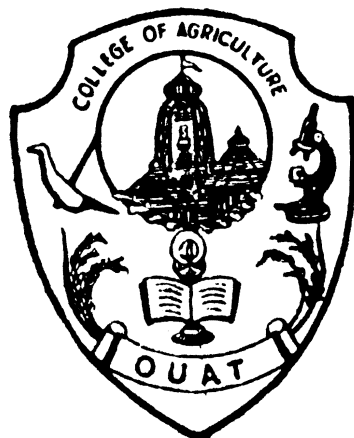


LOW MONETARY AGRO-TECHNIQUES IN MUSTARD

**A
THESIS SUBMITTED TO
THE ORISSA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY, BHUBANESWAR
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
MASTER OF SCIENCE IN AGRICULTURE
(AGRONOMY)**

BY

Mamata Mohapatra



**DEPARTMENT OF AGRONOMY
COLLEGE OF AGRICULTURE
Orissa University of Agriculture & Technology
BHUBANESWAR**

1996

THESIS ADVISOR

Dr. L. DIXIT

Dedicated
to
my
Beloved Parents

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[*Brassica juncea* (L.) Czernj.andCosson.]

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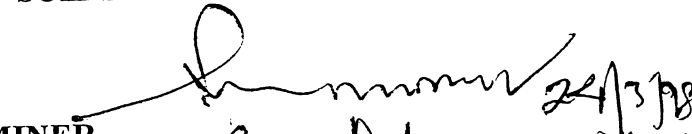

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C E R T I F I C A T E

This is to certify that the thesis entitled “**LOW MONETARY AGROTECHNIQUES IN MUSTARD**” submitted in partial fulfillment of the requirements for the award of the degree of **MASTER OF SCIENCE IN AGRICULTURE (AGRONOMY)** of the Orissa University of Agriculture and Technology, Bhubaneswar is a faithful record *bonafide* research work carried out by Ms. Mamata Mohapatra under my supervision and guidance and that no part of the thesis has been submitted for any other degree or diploma or published in any other form. It is further certified that all possible help and sources of information availed during the course of investigation, have been duly acknowledged by her.


(Dr. L. Dixit)

ACKNOWLEDGMENT

Availing this unique privilege, I express my profound sense of gratitude and indebtedness to Dr. L. Dixit, Associate Professor, Department of Agronomy, Orissa University of Agriculture and Technology (O.U.A.T), Bhubaneswar for his constant inspiration, valuable guidance, scholastic suggestions and painstaking efforts coupled with patience during the entire span of this investigation and in planning and preparing the manuscript.

I express my deep sense of gratification to Dr. S.C. Panda, Professor and Head, Department of Agronomy for his generous counsel and providing me the required facilities to work during the period of investigation.

I thankfully acknowledge Dr. S.K. Sahu, Professor, Department of Agricultural Chemistry, Soil Science and Bio-chemistry for his valuable suggestions and help during the course of investigation.

I avail this opportunity to express my deep sense of reverence to Mr. S.C. Satapathy, Junior Agronomist, AICORPO, O.U.A.T., Bhubaneswar for his sustained interest, benign attitude, relentless help and suggestions at various stages of investigation.

Words run short to express my sense of irreversible gratitude to Dr. S.K. Pattanaik, Department of Agricultural Chemistry, Soil Science and Bio-chemistry for his helping hand and laboratory facilities at the time of chemical analyses. I also express thankfulness to Mr.A.K. Sahu, College of Forestry for his help during the course of investigation.

My heartfelt gratefulness and special thanks are due to Dr. B.C. Nayak, Dr.P.K.Mohapatra, Mr. N. Patra, Dr. R.N. Pattnaik, Dr. M. Ray, Dr. S.S. Patro, Dr. S.S. Nanda, Dr. L.M. Garnayak, Dr. L. Pradhan, Mr. C.M. Khanda, Mr. B.K. Mohapatra, Mr. H.K. Patra ,the professors and lecturers of our department for their timely help and prudent suggestions during the course of preparation of this manuscript.

My diction falls short to express my unboundful gratitude to Dr. Parsuram Sahu, Head, Department of seed technology, O.U.A.T., Bhubaneswar for his help, love, constant inspiration and moral support during the course of this investigation.

My heartfelt thanks to Puspa, Sarbani and Bhanu whose inimitable love and affection has been a constant source of inspiration in every sphere of my life .

