105	1784	1624	1561
	Mean	792	2101	1019	1646	1589	1429
Seeds untreated	F_0	528	1592	886	1473	1245	1145
	$F_{20}+F_{40}$	853	2076	977	1565	1618	1418
	Mean	691	1834	932	1519	1432	1282
Fertilizer (Mean)	F_0	551	1756	910	1490	1399	1221
	$F_{20}+F_{40}$	932	2180	1041	1675	1621	1490
Grand mean		741	1968	976	1583	1510	

	C	S	F	CxS	CxF	SxF	CxSxF
S.Em ±	50.7	27.7	17.1	62.0	38.3	24.2	54.2
C.D. at 5%	165.3	108.7	49.7	N.S.	111.4	N.S.	157.6
C.V. %	12.97	11.21	6.92				

In 1986-87, the highest grain yield (1705 kg / ha) was recorded in *Lathyrus* (Nirmal) and the lowest (635 kg / ha) was recorded in linseed, which was significantly lower than all other crops. *Lathyrus* (local) and peas showed no significant difference in yield between them. In 1986-87 also pre-sowing seed treatment caused significant mean increase in grain yield of about 11 % ranging from 18 % in lentil to 5 % in *Lathyrus* (Nirmal). Top dressing with fertilizer also significantly increased the productivity of crops by about 23 % , ranging from 65 % in linseed to 10 % in *Lathyrus* (Nirmal). The interaction between crops and fertilizer was not significant.

4.5.2.7 Monetary evaluation of productivity (in Rs / ha)

Grain yield differences of different crops belonging to different species can be well evaluated if the values of the products are taken into consideration. The Rupee value of the produce from different crops have been summarised in Tables 4.57a, 4.57b and 4.57c for the years 1984-85, 1985-86 and 1986-87, respectively.

In 1984-85, the highest productivity in terms of Rs / ha (Rs.7073) was recorded in peas and the lowest (Rs.3735) was recorded in linseed which was significantly lower than the all other crops. No significant difference in the monetary values of the produce was observed between *Lathyrus* varieties. The effect of seed treatment could not show any significant difference in productivity (Rs / ha). Crops top dressed with fertilizer showed significantly higher productivity in Rs / ha

Table 4.56c Effect of seed treatment and fertilizer application on the productivity of winter crops, established as paira crop following rice in kg / ha, Field Experiment No. 2 (1986-87)

Seed treatment (S)	Fertilizer level (F)	Winter crops (C) Linseed	Peas	Lentil	Lathyrus-N	Lathyrus-L	Mean
Seeds treated	F_0	525	1523	888	1680	1513	1226
	$F_{20}+F_{40}$	802	1707	1200	1815	1839	1473
	Mean	664	1615	1044	1748	1676	1350
Seeds untreated	F_0	435	1393	722	1571	1227	1070
	$F_{20}+F_{40}$	777	1527	1048	1752	1700	1361
	Mean	606	1460	885	1662	1464	1216
Fertilizer (Mean	F_0	480	1458	805	1626	1370	1148
	$F_{20}+F_{40}$	790	1617	1124	1784	1770	1417
Grand mean		635	1538	965	1705	1570	

	C	S	F	CxS	CxF	SxF	CxSxF
S.Em ±	35.9	29.2	23.0	65.2	51.5	32.6	72.8
C.D. at 5%	117.1	114.6	66.5	N.S.	N.S.	N.S.	N.S.
C.V. %	9.73	12.48	9.85				

Table 4.57a Effect of seed treatment and fertilizer application on the productivity of winter crops, established as *paira* crop following rice in Rs / ha, Field Experiment No.2 (1984-85)

Seed treatment(S)	Fertilizer level (F)	Winter crops (C)					
		Linseed	Peas	Lentil	Lathyrus-N	Lathyrus-L	Mean
Seeds treated	F_0	3139	6883	5362	4732	4619	4947
	$F_{20}+F_{40}$	4587	7688	5539	5168	5013	5599
	Mean	3863	7286	5451	4950	4816	5273
Seeds untreated	F_0	2867	6635	4350	4343	4226	4484
	$F_{20}+F_{40}$	4347	7084	5406	4642	4660	5228
	Mean	3607	6860	4878	4493	4443	4856
Fertilizer (Mean)	F_0	3003	6759	4856	4538	4423	4716
	$F_{20}+F_{40}$	4467	7386	5473	4905	4837	5414
Grand mean		3735	7073	5165	4722	4630	

	C	S	F	CxS	CxF	SxF	CxSxF
S.Em ±	144.2	138.8	79.9	310.3	178.6	113.0	252.6
C.D. at 5%	470.3	N.S.	232.3	N.S.	519.3	N.S.	N.S.
C.V. %	9.9	15.0	8.6				

(Rs.5414) than those (Rs.4716) raised without fertilizer top dressing. Interaction between crops and fertilizer top dressing was also significant. The productivity in terms of Rs / ha of linseed, peas and lentil increased more than those recorded in Lathyrus varieties. No other interaction was significant.

In 1985-86 also, peas recorded the highest productivity in Rs / ha (Rs.8363) amongst all crops. Linseed recorded the lowest productivity in Rs / ha (Rs.3959) and it was at par with lentil and Lathyrus varieties. Crops raised from treated seeds and crops top dressed with fertilizer showed significantly higher productivities in Rs / ha than those crops raised from untreated seeds and without fertilizer top dressing. Interaction between crops and fertilizer top dressing was significant and it indicated that increase in productivities in Rs / ha were more in linseed and peas than others due to fertilizer top dressing. No other interaction was significant.

In 1986-87 also, peas recorded the highest productivity in Rs / ha (Rs.6534) amongst all crops and the lowest (Rs.3048) was recorded in linseed. No significant difference was observed between lentil and Lathyrus varieties. Seed treatment and fertilizer top dressing showed also increased monetary valuation in crops. Interaction was not found significant.

4.5.2.8 Evaluation of the treatments in terms of energy productivity

Grain yields in kg / ha of different crops were converted into energy in MJ / ha by multiplying the energy unit equivalent

Table 4.57b Effect of seed treatment and fertilizer application on the productivity of winter crops, established as paira crop following rice in Rs / ha, Field Experiment No.2 (1985-86)

Seed treatment (S)	Fertilizer level (F)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathy-rus-N	Lathy-rus-L	Mean
Seeds treated	F_0	2750	8158	3685	3693	3805	4418
	$F_{20}+F_{40}$	4856	9704	4364	4371	3980	5455
	Mean	3803	8931	4025	4032	3893	4937
Seeds untreated	F_0	2537	6766	3502	3608	3050	3893
	$F_{20}+F_{40}$	4072	8823	3860	3833	3965	4915
	Mean	3315	7795	3681	3721	3508	4404
Fertilizer (Mean)	F_0	2644	7462	3594	3651	3428	4156
	$F_{20}+F_{40}$	4474	9264	4112	4102	3973	5185
Grand mean		3559	8363	3853	3877	3701	

	C	S	F	CxS	CxF	SxF	CxSxF
S.Em ±	172.1	93.7	97.6	209.6	218.1	138.0	308.5
C.D. at 5%	561.2	367.9	283.8	N.S.	634.2	N.S.	NS.
C.V. %	12.8	11.0	11.4				

Table 4.57c Effect of seed treatment and fertilizer application on the productivity of winter crops, established as paira crop following rice in Rs / ha, Field Experiment No.2 (1986-87)

Seed treatment (S) / Fertilizer level (F)		Winter crops (C) Lin-seed	Peas	Lentil	Lathy-rus-N	Lathy-rus-L	Mean
Seeds treated	F_0	2520	6471	3510	4116	3708	4065
	$F_{20}+F_{40}$	3850	7253	4740	4446	4505	4959
	Mean	3185	6862	4125	4281	4107	4512
Seeds untreated	F_0	2089	5922	2851	3849	3005	3543
	$F_{20}+F_{40}$	3731	6488	4138	4292	4165	4563
	Mean	2910	6205	3495	4071	3585	4053
Fertilizer (Mean)	F_0	2305	6197	3181	3983	3357	3805
	$F_{20}+F_{40}$	3791	6871	4439	4369	4335	4761
Grand mean		3048	6534	3810	4176	3846	

	C	S	F	CxS	CxF	SxF	CxSxF
S.Em ±	132.0	88.4	92.0	197.7	205.8	130.2	291.0
C.D. at 5%	430.5	347.0	267.5	N.S.	N.S.	N.S.	N.S.
C.V. %	10.7	11.3	11.8				

to each kg of seeds of respective crops. This provided the scope for analysing the treatment differences between different winter crops of various species. The results have been summarised in Tables 4.58a, 4.58b and 4.58c for the years 1984-85, 1985-86 and 1986-87, respectively.

In 1984-85, the highest amount of energy accumulation (28332 MJ / ha) was observed in Lathyrus (Nirmal) grains but it did not differ significantly with the productivity of Lathyrus (local) (27780 MJ / ha). The lowest amount of productivity in terms of energy output (19220 MJ / ha) was obtained in lentil and did not differ significantly with linseed (19454 MJ / ha). Seed treatment showed no significant difference in energy accumulation in crops. Top dressing of fertilizer caused higher energy accumulation (25528 MJ / ha) than those raised without fertilizer top dressing (22173 MJ / ha). Interaction effect between crops and fertilizer top dressing showed increased productivity in terms of energy output (MJ / ha) in all the crops, though significant difference was not obtained in peas only. The other interactions were not significant.

In 1985-86, peas recorded the highest energy accumulation (28927 MJ / ha) and the lowest (14340 MJ / ha) was recorded in lentil which was significantly lower than all other crops. As in 1984-85, this year also no significant difference in energy accumulation was observed between two Lathyrus varieties. Crops raised from treated seeds showed higher productivity in terms

Table 4.58a Evaluations of the effect of seed treatment and fertilizer application in terms of energy productivity (MJ / ha) in winter crops, established as paira crop following rice, Field Experiment No.2 (1984-85)

Seed treatment (S) / Fertilizer level (F)		Winter crops (C) Lin-seed	Peas	Lentil	Lathy-rus-N	Lathy-rus-L	Mean
Seeds treated	F_0	16350	23809	19958	28395	27719	23246
	$F_{20}+F_{40}$	23892	26592	20615	31012	30081	26438
	Mean	20121	25201	20287	29704	28900	24842
Seeds untreated	F_0	14933	22951	16189	26063	25357	21099
	$F_{20}+F_{40}$	22642	24505	20119	27856	27964	24617
	Mean	18788	23728	18154	26960	26661	22858
Fertilizer (mean)	F_0	15642	23380	18074	27229	26538	22173
	$F_{20}+F_{40}$	23267	25549	20367	29434	29023	25528
Grand mean		19454	24464	19220	28332	27780	

	C	S	F	CxS	CxF	SxF	CxSxF
S.Em ±	705.3	621.8	334.7	1390.4	748.3	473.2	1058.3
C.D. at 5%	2300.1	N.S.	973.2	N.S.	2175.8	N.S.	N.S.
C.V. %	10.2	14.3	7.7				

of energy output (22646 MJ / ha) than those raised from untreated seeds. Crops top dressed with fertilizer also showed significantly higher productivity in terms of energy output (23821 MJ / ha) than those raised without fertilizer top dressing. Effect of interaction between crops and top dressing of fertilizer showed significant increase in energy accumulation (MJ / ha) in all the crops except in lentil. No other interaction was significant.