I am heartily indebted to my friends Pandey, Bhola, Bhaskar, Sahadev, Chaiti, Anita, Srimant, Chetan, Amulya, Santosh for their joucand company, timely help and cooperation in every sphere of my association with them.

Giving final shape to this manuscript with excellent quality was left in the competent hands of Softech Associate's personnels to whom I am deeply grateful.

From fathomless ocean of my heart, rise waves of blissful love for my sister Chinu, my brothers Muna and Kuna who made my task smooth by being themselves with me.

I feel dearth of words to express my deep regards to Bou, Nana and Ma, beacons of my life, for their supreme sacrifice, incessant persuasion and selfless love which brought me to the present level. I wish their blessings for an unhindered progress in my life.

At the nib but not at the neep tide, with heartfelt devotion, I bow my head before the Almighty, who is more benevolent and beneficent and whose blessings have solely contributed to my reaching this point.

Bhubaneswar

Date: 23rd Feb., 1998

Mamata Mohapatra
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LOW MONETARY AGROTECHNIQUES IN MUSTARD

[*Brassica Juncea* (L.) Czernj. and Cosson]

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ABSTRACT

A field experiment was conducted at the Central Research Station of the Orissa University of Agriculture and Technology, Bhubaneswar during the *rabi* season of 1995-96 to study the impact of various low monetary agrotechniques on growth, yield and yield attributes of Indian mustard [*Brassica juncea* (L.)]. The experiment was laid-out in randomised block design with three replications. There were altogether ten treatments contributing one local practice, one recommended practice, *Azotobacter* inoculation in both cases, inclusion of thinning, N-S direction of sowing, application of gypsum, application of nitrogen at the rate of 60 per cent topdressing only and recommended practice with limited irrigations. The soil was sandyloam in texture and acidic with PH 5.9. The test variety 'Pusa Bahar' was sown with spacing of 30x10 cm and the local check 'Pusa Bold' was sown broadcast.

The results revealed that among the low monetary agrotechniques tried in mustard gypsum application (@ 250 kg/ha) along with the recommended practice and thinning recorded the maximum seed and oil yields of 18.76 and 7.37 qha⁻¹ closely followed by the *Azotobacter* inoculation with only 50 per cent N-topdressing in recommended practice and thinning with 18.16 and 6.12 qha⁻¹ seed and oil yields respectively. However, from the economic point of view the latter practice recorded the higher net return per rupee invested of Rs.2.11 /ha with the benefit : cost ratio of 3.11. The higher yields (seed and oil) were associated with better expression of yield attributes like number of siliquae/plant, seeds/siliqua, test weight and growth parameters like more number of primary branches, LAI and DMP per plant. Thinning proved its superiority over no thinning in all cases. *Azotobacter* inoculation was found beneficial with higher productivity associated with lower cost of cultivation which was the objective of the study.

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CHAPTER - I

INTRODUCTION

INTRODUCTION

With growing concern over food security and sustainable agriculture all over the world, the need for boosting the production of oilseeds, an indispensable part of human diet, has been imperative. Viewed in the global context, India has a dubious distinction of having highest acreage under oil-seeds and placed among the countries of low productivity. It accounts for 20.8 per cent world acreage and 9.7 per cent world production with a productivity of 912 kg/ha. Realising the low production, productivity and multiplicity of problems of the sick segment of agriculture like the oil-seeds, the Technology Mission on Oilseeds (TMO) was established in 1986. Since then it has been contributing a lot to overcome the stalemate with speedy and effective transfer of the available scientific technologies to the farmer's field. The oilseed production of India has increased by 107 per cent during the last decade from 10.83 million tonnes in 1985-86 to 22.42 million tonnes in 1995-96. As a result, the import of edible oil has virtually been lowered and export of oil meals were up by 39.52 lakh tonnes valued at Rs.2,200 crores in 1995-96. Now, India has a golden opportunity after the GATT to earn foreign exchanges in these areas where it has strength and edge over others. Per capita availability of edible oils and fats in India is 6.7 kg as against minimum requirement of 7.5 kg. Against domestic supply of 6.4 million tonnes, the requirement is 7.2 million tonnes pertaining a gap of 0.8 million tonnes. In spite of steady, albeit marginal, increase in oil seed production, self sufficiency level has been declining. Hence, achieving self-sufficiency with sustainability assumes paramount importance.