In 1986-87, *Lathyrus* (Nirmal) showed the highest productivity in terms of energy output (25055 MJ / ha) as was recorded in 1984-85, and the lowest (14179 MJ / ha) was recorded in lentil, but it was statistically at par with linseed. This year, no significant difference in energy accumulation was observed between peas and *Lathyrus* (local). Effects of seed treatment and fertilizer application were similar to those observed in 1985-86. Interaction between crops and top dressing of fertilizer showed significant increase in energy accumulation in linseed, lentil and *Lathyrus* (local) due to top dressing of fertilizers but not in others. No other interaction was found significant.

4.5.2.9 Loss of soil moisture through winter crops sown by *paira* method

Under *paira* method of crops establishment seeds were sown in standing water (5 cm) and then 24 hours after sowing, the water was drained out. At this time soil was saturated and the loss of moisture consisted of percolation loss, evaporational loss through soil surface and transpirational loss both from standing rice crop (10 - 12 days before harvest) and the newly emerged winter crops.

Table 4.58b Evaluation of the effect of seed treatment and fertilizer application in terms of energy of productivity (MJ / ha) in winter crops, established as paira crop following rice, Field Experiment No.2 (1985-86)

Seeds treatment (S)	Fertilizer level (F)	Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathy-rus-N	Lathy-rus-L	Mean
Seeds treated	F_0	14325	28219	13715	22163	22829	20250
	$F_{20}+F_{40}$	25292	33565	16243	26225	23883	25042
	Mean	19809	30892	14979	24194	23356	22646
Seeds untreated	F_0	13217	23402	13034	21653	18306	17922
	$F_{20}+F_{40}$	21317	30522	14366	23000	23794	22600
	Mean	17267	26962	13700	22327	21050	20261
Fertilizer (Mean)	F_0	13771	25811	13375	21908	20568	19087
	$F_{20}+F_{40}$	23305	32044	15305	24613	23839	23821
Grand mean		18538	28927	14340	23261	22203	

	C	S	F	CxS	CxF	SxF	CxSxF
S.Em ±	802.5	449.0	308.2	1004.1	689.2	435.8	974.6
C.D. at 5%	2617.1	1762.7	896.1	N.S.	2003.9	N.S.	N.S.
C.V. %	13.0	11.5	7.9				

Table 4.58c Evaluation of the effect of seed treatment and fertilizer application in terms of energy productivity (MJ / ha) in winter crops, established as paira crop following rice, Field Experiment No.2 (1986-87)

Seed treatment (S) Fertilizer level (F)		Winter crops (C) Linseed	Peas	Lentil	Lathyrus-N	Lathyrus-L	Mean
Seeds treated	F_0	13125	22383	13064	24696	22246	19103
	$F_{20}+F_{40}$	20050	25088	17640	26676	27029	23297
	Mean	16588	23736	15352	25686	24638	21200
Seeds untreated	F_0	10883	20482	10609	23094	18032	16620
	$F_{20}+F_{40}$	19433	22442	15401	25754	24990	21604
	Mean	15158	21462	13005	24424	21511	19112
Fertilizer (Mean)	F_0	12004	21433	11837	23895	20139	17862
	$F_{20}+F_{40}$	19742	23765	16521	26215	26010	22451
Grand mean		15873	22599	14179	25055	23075	

	C	S	F	CxS	CxF	SxF	CxSxF
S.Em ±	533.8	427.4	399.2	955.7	892.6	564.5	1262.3
C.D. at 5%	1740.8	1677.9	1160.7	N.S.	2595.3	N.S.	N.S.
C.V. %	9.2	11.6	10.8				

In 1984-85 upto 60 DAS (Table 4.59a), peas recorded the highest percolation + evapotranspiration loss of soil moisture (667 mm) closely followed by Lathyrus (Nirmal); the minimum amount of loss of water was recorded in linseed (640 mm). The differences in losses of profile stored soil moisture between lentil and Lathyrus varieties and between linseed, lentil and Lathyrus (local) were statistically not significant. Upto 105 DAS also (Table 4.59a), peas showed the highest percolation + evapotranspiration loss of soil moisture (772 mm) and the lowest amount of loss was recorded in lentil (721 mm) and it was statistically at par with linseed (725 mm). Crops raised from treated seeds and also crops top dressed with fertilizer showed significantly higher losses of soil moisture than those recorded in crops raised from untreated seeds and unfertilized (no top dressing) crops upto 60 and 105 DAS. The interactions between treatments were not significant.

In 1985-86 upto 60 DAS, peas again recorded the highest (674 mm) loss of soil moisture closely followed by Lathyrus varieties (Table 4.59b) and the lowest amount of soil moisture loss was recorded in linseed (638 mm) and it was at par with lentil and Lathyrus (local). Again between lentil and Lathyrus (Nirmal) the difference in soil moisture loss showed no significant difference upto 60 DAS. Upto 105 DAS also, peas recorded the highest loss of soil moisture (758 mm) closely followed by Lathyrus (Nirmal) and the lowest was recorded in lentil (712 mm) which was statistically at par with linseed. The crops raised from treated seeds showed higher losses of

Table 4.59a Effect of seed treatment and fertilizer application on soil moisture loss (mm) in winter crops, established as paira crop upto 60 and 105 DAS, Field Experiment No.2 (1984-85)

Winter crops (C)	Fertilizer level (F)	Seed treatment (S)					
		Treated		Untreated		Mean	
		60 DAS	105 DAS	60 DAS	105 DAS	60 DAS	105 DAS
Linseed	F_0	627	713	625	705	626	709
	$F_{20}+F_{40}$	660	750	646	732	653	741
	Mean	644	732	636	719	640	725
Peas	F_0	662	770	644	741	653	756
	$F_{20}+F_{40}$	686	796	675	779	681	788
	Mean	674	783	660	760	667	772
Lentil	F_0	635	711	627	699	631	705
	$F_{20}+F_{40}$	667	746	651	727	659	737
	Mean	651	729	639	713	645	721
Lathyrus-N	F_0	655	749	641	738	648	744
	$F_{20}+F_{40}$	678	788	655	764	667	776
	Mean	667	769	648	751	658	760
Lathyrus-L	F_0	643	741	632	712	638	727
	$F_{20}+F_{40}$	665	773	652	751	659	762
	Mean	654	757	642	732	649	745
Fertilizer	F_0	644	737	634	719	639	728
	$F_{20}+F_{40}$	671	771	656	751	664	761
Grand mean		658	754	645	735		

	C	S	F	CxS	CxF	SxF	CxSxF
At 60 DAS							
S.Em ±	4.2	3.0	2.6	6.7	5.8	3.6	8.1
C.D. at 5%	13.7	11.8	7.6	N.S.	N.S.	N.S.	N.S.
At 105 DAS							
S.Em ±	2.8	3.4	1.3	7.6	2.8	1.8	4.0
C.D. at 5%	9.1	13.3	3.8	N.S.	N.S.	N.S.	N.S.

Table 4.59b Effect of seed treatment and fertilizer application on soil moisture loss (mm) in winter crops, established as paira crop at 60 and 105 DAS, Field Experiment No.2 (1985-86)

Winter crops (C)	Fertilizer level (F)	Seed treatment (S) Treated 60 DAS	Treated 105 DAS	Untreated 60 DAS	Untreated 105 DAS	Mean 60 DAS	Mean 105 DAS
Linseed	F_0	632	712	627	702	629	707
	$F_{20}+F_{40}$	647	736	644	727	646	732
	Mean	640	724	636	714	638	719
Peas	F_0	665	747	661	737	663	742
	$F_{20}+F_{40}$	695	782	676	765	686	773
	Mean	680	765	669	751	674	758
Lentil	F_0	638	708	626	692	632	700
	$F_{20}+F_{40}$	654	730	647	716	651	723
	Mean	646	719	637	704	641	712
Lathyrus-N	F_0	660	758	637	729	649	744
	$F_{20}+F_{40}$	686	779	662	759	674	767
	Mean	673	769	650	742	661	756
Lathyrus-L	F_0	651	735	636	710	643	723
	$F_{20}+F_{40}$	672	760	659	744	666	752
	Mean	662	748	648	727	655	738
Fertilizer	F_0	649	732	637	714	643	723
	$F_{20}+F_{40}$	671	757	658	741	664	749
Grand mean		660	745	648	728		

	C	S	F	CxS	CxF	SxF	CxSxF
At 60 DAS							
S.Em ±	7.0	3.4	2.2	7.5	5.0	3.2	7.1
C.D. at 5%	22.8	N.S.	6.4	N.S.	N.S.	N.S.	N.S.
At 105 DAS							
S.Em ±	2.9	2.5	1.1	5.6	2.5	1.6	3.5
C.D. at 5%	9.5	9.8	3.2	N.S.	N.S.	N.S.	N.S.

soil moisture than those recorded in crops raised from untreated seeds and the difference was significant only upto 105 DAS. Top dressing of fertilizer caused significantly higher loss of soil moisture than those crops raised with fertilizer (no top dressing) both upto 60 and 105 DAS. None of the interactions was found significant.

4.5.2.10 Water use efficiency (kg / mm / ha) of winter crops

The water use efficiency of the paira crop observed here was much lower than those observed under conventional tillage, in Field Experiment No.1. Here also, as mentioned in Field Experiment No.1, the seeds were sown in standing water and then 24 h after sowing, the water was drained out. About 60 % of the total rainfall (34.3 mm in 1984-85 and 15.3 mm in 1985-86) received during growth period was added to soil moisture loss also. As such, the water present in the soil at the time of sowing can be classified as moisture at saturated level which might have been lost as percolation, as transpiration from rice crop (10 - 12 days before harvest) and from the seedlings of winter crops, in addition to the loss of soil moisture from soil surface through evaporation.

The water use efficiency ranged from 1.08 kg / mm / ha in linseed to 2.54 kg / mm / ha in *Lathyrus* (local) in 1984-85 and 1.03 kg / mm / ha in linseed to 2.60 kg / mm / ha in peas in 1985-86. The effects of fertilizer and that of seed treatment were also appreciable and positive. The crops like peas and *Lathyrus* increased efficiency through proper management (Table 4.60).

Table 4.60 Effect of seed treatment and fertilizer application on water use efficiency (kg / mm / ha) of winter crops, established as paira crop, calculated on the basis of loss of soil water upto 105 DAS, Field Experiment No.2 (1984-85 and 1985-86)

Winter crops (C)	Fertilizer level (F)	Seed treatment (S)					
		Treated		Untreated		Mean	
		1984-85	1985-86	1984-85	1985-86	1984-85	1985-86
Linseed	F_0	0.92	0.80	0.85	0.75	0.89	0.78
	$F_{20}+F_{40}$	1.27	1.37	1.24	1.17	1.26	1.27
	Mean	1.10	1.09	1.05	0.96	1.08	1.03
Peas	F_0	2.10	2.57	2.11	2.16	2.11	2.37
	$F_{20}+F_{40}$	2.27	2.92	2.14	2.71	2.21	2.82
	Mean	2.19	2.75	2.13	2.44	2.16	2.60
Lentil	F_0	1.91	1.32	1.58	1.28	1.75	1.30
	$F_{20}+F_{40}$	1.88	1.51	1.88	1.36	1.88	1.44
	Mean	1.90	1.42	1.73	1.32	1.82	1.36
Lathyrus-N	F_0	2.58	1.99	2.40	2.02	2.49	2.01
	$F_{20}+F_{40}$	2.68	2.29	2.48	2.08	2.58	2.19
	Mean	2.63	2.14	2.44	2.05	2.54	2.10
Lathyrus-L	F_0	2.54	2.11	2.42	1.75	2.48	1.93
	$F_{20}+F_{40}$	2.65	2.14	2.53	2.17	2.59	2.16
	Mean	2.60	2.13	2.48	1.96	2.54	2.05
Fertilizer	F_0	2.01	1.76	1.87	1.59	1.94	1.68
	$F_{20}+F_{40}$	2.15	2.05	2.05	1.90	2.10	1.98
Grand mean		2.08	1.91	1.96	1.75		

CHAPTER 5

GENERAL DISCUSSION

5. GENERAL DISCUSSION

In eastern India comprising Assam, West Bengal, Bihar, Orissa, eastern U.P. and in Bangladesh about one third of the rice is cultivated in lowlying situations. Monocropping of aman rice is a general practice in lowlying situations. Land preparation, immediately after harvesting of aman rice, for growing winter crops is a problem, due to the presence of excessive soil moisture. On the other hand winter is short in eastern India as a result aman rice cultivated land in lowlying remain fallow in winter months in most of the places. Sometimes, cultivators broadcast Lathyrus seeds in aman rice fields 10 - 20 days prior to it's harvesting in lowlying situation where rice crop is expected to be harvested by November or early December. In a survey work conducted, before taking up this project to diagnose the problem in seven villages in P.S. Kalyani of Nadia district it has been observed that cultivators sow Lathyrus seeds in aman rice fields about 20 - 30 days before the harvest of preceding rice crop. They use 40 - 50 kg seeds / ha and harvest 10 - 20 q / ha of grain. Now-a-days they grow Lathyrus in compact blocks as fodder and earn about Rs.1500 / ha, without any investment except the cost of seed by taping the profile stored soil moisture.

As Lathyrus contains neurotoxin which causes lathyrism and the male consumers are more prone to be affected by it, the World Health Organisation has banned it's cultivation.

So to find out substitute crops for *Lathyrus* and also to increase cropping intensity in lowland rice cultivated fields a series of experiments (the results of which have been presented earlier) were carried out. In this chapter a broad discussion on the results have been attempted.

5.1 Stand establishment

Establishment of adequate population of plants per unit area in right time is the most important factor affecting the productivity of crops. The series of experiments (Net House Experiment No.1, 2 and 3) conducted in Net House on puddled soil proved that peas under puddled soil without any standing water and without shade showed very poor establishment. The reason might be the seed size. The big sized seeds when sown on puddled soil without standing water or any soil / mulch coverage might have failed to imbibe sufficient moisture required for germination. While absorbing water, the permeability of seeds for gas exchange increases, allowing for the free movement of gas in both directions (Gupta, 1981). The water dilutes the reserve materials stored in the seed, while activating the various enzymatic cycles, enabling the breakdown of the various storage tissues. It has been observed that from 0 level to 72 h of submergence on puddled soil and in presence of shade peas seeds germinated well though as compared to conventional tillage the percentage was less (about 20 %). But without shade upto 72 h of submergence the stand establishment was far below (> 46 %) the conventional tillage; this might have something to do with temperature variations and low rate of imbibation of water. Seed treatment both at Net House and in Field Experiment could not improve stand establishment significantly in any of the crops. In case of linseed, stand establishment was high on puddled soil at all the levels of submergences upto 36 h. In case of lentil, stand establishment was better when submergence ranged from 12 to 24 h and inferior at 0 level and above 24 h of submergences. *Lathyrus* varieties on the other hand germinated and established well upto 72 h of submergence though the germination percentage was lower than those under conventional tillage (upto 28 % lower). It has further been observed that linseed and lentil penetrate the radicles into the soil earlier in puddled soil condition than peas resulting better establishment. Under field condition there was lesser stand establishment to the extent of 5.2 % in linseed, 18.1 % in peas, 16.5 % in lentil, 11.1 % in *Lathyrus* (Nirmal) and 6.4 % in *Lathyrus* (local) under *paira* cropping than under conventional method of stand establishment. In *paira* method of crop establishment, fertilizer and seed treatment had virtually no contribution in improving stand establishment. Rhixon (1969) reported 20 % less stand establishment in minimum tillage than under normal tillage method.

5.2 Shoot dry matter production

Shoot dry matter production was more under conventional tillage (about 15 %) than under *paira* cropping (Fig. 5.1, 5.2 and 5.3). In conventional tillage higher amount of root growth in different depths of soil enabled the plant to extract more

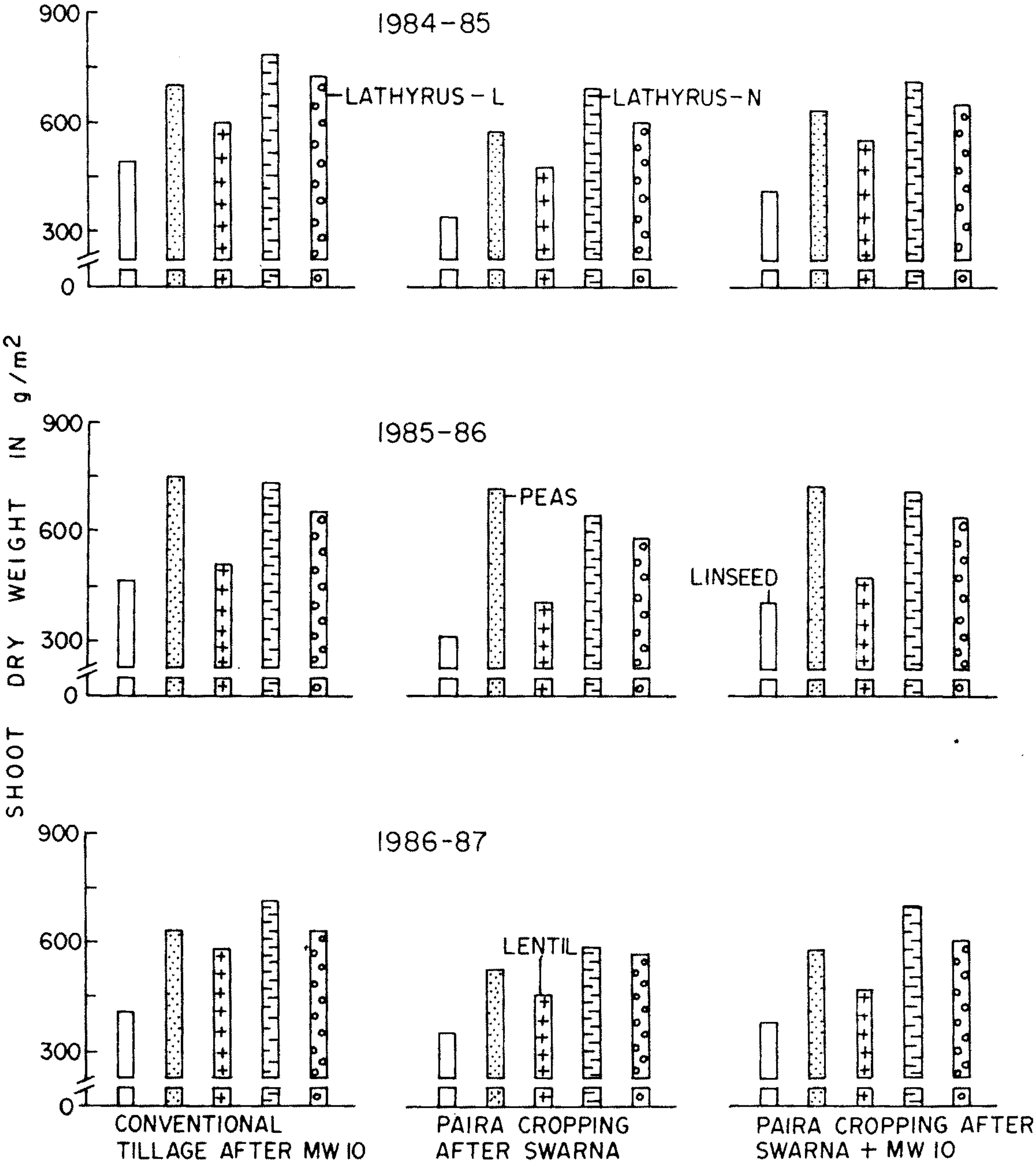


FIG.5.1 SHOOT DRY WEIGHTS OF WINTER CROPS (IN g / m^2) AT 90 DAS WHEN ESTABLISHED UNDER DIFFERENT SOIL CONDITIONS.

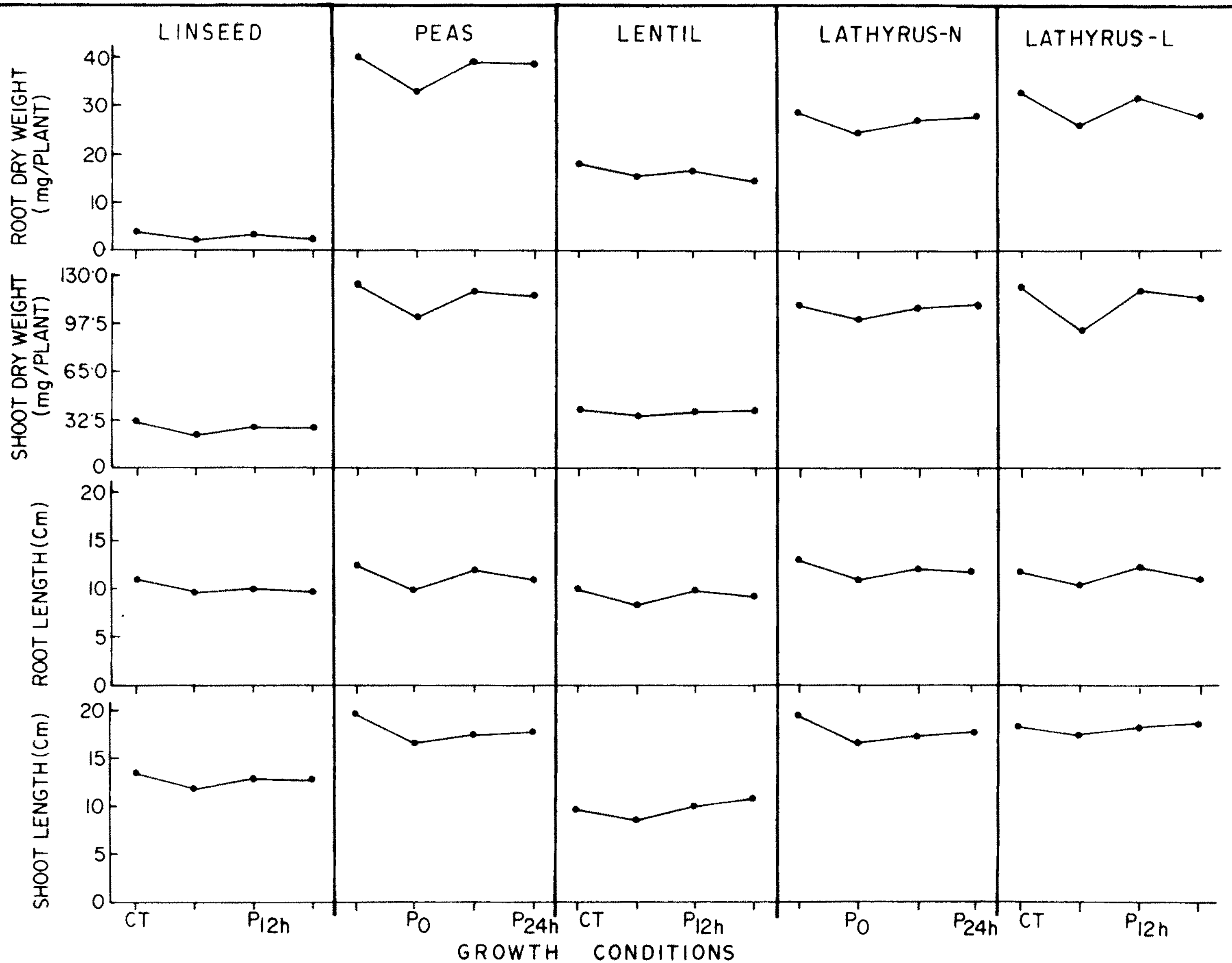


FIG.5.2 GROWTH ATTRIBUTES OF CROPS (AT 26 DAS) SOWN UNDER DIFFERENT CONDITIONS [CT=CONVENTIONAL TILLAGE, P=PUDDLED SOIL SUBMERGED FOR 0,12 AND 24 HOUR(h)], NET HOUSE EXPERIMENT NO. 1.