Blessed with the favourable agro-ecological conditions for growing nine major oilseed crops, India has become the third largest edible oil economy in the world after U.S.A and China. Among the nine major oilseed crops, rapeseed-mustard occupies the second most important place after groundnut with a production of 6.02 million tonnes in 1995-96. It contributes 26.85 per cent of the total oilseed production (22.4 million tonnes) of the country. The chief states growing rapeseed and mustard are Uttar Pradesh, Rajasthan, Madhya Pradesh, Haryana, Punjab, Orissa,

Assam, Bihar, Gujrat and West-Bengal which together account for 82.3 and 80.4 per cent of the total area and production respectively.

In Orissa, rapeseed-mustard rank fourth with respect to area as well as production. It is grown in an area of 1.6 lakh hectares with the production of 0.8 lakh tonnes and productivity of 495 kg/ha which is much below the national average. The low productivity is mostly ^{due to} growing of the crop in rainfed marginal lands deprived of soil fertility and optimum moisture. Build up of serious pests and diseases and depletion of critical nutrients from the feeding zone due to continuous monocropping cause a loss up to 40 per cent. Lack of awareness, weak technology transfer and poor progress in evaluation and introduction of high yielding varieties add to the problem. Hence, increase in the yield level through adoption of viable and well founded technologies relevant to Indian farmer and his environment is indispensable. With currently available technologies farmers can raise the yield by 25 to 152 per cent, according to a study on the data available from the Frontline Demonstration Project (FDP) under Oilseed Production Programme (OPP) pertaining to last eight years (1988-89 to 1995-96). Excepting few, all the improved technologies do not involve sizable investment affordable by Indian farmers. Invariably at all locations, use of the low cost inputs such as appropriate choice of varieties, timely planting, use of recommended seed rate, method and direction of sowing, time, dose and method of fertilizer application in conjunction with use of gypsum, bio-fertilizers, irrigation management play a very crucial role. These determine the extent of yield advantages from improved technologies keeping proper harmony with resource status of the poor and marginal farmers who generally take decision on the technologies to be adopted on the basis of cost, risk and return calculations. Therefore, the judicious combination of low monetary agro-inputs are gaining emphasis with optimum use of the existing economic status without compromising the sustainability in higher production level.

Variety plays an important role in increasing the productivity of any crop and rapeseed-mustard is no exemption to this. Further the varieties represent the inherent potential of crop plants conferred by their genetical constitution for higher production. Success of all other technologies

largely depend upon the variety to increase the productivity. Varieties suitable to various agro-climatic conditions have been developed. A number of research works revealed the better performance of the improved varieties over the traditional ones with very meagre difference in cost. To bridge the gap of demand and supply varieties with more production potential would be useful (Fererer *et al.*, 1983).

The method and direction of sowing are non-monetary inputs which decide the plant population and the rate of light interception thereby influencing the leaf characteristics as well as net assimilation rate. It influences the seed and oil yields. The timely intercultural operations like thinning and weeding contribute significantly towards yield with maintenance of optimum plant stand. This results reduced competition with excess plants and weeds for space, light, water and nutrients.

The use of sulphur particularly in oilseeds deserves to be promoted. It has been found that each unit of sulphur added to the soil can augment the supply of edible oils by 3-3.5 units. The oilseed crops need sulphur three times higher than cereals for the synthesis of sulphur containing aminoacids like cystine (27%S), Cysteine (25%S) and methionine (21%S). Sulphur fertilization to mustard is a great promise to increase the seed and oil yield. The gypsum is the cheapest source of sulphur and easily available to the plant. Provision of subsidy on use of gypsum by Government of India is a step towards achieving higher productivity, in mustard, indirectly.

Of all the management practices, fertilizer plays an important role in expressing the yield potential of the crop (Vullioud, 1970). Nitrogen along with phosphorus and potassium being three major nutrients of plant growth with proper dose contribute significantly towards the production affecting the morphological characters and biochemical functions of the plant. The nitrogen fertilizer with prime importance for mustard can be applied in splits at the critical stages of nutrient requirement in stead of applying the whole amount as basal to avoid unnecessary losses and luxury consumption.

Irrigation has far long been recognised as a basic necessity for sustaining high productivity of crops. Other cultural practices are hardly effective without irrigation which is one of the basic constraints in the marginal and submarginal lands where mustard is grown. Rapeseed and mustard though can successfully be raised on conserved moisture, satisfactory yield can be achieved especially in loamy and sandy loam soils unless supplemental irrigations are provided at the critical stages of the crop growth.