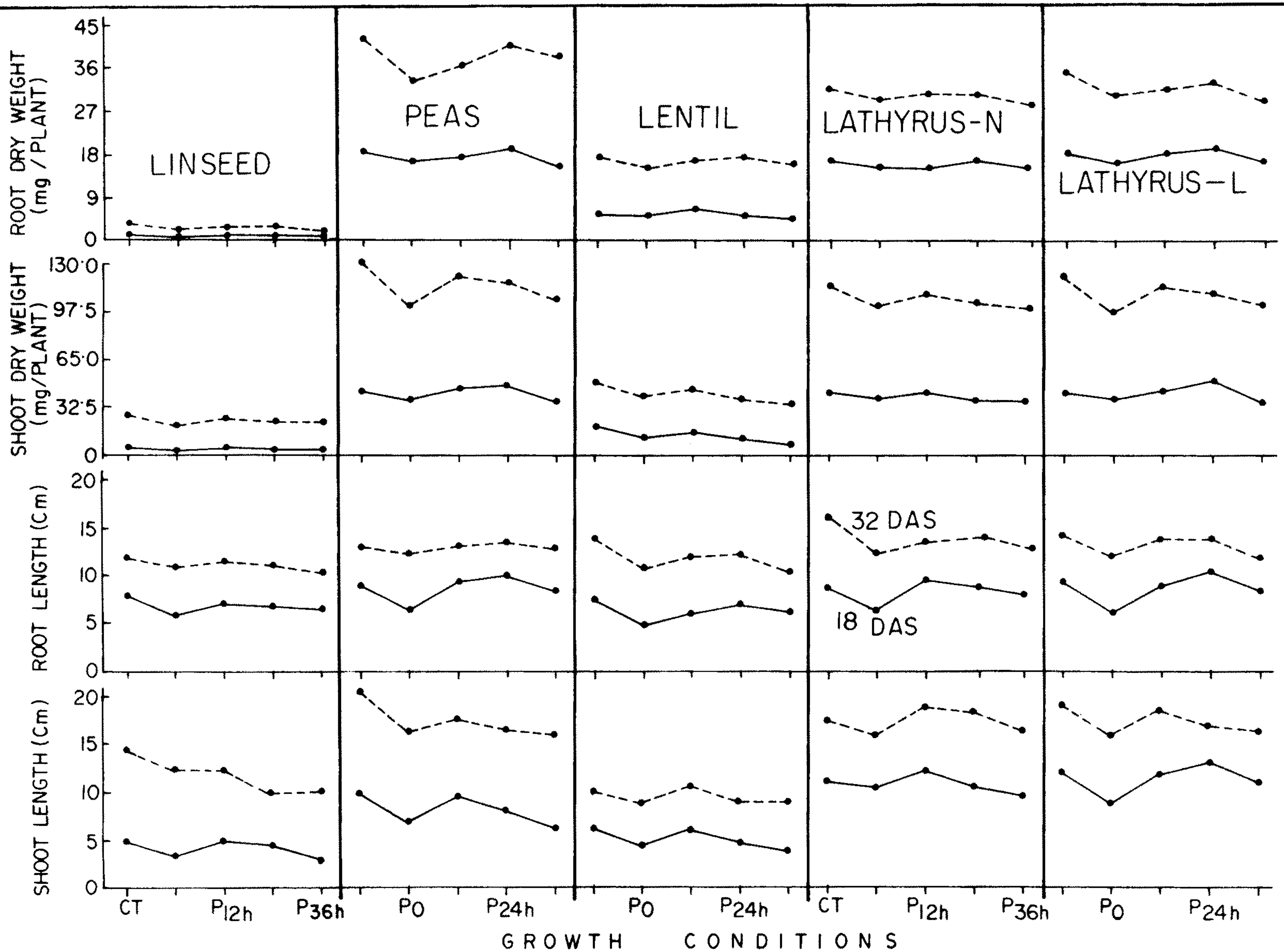


FIG. 5.3 GROWTH ATTRIBUTES OF CROPS (AT 19 AND 32 DAS) SOWN UNDER DIFFERENT CONDITIONS [CT = CONVENTIONAL TILLAGE, P = PUDDLED SOIL SUBMERGED FOR 0, 12, 24 AND 36 HOURS (h)], NET HOUSE EXPERIMENT NO. 2.

nutrient and moisture from lower depth of soil in comparison to those plants established under paira method of crop establishment. The higher nutrient and moisture extraction from the soil in turn might have produced higher shoot dry matter under conventional method than in paira method of crop establishment in all the crops. Again higher shoot dry matter production in paira crop (> 9.2 %) was recorded in intercropped rice (alternate paired row planting of early 'MW 10' + late 'Swarna') due to higher nutrient and moisture utilization than those under sole cropping (Swarna) rice under paira method.

5.2.1 Effect of pre-sowing seed treatment on shoot dry matter production of winter crops under paira method

The increase in shoot dry matter production due to pre-sowing seed treatment in all crops under paira cropping was due to increased vigour of the plants than those raised from untreated seeds. Basu et al. (1975) observed that seed treatment with sodium phosphate, oxalic acid, sodium chloride and others enhanced vigour of seeds of gram, Lathyrus, lentil, greengram etc. The percentage increase of shoot dry matter production varied between years (Table 5.1 and Fig. 5.4) during the period of experimentation.

Helton and Dilback (1982) observed increase in shoot weight of peas when seeds were treated with different concentration of H_2O_2 for different length of time.

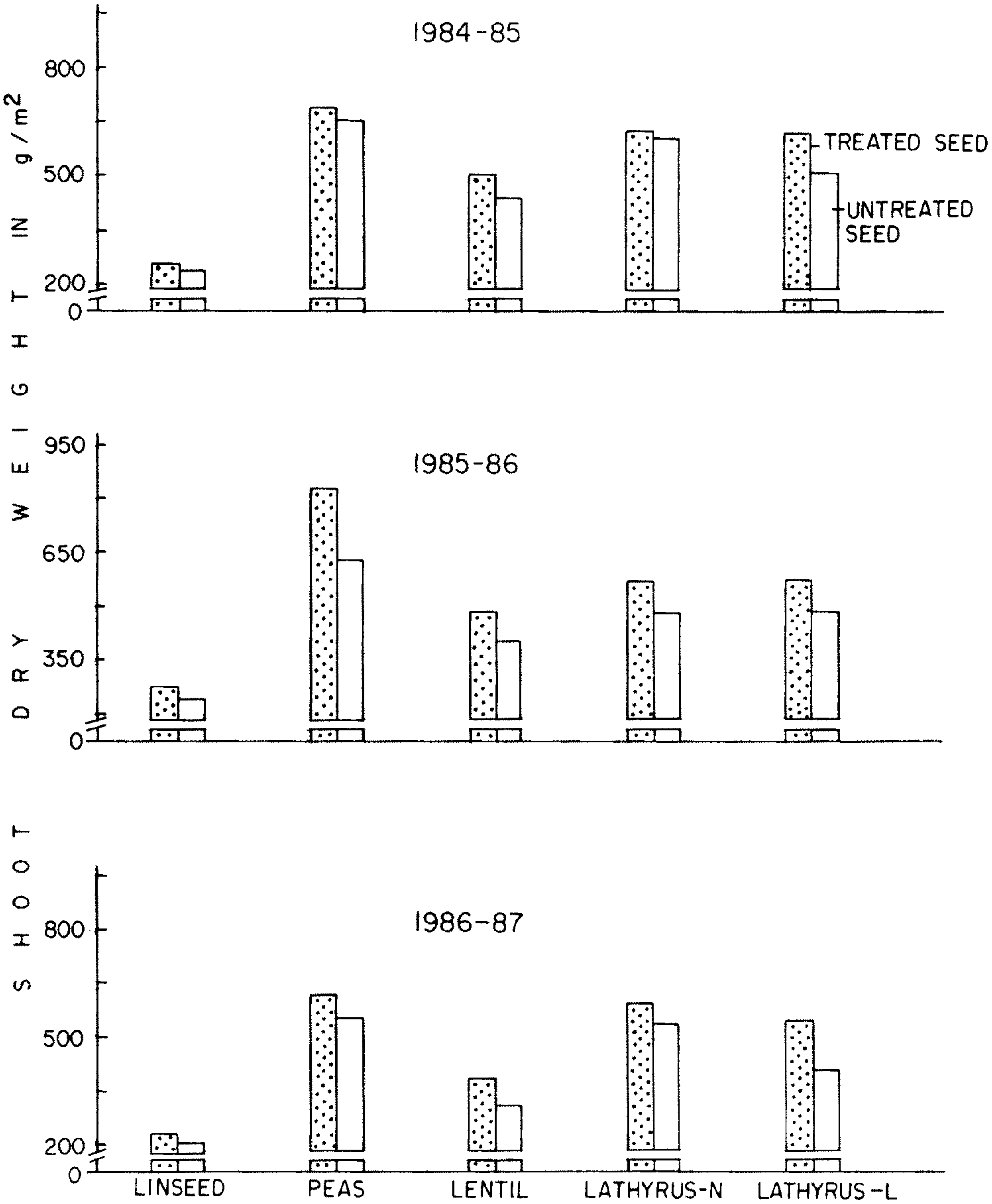


FIG.5.4 EFFECT OF PRE-SOWING SEED TREATMENT ON THE SHOOT DRY WEIGHTS (IN g/m^2) OF WINTER CROPS AT 90 DAS.

Table 5.1 Percentage increase in shoot dry matter production due to pre-sowing seed treatment in winter crops under *paira* method of crop establishment (1984-85 to 1986-87)

Crops	Percentage increase in short dry matter			
	1984-85	1985-86	1986-87	Mean
Linseed	10.3	20.6	7.6	12.8
Peas	6.1	24.0	11.9	14.0
Lentil	16.4	20.4	19.7	18.8
Lathyrus-N	9.4	20.3	7.1	12.3
Lathyrus-L	13.9	11.1	19.2	14.7

5.2.2 Effect of fertilizer top dressing on shoot dry matter production of winter crops under *paira* method

In all crops, shoot dry matter production increased due to top dressing of fertilizer. This was due to the availability of more nutrient for plant growth. The maximum advantage of fertilizer top dressing was observed in linseed than the other legumes under experimentation. The increase in percentage of shoot dry matter production varied between years (Table 5.2 and Fig. 5.5).

The mean percentage increase in shoot dry matter production in grain legumes i.e. in peas, lentil and *Lathyrus* varieties varied from 15.5 % in *Lathyrus* (Nirmal) to 24.8 % in lentil due to fertilizer top dressing.

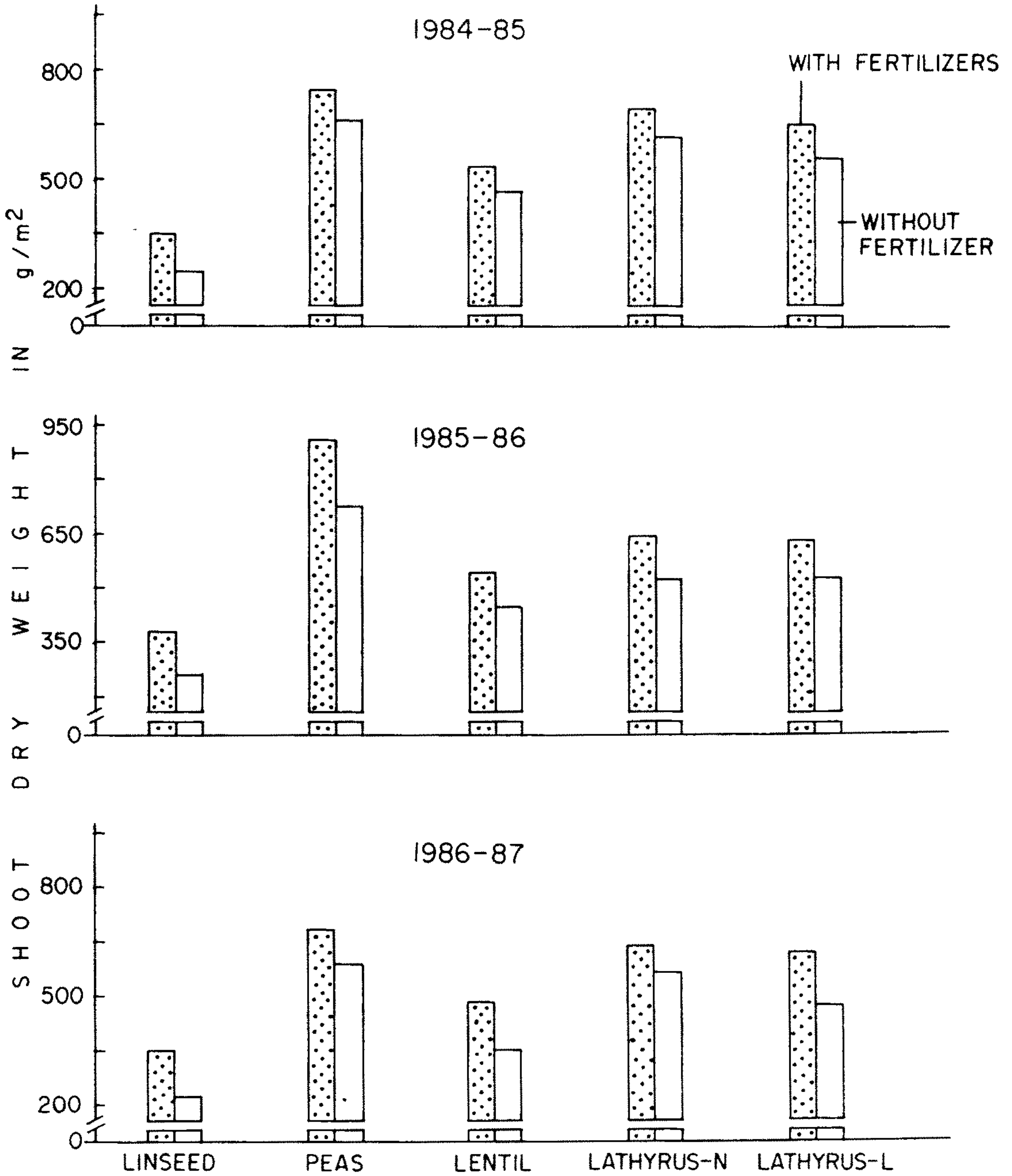


FIG.5.5 EFFECT OF FERTILIZERS ON THE SHOOT DRY WEIGHTS (IN g/m²) OF WINTER CROPS AT 90 DAS.

Table 5.2 Percentage increase in shoot dry matter production due to fertilizer top dressing in winter crops under *paira* method of crop establishment (1984-85 to 1986-87)

Crops	Percentage increase in shoot dry matter			
	1984-85	1985-86	1986-87	Mean
Linseed	42.0	43.1	49.5	44.9
Peas	11.9	25.6	16.3	17.9
Lentil	14.5	21.9	38.0	24.8
Lathyrus-N	12.3	22.0	12.2	15.5
Lathyrus-L	15.9	19.9	31.5	22.4

5.3 Root dry matter production

Higher root dry matter production was recorded in winter crops when established under conventional method of crop establishment than under *paira* cropping. This might be due to higher root aeration under conventional tillage (due to less soil compaction) than under *paira* method of crop establishment and under different periods of submergence in Net House Experiments (Fig. 5.2 and 5.3). Again *paira* crops relayed in intercrop of 'early MW 10 + late Swarna' rice produced higher root weight than the *paira* crop relayed in sole crop of 'late Swarna' rice. This might be due to greater availability of soil moisture and nutrients than those relayed in late variety (sole rice Swarna).

5.3.1 Effect of pre-sowing seed treatment on root dry matter production of winter crops under *paira* method

Higher root dry matter productions were observed in winter crops raised from pre-sowing treated seeds under *paira* method of crop establishment than those raised from untreated seeds. This was partly because of increased vigour of crop roots. The increased vigour in turn enabled the roots to increase in weight (Table 5.3).

Table 5.3 Effect of pre-sowing seed treatment on root dry matter production of winter crops under *paira* method of crop establishment in 0 - 60 cm soil depth at 105 DAS (1984-85 and 1985-86)

Crops	Root dry weight mg / 2312 cc of soil					
	1984-85		1985-86		Mean	
	Treated	Untreated	Treated	Untreated	Treated	Untreated
Linseed	235	221	238	210	237	216
Peas	310	290	324	284	317	287
Lentil	261	250	237	214	249	232
Lathyrus-N	294	274	292	262	293	268
Lathyrus-L	280	261	268	245	274	253

Chatterjee and Singh (1983) found that crops raised from pre-sowing treated seeds with Na_2HPO_4, $Al(NO_3)_2$ and $CO(NO_3)_2$ increased in the root and shoot growth and ultimately increased the grain yield of barley. In 1980, Chatterjee and

Singh also reported that pre-sowing seed treatment of rice in Na_2HPO_4, water and $Al(NO_3)_3$ resulted in better root growth.

5.3.2 Effect of fertilizer top dressing on root dry matter production of winter crops under <u>paira</u> method

Root dry matter production (Table 5.4) increased in all the crops due to top dressing of fertilizer. Better root development must have caused better absorption of moisture and through moisture the nutrients.

Table 5.4 Effect of top dressing of fertilizer on root dry matter production of winter crops under <u>paira</u> method of crop establishment in 0 - 60 cm soil depth at 105 DAS (1984-85 and 1985-86)

Crops	Root dry weight mg / 2312 cc of soil					
	1984-85		1985-86		Mean	
	Fertilized	Unfertilized	Fertilized	Unfertilized	Fertilized	Unfertilized
Linseed	243	213	242	206	243	210
Peas	317	283	322	286	320	285
Lentil	266	245	241	210	254	228
Lathyrus-N	296	272	286	268	291	270
Lathyrus-L	285	257	268	245	277	251

5.4 Productivity of winter crops

5.4.1 Productivity (of grains) in kg / ha

Under conventional tillage all winter crops produced higher seed yield (1667 kg / ha) than under <u>paira</u> method

(1423 kg / ha) of crop establishment during the period of experimentation, when they were sown almost at the same time. This might be due to the fact that the soil pore space available in conventional method of crop establishment have enabled better root growth. Better root growth extracted more nutrient and soil moisture from the soil and ultimately yielded high. Sipos (1972) and Kaul et al. (1970) reported similar results obtained between tillage and no-tillage crop production. Further the loose soil mulch might have caused better conservation of profile stored soil moisture and its conventional tillage than under minimum tillage. Placement of seeds and fertilizer in furrow might have also caused better stand establishment and increased efficiency of moisture (along with nutrients) and nutrient utilisation. Paira crop following intercrop of 'early MW 10 + late Swarna' rice produced higher grain yield (1529 kg / ha) than paira crop followed in sole crop of 'late Swarna' rice (1389 kg / ha). This was due to the harvesting of 'MW 10' rice, well ahead (35 - 45 days earlier) of sowing of paira crop seed, which facilitated more sunlight penetration inside the mixed culture of rice field and less drainage on the profile stored soil moisture. The higher amount of sunlight availability caused better early vegetative growth in paira crops followed in mixed culture of rice than those which followed lately harvested crop of rice.

Amongst the substitute crops for Lathyrus (local), the highest grain yield was recorded in Lathyrus (Nirmal) (1835 kg/ha) followed by peas (1714 kg / ha) and the lowest in linseed (883 kg / ha). These variations in grain yield amongst different crops were due to the variation in their genetical make up.

5.4.1.1 Effect of pre-sowing seed treatment on productivity of winter crops under paira method

The higher productivity in crops established with pre-sowing treated seeds was due to the better initial growth than the crops established with untreated seeds (Table 5.5). Many workers have studied effect of seed treatment with different chemicals and reported increases in crop yields (Abhichandani and Ramiah, 1951; Pawar et al., 1960; Mehrotra et al., 1967; Barthakur et al., 1973; Basu et al., 1974, 1975; Singh and Chatterjee, 1980 and Chatterjee et al., 1985).

Table 5.5 Percentage increase in productivity due to seed treatment under paira method of crop establishment in winter crops (1984-85 to 1986-87)

Crops	Percentage increase in productivity			
	1984-85	1985-86	1986-87	Mean
Linseed	7.2	14.2	9.6	10.3
Peas	6.2	14.6	10.6	10.5
Lentil	11.7	9.3	18.0	13.0
Lathyrus-N	10.1	8.4	5.2	7.9
Lathyrus-L	8.4	11.0	14.5	11.3

5.4.1.2 Effect of fertilizer top dressing on productivity in winter crops under *paira* method

The mean percentage increase in productivity due to fertilizer top dressing was more in linseed (60.8 %) and least in *Lathyrus* - Nirmal (10.1 %) amongst the substitute crops for *Lathyrus* (local) (Table 5.6). In *paira* method of crop establishment it was not possible to incorporate fertilizer with the soil, as it could be done under conventional tillage.

Table 5.6 Percentage increase in productivity due to fertilizer top dressing in winter crops under *paira* method of crop establishment (1984-85 to 1986-87)

Crops	Percentage increase in productivity			
	1984-85	1985-86	1986-87	Mean
Linseed	48.6	69.2	64.6	60.8
Peas	9.3	24.2	10.9	14.8
Lentil	12.7	14.4	39.6	22.2
Lathyrus-N	8.1	12.4	9.7	10.1
Lathyrus-L	9.4	15.9	29.2	18.2

5.4.1.3 Grain yield and its relation with root growth

The variation in grain yield in winter crops were positively correlated with root growth (0 - 60 cm soil depth) as summarized in Table 5.7. This might be because of utilisation of soil moisture and nutrients through roots. Dawson (1965), Singh and Chatterjee (1980), Chatterjee and Singh (1983) and

Sen Gupta *et al.* (1984) reported positive correlation between root growth and grain yield of crops when established from pre-sowing treated seeds. Besides these, similar relationship has been reported by a large number of workers.