Use of bio-fertilizer is one of the components of organic farming concept. The use of *Azotobacter* and other species maintain the productivity satisfying the need of the crop with proper maintenance of soil health. It reduces the cost of cultivation of the crop minimising use of costly chemical fertilizers. Research data revealed that use of *Azotobacter* adds about 20-30 kg N/ha.

The low monetary farm-based agro-technologies are need of the farm -ing community. There exist production technologies having considerable production potential unexploited and under-exploited as economically unsuitable for resource-poor Indian farmers. Low cost agro-technologies are lacking at this juncture. Hence, keeping an eye on the need and niche of the crop, area and farm-ing community the production technologies can be manipulated with scientific implementations to attain higher productivity with low investment. With this aim , the present investigation was undertaken at the Central Research station of the Orissa University of Agriculture and Technology, Bhubaneswar during *rabi* season of 1995-96 with the following objectives :

1. To find out the best suitable low monetary agro-techniques influencing the growth, yield attributes, seed and oil yields of mustard.
2. To study the nutrient uptake pattern as influenced by different agro-techi ques used in mustard.
3. To study the economics of different agro-techniques involving the local and improved varieties.

CHAPTER - II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Indian mustard (*Brassica juncea*) is the most extensively grown and studied oleiferous Brassicas in India occupying about 75 per cent area under this group of crops. However, its contribution is only about 22.0 per cent to the total global production with an average productivity of 912 kg/ha as against the world average of 1286 kg /ha during 1995-96 (Indian Economic Survey, 1996-97). The National Commission on Agriculture has worked out the production target of 9.75 million tonnes of mustard by 2000 A. D. to cater to the need of the country. Majority of the farmers in India are resource-poor, traditional bound and technologically backward. Hence, the low monetary agro-techniques should be developed to be implemented in the field using limited resources. There should be a perfect balance of traditional methods with scientific and technological implications.

A great wealth of relevant information has been accumulated through years of research on various aspects of rapeseed-mustard. Since the present work is on Indian mustard, an attempt has been made in this chapter to review the fundamental and applied research carried out so far to study the effect of different low monetary agro-techniques such as methods and direction of sowing, intercultural operations, use of variety, bio-fertilizers, gypsum, proper time, dose and method of fertilizer application on growth parameters, yield and yield attributes of rapeseed-mustard.

2.1 CONTRIBUTION OF VARIETY

Variety plays a key role in improving productivity of the crop. The recently released improved varieties give higher seed yield than the local ones of rapeseed mustard (Kumar and Singh, 1989). Among the improved varieties, some perform better in one set of agro-ecological conditions where as others perform better in another set of conditions. Different location-specific experiments have shown a yield advantage of about 18 per cent by use of improved varieties alone over the traditional variety.

Singh *et al.* (1985) reported 12.7 per cent higher yield with mustard variety RH-30 than Prakash from Hissar. Variety Diara-337, Pusa Bold and Rohini also recorded 20, 15.23 and 8.18 per cent more yield respectively over the local check, Varuna at Morena, MP as reported by Tomor and Namedo (1989). They also observed highest return of Rs. 12325.00 to Rs. 13237.00 / ha in DIARA -337 followed by Pusa Bold and Rohini. But Varuna recorded 18.8 per cent higher yield than the mean seed yield of five mustard varieties tried viz, Pusa Bold, KRV-47, PR-18, RK-1467 and RK-8201 (Khan *et al.*, 1990).

From a comparative study among Toria varieties Bhawani, T-9 and BR-23 at Ranchi, Bhagat *et al.* (1989) reported the highest seed yield of 0.66 t/ha with the oil content of 30.04 per cent in BR-23. From a varietal trial conducted at Pantnagar, UP, Sharma (1992) reported that variety RK-1467 and Krishna out-yielded Varuna, KLM-185 and KVR-47. From the same location, Shukla and Kumar (1993) reported higher seed yield from variety, Vardhan as against Rohini and Pusa Bold. Under agro-climatic conditions of Hissar, the variety, RH-30 performed better and produced the highest seed yield of 1.92 t/ha as against 'RH-8113' and Varuna (Ram *et al.*, 1993). Shukla and Kumar (1992) with the varieties Varuna and Vardhan reported seed yield of 2.19 t and 2.11 t/ha respectively with highest oil content in 'vardhan' (40.25%) under agro-ecological niche of Pantnagar. He also reported 3.44, 7.98 and 9.44 per cent more dry matter accumulation, N-uptake and seed yield /ha in Vardhan over Pusa Bold from the same place in 1994. Rai (1991) observed the variety, Kranti yielded more than 2.5 t/ha of seed and Krishna 2.9 t/ha. He reported that the variety Kranti is resistant to frost and white rust whereas Krishna is resistant to frost and saw fly attack.