Table 5.7 Correlation between grain yield and dry weights of roots (0 - 60 cm) of winter crops, expressed in r values

Particulars	1984-85	1985-86
Experiment No.1		
Linseed	0.671*	0.639*
Peas	0.717*	-
Lentil	0.898*	0.714*
Lathyrus-N	0.893*	0.594*
Lathyrus-L	0.828*	-
Experiment No.2		
Linseed	0.678*	0.878*
Peas	0.316 N.S.	0.771*
Lentil	0.581*	-
Lathyrus-N	0.700*	0.670*
Lathyrus-L	0.427 N.S.	0.518*

* Significant at 5 % level

5.4.2 Productivity in terms of Rs / ha

The productivity of different winter experimental crops were compared from the monetary point of view to explain the relative efficiency of different crops whose genetical make up differed. It has been observed in result chapter that productivity of peas in terms of Rs / ha was always much higher in all the treatments than all other winter crops in all the years (Fig. 5.6). From the pooled analysis of three years data, of two field experiments conducted, showed, amongst the substitute crops for Lathyrus (local), the highest monetary advantages in growing peas were 81 and 62 per cent more than Lathyrus (local) in Field Experiment No.2 (Table 5.8) and Field Experiment No.1 (Table 5.9), respectively. The high monetary advantages in peas were due to high grain yield except Lathyrus (Nirmal) amongst the substitute crops of Lathyrus (local). Another most significant reason was high market value (in Rupees) of pea seeds than that of Lathyrus grain which are less favoured by consumers. After peas, lentil and linseed gave monetary advantages which were almost equal or slightly more than Lathyrus (Local). However, the demand of linseed and lentil are more amongst consumers than Lathyrus growing. So it's marketing is not a problem.

Pre-sowing seed treatment, which actually cost little, significantly increased productivity in terms of Rs / ha as well (Fig. 5.7). Similarly, fertilization of winter paira crops also increased the productivity (Fig. 5.8). The mean benefits per rupee investment on fertilization were Rs.3.90, Rs.2.50, Rs.2.00, Rs.1.00 and Rs.1.60 in linseed, peas, lentil, Lathyrus (Nirmal) and Lathyrus (local), respectively.

5.4.3 Productivity in terms of energy output (MJ / ha)

From the mean of three years result it has been observed that the high energy output was recorded in Nirmal variety of Lathyrus (26976 MJ / ha) followed by peas (25199 MJ / ha) amongst the substitute of Lathyrus (local).

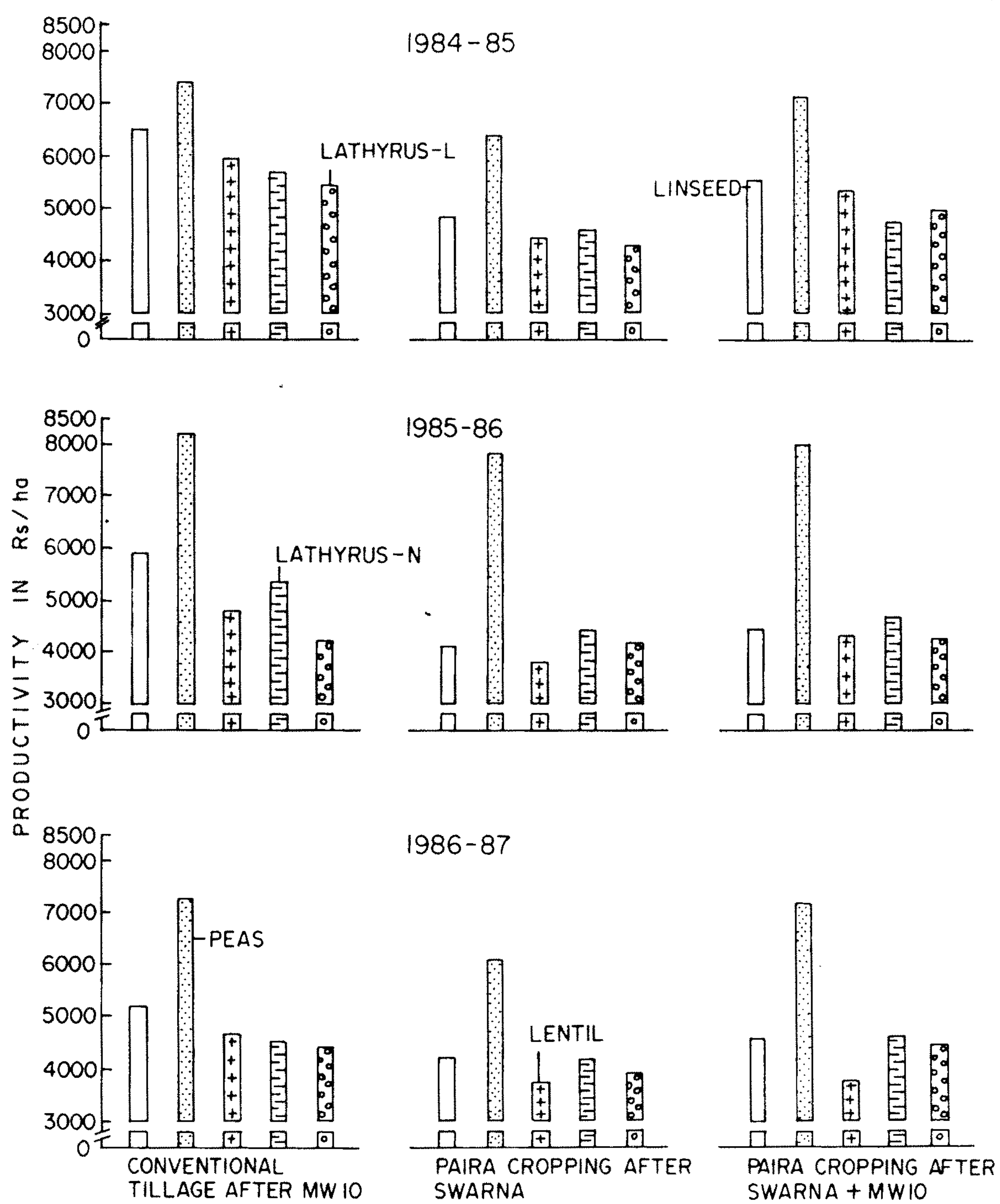


FIG.5.6 PRODUCTIVITY OF WINTER CROPS (IN Rs/ha) WHEN ESTABLISHED UNDER DIFFERENT SOIL CONDITIONS.

Table 5.8 Pooled analysis of three years productivity in Rs / ha of winter crops grown as paira crop under different seed treatments and fertilizer levels (1984-85 to 1986-87 - Field Experiment No.2)

Seed treatment (S) / Fertilizer levels (F)		Winter crops (C)					
		Lin-seed	Peas	Lentil	Lathy-rus-N	Lathy-rus-L	Mean
Seeds treated	F_0	2803	7171	4186	4181	4044	4477
	$F_{20}+F_{40}$	4431	8215	4881	4662	4499	5338
	Mean	3617	7693	4534	4422	4272	4908
Seeds untreated	F_0	2498	6451	3567	3934	3427	3975
	$F_{20}+F_{40}$	4057	7465	4468	4256	4264	4902
	Mean	3278	6958	4018	4095	3846	4439
Fertilizer	F_0	2651	6811	3877	4058	3736	4226
	$F_{20}+F_{40}$	4244	7840	4675	4459	4382	5120
Grand mean		3448	7326	4276	4259	4059	4673

	C	S	F	CxS	CxF	SxF	CxSxF
S.Em ±	116.8	82.7	48.1	184.9	107.5	68.0	152.0
C.D. at 5%	380.9	324.7	139.9	N.S.	312.6	N.S.	N.S.
C.V. %	8.7	9.7	5.6				

Table 5.9 Pooled analysis of three years productivity in Rs / ha of winter crops grown under different methods of crop establishment and management (1984-85 to 1986-87 - Field Experiment No.1)

Particulars of winter crops (C)	Previous crops (R)			
	Sole MW 10 (M)	Sole Swarna (S)	Inter-crops (S+M)	Mean
Linseed	5867	4364	4844	5025
Peas	7613	6747	7388	7249
Lentil	5118	3988	4456	4521
Lathyrus-N	5168	4367	4665	4733
Lathyrus-L	4700	4118	4570	4463
Mean	5693	4717	5185	5198

	R	C	RxC
S.Em ±	149.9	85.9	148.8
C.D. at 5%	588.0	250.7	N.S.
C.V. %	11.2	5.0	

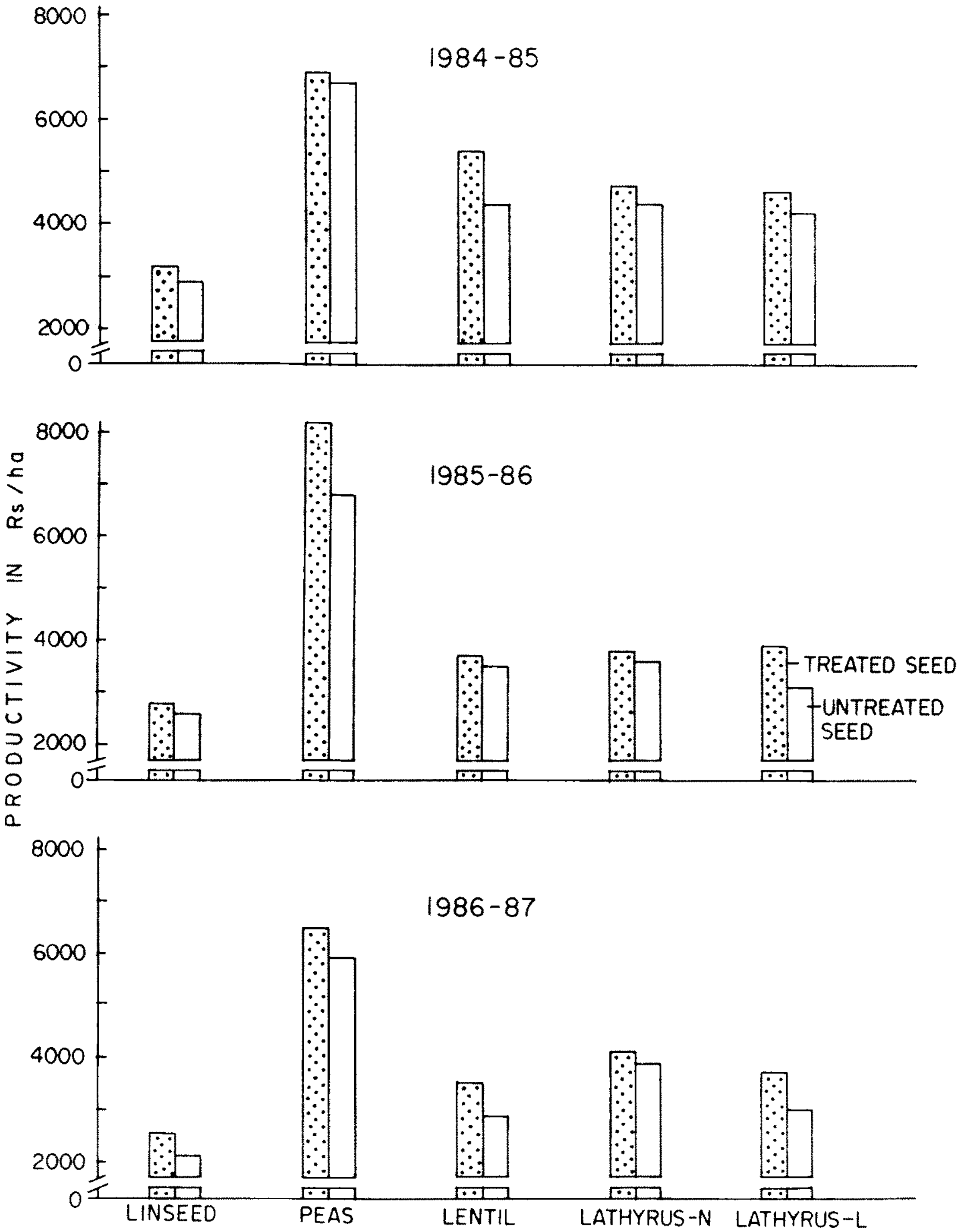


FIG.5.7 EFFECT OF PRE-SOWING SEED TREATMENT ON THE PRODUCTIVITY OF WINTER CROPS (IN Rs/ha).