Rajput *et al.* (1991) reported that the per hectare seed yield of mustard variety Pusa Bold was 109 kg more than that of Varuna while in case of rapeseed variety T-9 produced 121 kg more than that of TWC-3 at Morena. On the other hand, Bharadwaj (1991) reported 171.3 per cent more yield from Varuna over the average yield of both Pusa Bold and Kranti. Whereas Kranti showed superiority with respect to N-uptake over Varuna by 13.17 per cent under Navasari (Gujrat) agro-ecological conditions (Patel *et al.*, 1992). Patro and Kar (1995) under rainfed agro-climatic condition of Orissa found that the toria variety M-27 is the best with mean yield of 8.5 q/ha against Agroni, BR-23 and TS 29 varieties tried.

Tyagi and Rana (1992) under agro-climatic conditions of Lakhaoti, UP reported the varying seed yields of 1.77, 1.40, 1.92 and 1.33 t/ha and seed oil content of 39.8, 37.3, 40.6 and 36.6 per cent from the varieties Pusa Bold, RH-30, Varuna and Krishna respectively. Tomer *et al.* (1996) reported significantly more plant height, branches per plant, dry matter accumulation /plant, number of siliqua/plant, 1000 seed weight with Varuna and Pusa Bold as compared to Prakash and RH- 8113 from Baraut (UP). They also observed 24.68 and 7.8 per cent increase in oil yield /ha over mean of Prakash and RH- 8113.

2.2 EFFECT OF NITROGEN ON MUSTARD

Nitrogen has most recognised role in plant due to its presence in the structure of protein molecules, purines, pyrimidines, porphyrins and coenzymes. Mustard has a good response to nitrogen application.

2.2.1 Growth parameters

At Mymensingh, Bangladesh, Mondal and Gaffar (1983) observed an increase in plant height of mustard cv. Sampad up to 105 kg N/ha level. Joshi *et al.* (1991) also found a significant increase in plant height of 193 cm in mustard up to 60 kg N/ha level which was in close conformity with the earlier result obtained by Nepalia (1990) in toria. On the other hand, under Hoshangabad agro-climatic condition, Dubey *et al.* (1992) marked a significant increase in plant height up to 90 kg N/ha level. They further concluded that plant height was positively and significantly correlated with seed yield in Indian mustard variety Varuna. Keshwa and Jain (1993) reported the increase in plant height of taramira with increase in levels of nitrogen upto 45 kg/ha at Jobner, Rajasthan agro-climatic conditions.

Giri and Saran (1985) reported from IARI, New Delhi that increase in levels of nitrogen up to 60 kg/ha increased the number of branches per plant which was at par with that of 30 kg N/ha level. Similar response was observed by Mohapatra (1993) in variety, Pusa Bold under agro-climatic conditions of Ranital, Orissa up to 75 kg N/ha. Number of branches per plant in mustard significantly increased to the extent of 40 per cent up to 90 kg N/ha, but it was adversely affected beyond this level

(Gangwar and Kumar, 1986). Contrary to this, Sharma and Kumar (1988) observed a significant increase in the number of branches per plant up to 22.6 with 120 kg N/ha level. Dubey *et al.* (1992) observed an increase in the number of primary branches of mustard variety Varuna up to 90 kg/ha level of nitrogen application.

Morgan (1981) observed in pot experiment that added nitrogen increased leaf area in rapeseed which was again confirmed by Rood *et al.* (1984). Budzynski *et al.* (1993) at agro-climatic conditions of Poland observed an increase in the number of leaves in rosette stage and dry weight in the rape cultivar, Bolko with 60 kg N/ha as against 40 kg N/ha. Kumar and Gangwar (1985) recorded maximum LAI at 55 days after sowing (DAS) in toria with 120 kg N/ha. From similar studies, Shukla and Kumar (1993) observed that the mustard variety Vardhan recorded the highest LAI, net assimilation rate (NAR) under 120 kg N/ha at 35-65 DAS. With the increase in nitrogen levels from 0 to 90 kg/ha, there was significant increase in LAI which reflected better plant growth. Dubey *et al.* (1992), Bikram *et al.* (1994) have also reported increase in LAI and crop growth rate (CGR) with increasing rate of N application.

Rout (1981) from Bhubaneswar reported that fertility levels of 60:30:30 N:P:K (kg/ha) produced significantly more dry matter in all the seven varieties tested than that of 40:20:20 kg/ha level of N:P:K. At Hissar, Antil *et al.* (1996) found significant increase of dry matter production upto 90 kg N/ha level in Indian mustard, while application of 120 kg N/ha reduced it. This was corroborated by Dubey *et al.* (1992) who observed positive and significant correlation between levels of N application, seed yield and dry matter yield.

2.2.2 Yield and yield attributing characters

Giri and Saran (1985) reported that under IARI condition there was increase in the number of siliquae/plant with the application of nitrogen upto 60 kg/ha level in rainfed mustard. From similar studies, Gangwar and Kumar (1986) reported 31.1 per cent more number of siliquae/plant in mustard up to 90 kg N/ha level but application beyond that adversely affected the siliquae number. Similar response was observed by Dubey *et al.* (1993). Choudhury *et al.* (1990) with cultivar M-27 at Jorhat and Sarandon *et al.* (1993) with cultivar, Printol in Argentina have reported an increase in number of siliquae/plant and number of seeds per siliquae with increasing rate of N application.

Under Faizabad agro-climatic condition Singh and Singh (1987) however, observed no significant difference in siliqua length with the varying levels of N. Kalra (1983) under Hissar condition observed that heavy nitrogen fertilization had no effect on number of seeds /siliquae in Indian mustard. On the contrary, Sharma and Kumar (1988) found favourable increase in number of seeds/siliqua by 18.4 per cent with 120 kg level of N/ha. Giri and Saran (1985) up to 60 kg N/ha level in rainfed toria and Singh and Singh (1987) up to 120 kg N/ha level in RH-30 and Prakash observed no significant difference in test weight with the increasing levels of N. On the other hand, Gangwar and Kumar (1986) from Pantnagar reported significant increase in test weight of mustard by 11 per cent up to 90 kg N/ha but difference between 90 and 120 kg N/ha was not significant. Similar results were reported by Dubey *et al.* (1993) and Parihar and Tripathy (1989).

At Hissar, mustard varieties, Prakash and *RH-30* showed a linear increase in seed yield up to 120 kg N/ha level (Singh and Singh, 1985). Similar results were reported by Singh and Singh (1991) in Indian mustard. Singh and Singh (1987) recorded significantly higher seed yield /ha in mustard up to 75 kg N/ha, but the yield was at par with 100 kg N/ha level. Giri and Saran (1985) at IARI, New Delhi observed significant increase in yield upto 60 kg N/ha in rainfed toria. Application of nitrogen at 30 and 60 kg levels increased the seed yield by 17 and 33 per cent over the no nitrogen respectively. Tomar and Naredo (1989) noticed no significant difference in seed yield of mustard variety. Pusa Bold under 60 and 90 kg N/ha levels yielding 23.4 and 27.1 q/ha, respectively. Optimum seed yield 21.64 q/ha was observed by Khanpara (1993) under 60 kg level of N with variety Kranti at Velpur. Mohapatra (1993) in coastal plains of Orissa recorded 0.8 t/ha in Pusa Bold at 60 kg N/ha level.

From similar studies Padhi and Sahoo (1992) at Udayagiri (Orissa) observed that application of 65 kg N to varuna and 70.3 kg N to Pusa Bold per ha were optimum producing seed yield of 1.39 t and 1.33 t /ha respectively, while Mohanty *et al.* (1992) reported the highest seed yield of 0.58 t per ha with 40 kg N/ha in case of variety Pusa Bold which showed a decrease in seed yield with further increase in N level but the oil content remained unaffected. Application of graded doses of nitrogen (30,60,90 and 120 kg /ha) to toria increased the yield significantly up to 90 kg N/ha which was at par with that of 120

kg N/ha, the percentage of increase in seed yield with nitrogen levels of 30, 60, and 90 kg /ha were 41.2, 56.0 and 92.2 per cent over the control, respectively (Gangwar and Kumar, 1986). Shrivastova *et al.* (1989) have also reported the seed yields of 0.3,0.6,0.9 and 0.31 t/ha and oil yields of 0.11, 0.22, 0.32 and 0.51 t/ha respectively from 0, 30, 60 and 90 kg N/ha levels respectively.