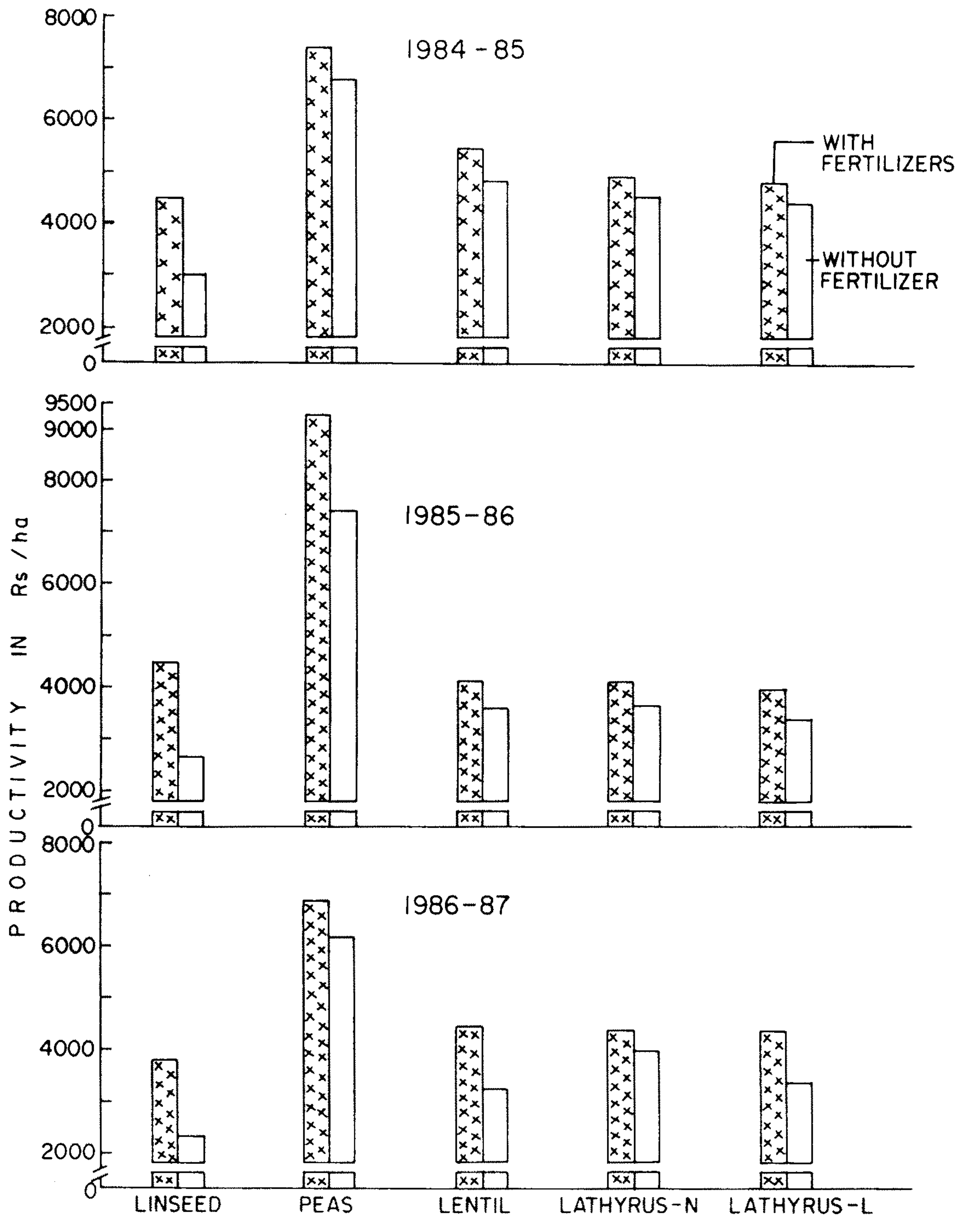


FIG.5.8 EFFECT OF FERTILIZERS ON THE PRODUCTIVITY (IN Rs / ha) OF WINTER CROPS.

Though the grain yield was more in lentil in most of the years still higher productivity in terms of energy output was more in linseed due to the fact that energy value of linseed is far more than lentil. The higher mean energy output in *Lathyrus* (Nirmal) than peas was due to higher grain yield of *Lathyrus* (Nirmal).

5.5 Moisture utilization by winter crops

Under paira method of crop establishment it was observed that loss of moisture through evapotranspiration under *paira* crops was higher than under conventionally cultivated crops in winter months.

In *paira* crops seeds were broadcasted on standing water in paddy cultivated field and then water was drained from the paddies after 24 h. The bulk of moisture was lost through evaporation from the surface of the soil, transpiration from the rice plants (10 - 12 days before harvest) and younger seedlings of winter crops. The maximum water loss was observed in peas. This might be due to higher root dry matter production in peas than others. *Paira* crop following intercrop of 'early MW 10 + late Swarna' rice also showed higher loss of soil moisture (about 3.5 %) than the *paira* crop followed in sole crop of 'Swarna' rice, might be due to higher root dry matter production of winter crops in mixed culture of rice.

Loss of soil moisture calculated between 60 and 105 DAS proved that under *paira* and conventional method of crop establishment, the differences in moisture utilization between the winter crops was narrow (Table 5.10). This might be because, at 105 days most of the soil moisture losses were due to transpiration.

Table 5.10 Loss of soil moisture (mm) through evapotranspiration in winter crops established under different methods of crop establishment and management between 60 and 105 DAS

Winter crops	Previous crops (R)					
	Sole MW 10 (M) (Conventional tillage)		Sole Swarna (S) (Paira cropping)		Intercrop (S+M) (Paira cropping)	
	1984-85	1985-86	1984-85	1985-86	1984-85	1985-86
Linseed	89	81	85	77	102	71
Peas	80	80	104	85	101	58
Lentil	88	75	76	60	91	67
Lathyrus-N	86	75	105	69	103	78
Lathyrus-L	93	75	79	66	87	79

5.5.1 Effect of pre-sowing seed treatment on soil moisture extraction (mm) on the basis of loss of soil moisture through evapotranspiration in winter crops established as paira crop

Crops raised from pre-sowing treated seeds extracted more soil moisture as determined from water balance calculations from the soil than those raised from untreated seeds (Table 5.11). Seed treatment increased the vigour of winter crops, which in turn produced higher root and shoot dry matter.

Better growth of root might have made the plants to extract greater amount of soil moisture than those from crops raised through untreated seeds.

Table 5.11 Effect of seed treatment on soil moisture extraction on the basis of loss of soil moisture (mm) between 60 and 105 DAS in winter crops established as *paira* crop through pre-sowing treated and untreated seeds

Winter crops	Moisture loss (mm)					
	1984-85		1985-86		Mean	
	Treated	Untreated	Treated	Untreated	Treated	Untreated
Linseed	89	83	82	79	86	81
Peas	110	101	85	82	98	92
Lentil	78	74	73	67	76	71
Lathyrus-N	102	103	96	82	99	93
Lathyrus-L	104	90	86	80	95	85

5.5.2 Effect of fertilizer top dressing on soil moisture extraction

Application of fertilizer again helped the plants to extract greater (Table 5.12) amount of soil moisture (through evapotranspiration) than those receiving no fertilizer top dressing. This could be possible because fertilizer top dressing as discussed earlier encouraged the *paira* crops to produce higher root dry matter which in turn enabled the crops to extract more of soil moisture, than those which was not fertilized. Similar observations has been recorded by Singh (1983) under dry land farming.

Table 5.12 Effect of fertilizer top dressing on soil moisture extraction (mm) on the basis of loss of soil moisture between 60 and 105 DAS in winter crops, established as paira crop

Crops	Moisture loss (mm) 1984-85 With fertilizer	1984-85 Without fertilizer	1985-86 With fertilizer	1985-86 Without fertilizer	Mean With fertilizer	Mean Without fertilizer
Linseed	89	83	84	78	87	81
Peas	108	103	88	79	98	91
Lentil	78	74	72	68	75	71
Lathyrus-N	110	96	93	85	102	91
Lathyrus-L	104	90	86	79	95	85

5.5.3 Relationship between loss of soil moisture and root dry weight at 0 - 60 cm soil depth under paira cropping

The loss of profile stored soil moisture (or in otherwords utilisation of soil moisture through evapotranspiration) was positively correlated with root dry weight (0 - 60 cm soil depth). The r- value of the correlation have been summarised in Table 5.13. The loss of soil moisture was high during the period of 0 to 60 days after sowing than between 60 - 105 DAS;

this was because the ground was fully covered with foliage during the period of 60 - 105 DAS and onwards and to start with the soil was saturated.

Table 5.13 Correlation between loss of soil moisture and root dry weight of winter crops (0 - 60 cm) expressed in r values under paira cropping

Crops	1984-85	1985-86
Linseed	0.856*	0.870*
Peas	0.834*	0.800*
Lentil	0.783*	0.887*
Lathyrus-N	0.742*	0.928*
Lathyrus-L	0.944*	0.748*

* Singinficant at 5 % level

5.5.4 Water use efficiency (kg / mm / ha) of winter crops

Water use efficiency (WUE) was more in crops established through conventional tillage than those under paira cropping. Again paira cropping followed in'intercropped' rice showed higher WUE than the paira crop relayed in sole crop of rice as already summarised in Table 4.44 in the chapter of results. Large seeded crops like peas and *Lathyrus* varieties showed comparatively higher WUE than the small seeded one i.e. linseed and lentil in all the methods of crop establishment and management. Under conventional tillage, WUE were 12.2, 11.0 and 9.6 kg / mm / ha in *Lathyrus* (Nirmal), *Lathyrus* (local) and peas, respectively. Chatterjee and Sen (1977) reported WUE under rainfed conditions under conventional tillage 21, 17 and 10 kg / mm / ha in barley, gram and peas, respectively. Under paira cropping highest WUE was recorded to be 2.4 kg / mm / ha in Lathyrus (Nirmal).

5.5.4.1 Effect of pre-sowing seed treatment on water use efficiency (kg / mm / ha) in winter crops established as paira crop

In paira method of crop establishment, all the crops raised from pre-sowing treated seeds with Na_2HPO_4 showed higher WUE than the crops raised from untreated seeds (Table 5.14). The highest WUE was recorded in peas both from treated (2.5 kg / mm / ha) and untreated (2.3 kg / mm / ha) seeds. High WUE in crops, raised from treated seeds was due to the invigoration of seeds, which in turn produced more healthy plant and ultimately better grain yields. Invigoration of seeds also enabled the plants to use soil moisture more efficiently.