Dongale (1990) observed the seed yield, oil content and oil yield to be 157,14.6 and 198.2 per cent higher at 90 kg N/ha level over control (no Nitrogen fertilization). Bharadwaj (1991) also observed a linear response of mustard yield upto 90 kg N/ha. A result in close conformity with this was obtained by Shukla and Kumar (1992). Khanday *et al.*, 1993 reported seed yields of 0.88 t and 1.12 t/ha respectively from variety KOSI at Shalimar, J & K with the application of 30 and 60 kg N/ha. An increase in seed and oil yield was observed by Gawai *et al.* (1994) with increasing level of N from 0 to 100 kg /ha from the variety, *TM-17* but reached a plateau after 75 kg /ha. From similar studies, Mishra and Rana (1992) have reported an increase in seed yield with increased rates of N-application, where as the test weight and oil content in seed remained unaffected. But Pramanik *et al.* (1996) reported an increase in seed yield with increasing rate of N application, while oil content in seeds showed a declining trend.

Patel *et al.* (1992) noticed 9.5 and 8.3 per cent more N content in seed and stover respectively and 34.19 per cent more total N uptake with increasing level of N up to 100 kg/ha from Navsari agroecological conditions. Rathore and Manohar (1992), Bikram *et al.* (1993) and Shukla and Kumar (1994) reported similar results of increase in N content in seed and plant with the increasing levels of N-application. Giri and Saran (1985) however, did not observe any variation in the harvest Index with increasing levels of N-application, whereas Narang and Singh (1985) observed a significant increase, but beyond that the increase was not significant.

2.2.3 Net Return

Under agroclimatic situation of Morena (MP) Tomar and Naredo, 1989, reported net return of Rs. 10074 and Rs. 12585/ha with application of 60 kg and 120 kg N/ha.

Ram *et al.* (1991) reported the highest net return of Rs. 2544 /ha with the cost : benefit ratio of 1:1.8 for variety *T-9* at 80 kg N/ha level. Singh *et al.* (1993) have also reported the highest net return with the same level of nitrogen application.

2.3 EFFECT OF TIME OF APPLICATION OF NITROGEN ON MUSTARD

The time of application plays a crucial role in determining the growth and development of the crop. It is accounted with the need of the crop at various stages deciding the optimum output.

2.3.1 Growth parameters

Saran and Giri (1988) trying with variety Pusa Bold under New Delhi agroclimatic conditions increased the leaf area by 12.9 per cent and number of branches by 61.9 per cent with two equal split applications (half basal + half 30 DAS) over the single application of 80 kg N/ha. Budzynski *et al.* (1993) reported that split applications of urea (50% before sowing and 50 % at 4-5 leaf stage) showed improved plant confirmation over single basal application. The split application could also show increased number of leaves in the rosette stage and dry matter accumulation over the single basal application.

Studying the effect of time of nitrogen application on growth and yield of mustard, Sarandan *et al.* (1993) observed that the split application of nitrogen at the rate of 50 kg/ha at sowing and 50 kg /ha at stem elongation stage significantly increased the initial plant height over application of 50 kg N/ha at sowing. Nouredin *et al.* (1993) reported that application of nitrogen in three equal splits at 7+21+35+ days after sowing (DAS) proved better than application in two equal splits at 7 and 35 days after sowing with significantly taller plants, higher dry matter production per plant, more number of branches and pods/plant.

Mohapatra (1993) observed 48 per cent more number of branches per plant with split application of N (1/3rd at sowing + 2/3rd 21 DAS) than the whole applied at sowing under rainfed agroclimatic conditions of Ranital. However, Jasinka *et al.* (1993) with variety Bolko reported no significant difference in plant morphology, yield components and lodging due to application of nitrogen either as whole at sowing or in two equal splits at sowing and budding stage.

2.3.2 Yield and yield attributes

Saran and Giri (1988) observed that under rainfed condition the seed yield were markedly higher with two equal split application of Nitrogen (50 % basal and 50 % topdressed at 30 days after sowing) by 25.82 and 42.25 per cent respectively with 40 kg and 80 kg N/ha than single basal application. From similar studies, Prasad and Shukla, 1992, observed higher yield and nutrient uptake in Indian mustard with split application of nitrogen i.e. 50 per cent at sowing and 50 per cent at 40 days after sowing over single basal application. On the other hand, Rajput *et al.* (1994) under rainfed conditions observed higher seed yield, net profit and benefit cost ratio in case of basal application as against split application.