Table 5.14 Effect of pre-sowing seed treatment on water use efficiency in winter crops, established as paira crop

Crops	1984-85		1985-86		Mean	
	Treated	Untreated	Treated	Untreated	Treated	Untreated
Linseed	1.10	1.05	1.09	0.96	1.10	1.01
Peas	2.19	2.13	2.75	2.44	2.47	2.29
Lentil	1.90	1.73	1.42	1.32	1.66	1.53
Lathyrus-N	2.63	2.44	2.14	2.05	2.39	2.25
Lathyrus-L	2.60	2.48	2.13	1.96	2.37	2.22

5.5.4.2 Effect of fertilizer top dressing on water use efficiency (kg / mm / ha) of winter crops, established as paira crop

In paira method of crop establishment, all the crops top dressed with fertilizer showed higher WUE than those recorded in crops without fertilizer top dressing. The percentage increase in WUE, due to fertilizer application was more in linseed (51.2 %) than all other crops (Table 5.15); the highest WUE was recorded in peas (2.52 kg / mm / ha). The highest WUE, however, in crops grown without fertilizer top dressing, was recorded in Lathyrus (Nirmal) and peas (2.25 and 2.24 kg / mm / ha, respectively). As linseed is a non-leguminous crop, it responded to fertilizer more than the other leguminous crops; this was the reason for higher percentage increase in WUE in linseed than in other leguminous crops.

Table 5.15 Effect of fertilizer top dressing on water use efficiency in winter crops, established as paira crop.

Crops	1984-85		1985-86		Mean	
	With fertilizer	Without fertilizer	With fertilizer	Without fertilizer	With fertilizer	Without fertilizer
Linseed	1.26	0.89	1.27	0.78	1.27	0.84
Peas	2.21	2.11	2.82	2.37	2.52	2.24
Lentil	1.88	1.75	1.44	1.30	1.66	1.53
Lathyrus-N	2.58	2.49	2.19	2.01	2.39	2.25
Lathyrus-L	2.59	2.48	2.16	1.93	2.38	2.21

It may thus be concluded that under *paira* cropping, the efficiency of profile stored moisture utilization was lesser than under crops grown with conventional tillage; in later case the root growth was better than under *paira* cropping. Pre-sowing seed treatment and fertilizer top dressing both helped a better root and shoot growth and helped the winter crops established under *paira* cropping to increase WUE.

CHAPTER 6

SUMMARY AND CONCLUSION

6. SUMMARY AND CONCLUSION

Two field experiments and three Net House Experiments were conducted through three consecutive seasons (1984-85 to 1986-87) in the Indo-gangetic alluvial soils (Entisols) of West Bengal. The objectives of the experiments were to study and find out (i) the productivity of rabi crops viz. linseed (cv. B 67), peas (cv. B 22), lentil (cv. B 77) and Lathyrus (cv. Nirmal, a variety having low neurotoxin content) as substitute of Lathyrus (cv. local) grown as paira (or relay) crop either with a sole aman rice crop of long duration variety or a mixed crop of rice in alternate rows of early (cv. MW 10) and late (cv. Swarna) varieties, (ii) suitable package of practices of the rabi crops to augment their production under paira cropping as against conventional method of crop establishment, (iii) the effect of pre-sowing seed treatment (with Na_2HPO_4) to improve the stand establishment, growth and development of the crops under paira cropping and (iv) the effect of fertilizer application as top dressing, on the performance of the various crops.

Stand establishment was better under conventional than under minimum tillage on puddled soil in all the crops. Relay sowing of peas in all the treatments of submergence and lentil at 36 h of submergence and above showed comparatively lower stand establishment than linsed and Lathyrus varieties. Stand establishment of Lathyrus varieties was least affected due to varied period of submergences, even upto 72 h. Amongst all crops, linseed showed better stand establishment (only 5.2 % lesser under *paira* cropping than conventional stand establishment) than others under *paira* cropping; peas and lentil showed lower percentage of stand establishment (18.1 and 16.5 % lesser than conventional tillage, respectively) than others. Seed treatment and fertilizer top dressing had no significant effect on stand establishment under *paira* cropping.

The shoot dry matter production was higher in winter crops when grown under conventional tillage (15 %) than under *paira* cropping. Under *paira* cropping following intercrop of early 'MW 10' + late 'Swarna', rice showed higher amount of shoot dry matter accumulation (9.2 %) than under *paira* cropping following sole crop of rice 'Swarna'. Higher shoot dry matter accumulation was recorded in peas and *Lathyrus* varieties than lentil and linseed. Pre-sowing seed treatment and fertilizer top dressing increased shoot dry matter accumulation in winter crops established under conventional as well *paira* method of crop establishment. The highest benefit of fertilizer top dressing (45 % increase) in shoot dry matter production was recorded in linseed.

Winter crops raised under conventional tillage produced higher amount of root dry matter than those under *paira* cropping. The highest root dry weight was recorded in peas. Seed treatment and fertilizer top dressing also increased root dry weight in winter crops raised under *paira* method of crop establishment.

Number of pods or capsules / m^2 were more in all crops under conventional method of crop establishment than under paira method. The highest number of pods / m^2 was recorded in lentil and the lowest number of pods / m^2 was recorded in peas. But the test weight of seeds (100 seeds weight in g) and number of seeds / pod except linseed were higher in peas than in all other winter crops. The lowest test weight (0.52 g / 100 seeds) was recorded in linseed and the seeds / capsule (8.5 / capsule) in it were highest amongst all winter crops. Seed treatment and fertilizer top dressing increased number of pods or capsules / m^2 in winter crops under paira method of crop establishment. The highest benefit of fertilizer top dressing was observed in linseed in respect of number of capsules / m^2. Seed treatment, fertilizer top dressing and method of crop establishment had no significant effect on test weight and number of seeds / pod or capsule in the tested crops.

Under conventional tillage which followed early variety of rice ('MW 10'), and where fertilizer and the seeds could be drilled and where a soil mulch could be provided yielded more (about 17 %) than those established with minimum tillage as relay crop (Paira method of cropping). Under paira cropping again the average productivity of winter crops was slightly more where mixed culture of early and late varieties of rice were grown than the paira crop raised in a tall and late variety of rice ('Swarna') field.

The low neurotoxin containing *Lathyrus* variety - 'Nirmal', although maturing 10 - 15 days later than local variety, showed an edge (5.5 % increase in yield) over the productivity of local variety and in the utilization of the scarce profile stored soil moisture. The highest grain yield was recorded in peas followed by lentil amongst the substitute crops of *Lathyrus*. Seed treatment and fertilizer top dressing increased grain yield of all winter crops established under *paira* method of crop establishment. Maximum advantage of fertilizer top dressing was observed in linseed (61 % more).

From the monetary point of view, the highest productivity was recorded in peas (Rs.7288 / ha) amongst all the winter crops included in the experiments. Though the grain yield of linseed was lower than lentil and *Lathyrus*, yet from the monetary point of view the productivity of linseed with adequate fertilization under *paira* cropping was similar to lentil and *Lathyrus* (cv. Nirmal). The productivity of lentil (Rs.4399 / ha) was higher than *Lathyrus* local (Rs.4261 / ha). From the point of view of evaluating productivity of the crops in terms of MJ / ha, the highest energy output was recorded in peas (25199 MJ / ha) followed by linseed amongst the substitute crops of *Lathyrus*. The energy output in MJ / ha from peas was as good as *Lathyrus* (local). From the point of view of grain productivity (kg / ha) and energy output (MJ / ha) *Lathyrus* (local) always showed better performance than lentil.

Soil moisture losses (0 - 60 cm profile) was positively correlated with root dry weights of winter crops under *paira* cropping; r values here 0.94 and 0.93 in 1984-85 and 1985-86, respectively. The total soil moisture loss was much higher under *paira* cropping than those raised under conventional tillage, because bulk of soil moisture loss was through evaporation from the bare surface of the soil at the initial stage of the *paira* crop.

The water use efficiency was maximum (12.2 kg / mm / ha) in *Lathyrus* (Nirmal) under conventional tillage and least (1.18 kg / mm / ha) in linseed under *paira* crop. The water use efficiency under *paira* cropping raised from pre-sowing treated seeds, and adequately fertilized were 1.32, 2.62, 1.70, 2.49 and 2.4 kg / mm / ha in linseed, peas, lentil, *Lathyrus* (Nirmal) and *Lathyrus* (local), respectively. The water use efficiency in winter crops was always much higher and appreciable under conventional tillage than under *paira* cropping.

It was, thus, concluded that in low land paddy cultivated field where harvesting of *aman* rice is delayed peas can be grown as *paira* crop as substitute crop of *Lathyrus*, by broadcasting the peas seeds in standing *aman* rice 10 - 12 days prior to rice harvesting. Further, productivity of peas under *paira* crop can be much improved if pre-sowing treated seeds (with Na_2HPO_4 of 5×10^{-4}M solution) are sown and crops are top dressed with fertilizer (20 kg N + 40 kg P_2O_5/ha). Where peas can not be grown as *paira* crop next best choice from monetary point of view can be linseed with proper fertilization and then lentil as substitute crops of *Lathyrus*. Nirmal variety of *Lathyrus*, whose neurotoxin content is low and is only 10 - 15 days later in maturity than *Lathyrus* (local) can yield as good as or slightly more than the local variety tried in this investigation. *Rabi* crops, sown as a *paira* crop with a mixed culture of early ('MW 10') and late variety ('Swarna') of rice, performed better than those relayed with late maturing rice variety ('Swarna'); it was due to greater utilisation of profile stored soil moisture.

CHAPTER 7

FUTURE SCOPE OF RESEARCH

7. FUTURE SCOPE OF RESEARCH

There is wide scope of working on _paira_ crops, for rice fallows to tap the most precious input in rainfed areas, the water. In the present investigation in evaluating the substitute crops of high neurotoxin containing varieties of _Lathyrus_ under _paira_ cropping, no attempt has been made to find out the optimum plant population of _rabi_ crops to be required for maximizing productivity. Moreover there are other winter crops like gram, sweet clover (Senji) for fodder etc. which need further to be studied as substitute crops of _Lathyrus_.

In _paira_ cropping it is difficult to incorporate fertilizer into the soil and so the fertilizer are usually not properly utilised, particularly under rainfed condition. The efficacy of spraying fertilizer to supply the nutrients to _paira_ crops need to be further investigated.

Further, in _paira_ cropping a good amount of money is spent for giving one weeding to remove the germinating stubbles as well as weeds. There is scope to do some work on weed management of _paira_ crops at a cheaper cost.

As the productivity of the same crop differs from variety to variety under the same management practices, so varietal trial on winter crops established as _paira_ crops need to be carried out.

The experiments were carried out only at one location as stated earlier. But the characteristics of lowland rice field varies widely and there is wide scope to do some location specific trials on different types of soil where rice crop is harvested at different times. It may be worthwhile to study some effective pre-sowing seed treatment with chemicals as well as effective *Rhizobium* culture (including pelleting) for increasing the vigour and growth of the *Rabi* crops.

The last but not the least there is necessity to evolve some low neurotoxin varieties of *Lathyrus* which show fairly high productivity under *paira* cropping.

CHAPTER 8

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8. BIBLIOGRAPHY

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