Application of nitrogen in two splits i.e. 1/3 rd at sowing and 2/3rd 60 days after emergence at Brazil to variety *CTC-4* has shown increased seed yield over either full dose applied at sowing or split application of 1/3rd at sowing and 2/3rd at 30 days after emergence (Cordeiro *et al.*, 1995). Jagpal *et al.* (1993) from similar studies conducted at Bulandsahar, UP observed a significant variation in seed yield from 690-840 kg per ha (with full basal application of nitrogen) to 1200-1750 kg/ha obtained from split application (half basal + half at 30 days after sowing).

Chettri *et al.* (1993) at Kalyani, Mohanpur with the variety Varuna observed a seed yield of 1.54 t/ha by applying 45 kg N as basal and 45 kg 30 DAS which was statistically at par with that of 60 kg N/ha applied as basal and 30 kg N at 30 DAS. Basal application of 60 kg N/ha with 15 kg topdressed produced 0.6 t/ha more seed yield in case of Varuna under agro-climatic condition of Aligarh, over basal application of 90 kg N/ha (Khan and Samiullah, 1993). With close proximation to this, from coastal plains of Ranital, Orissa, Mohapatra (1993) reported that application of 25 per cent N at sowing and 75 per cent 21 days after sowing (DAS) was the best with the production of 0.83 t/ha among the treatments viz. all basal, 50 per cent basal + 50 per cent at 21 DAS and 75 per cent basal + 25 per cent at 21 DAS. The seed yields of 832, 619, 1913 and 1078 kg /ha were obtained from Varuna, at Wakwali, Maharashtra with application of nitrogen by broadcasting, band placement of whole at sowing, split application of 50 per cent at sowing and 50 per cent at 30 days after sowing and band placement in two splits (25 % at sowing + 75% 30 DAS) respectively (Jadhav *et al.*, 1995). From Aligarh, UP, Khan

(1996) reported that application of 60 kg N as basal + 10 kg as foliar spray resulted seed yield of 1.48 t/ha and oil yield of 0.52 t/ha which were 12.5 and 14.8 per cent higher than the application of 90 kg N/ha as basal, respectively.

2.4 EFFECT OF GYPSUM AS SOURCE OF SULPHUR ON MUSTARD

2.4.1 Growth parameters

Studying the effect of S-nutrition in toria variety, T-9, Tomar *et al.* (1992) under Tikamgarh (MP) agroclimatic conditions, observed 12.6, 7.3 and 20.5 per cent increase in plant height, number of primary and secondary branches per plant respectively with 30 kg S/ha.

Panigrahi (1993) observed a significant increase in growth parameters like plant height, number of branches/plant, leaf area Index (50 days after sowing) and dry matter production/plant due to application of 50 kg S per hectare as gypsum at the time of sowing. Singh and Kumar (1996) experimenting with NDR 8501 Indian mustard reported 13.8 per cent increased in plant height with 40 kg S/ha under rainfed conditions of Faizabad. Similar result was observed with 50 kg S/ha by Mohan and Sharma (1992).

On the other hand, Chauhan *et al.* (1995) reported that plant height, number of primary branches per plant did not show any significant increase with the application of gypsum at the rate of 125 kg/ha over the control. This result was corroborated by Joshi *et al.* at Navasari agro-climatic conditions. Narang *et al.* (1993) noticed 10.2 per cent increase in leaf area with application of 50 kg S/ha in toria variety TL 15 under Ludhiana condition.

2.4.2 Yield and yield attributing characters

The yield attributing characters like siliqua length, number of siliquae per plant and number of seeds per siliqua increased significantly with the application of 50 kg S per hectare as gypsum at the time of sowing as reported by Panigrahi (1993). Trying with variety Pusa Bold under New Delhi agro-

climatic conditions Sharma (1994) observed increase in number of siliquae / plant, length of siliqua , seeds/siliqua, 1000 grain weight by 42, 94, 110, 83 per cent respectively with 60 kg S level/ha over no S- fertilization. From similar studies, Chauhan *et al.* (1995) observed that pod length, pods per plant, 1000 seed weight, seed yield and oil content increased significantly with the application of 125 kg/ha of gypsum. Saran and Giri (1990) from their study conducted under 7 agro-ecological conditions of New Delhi reported that application of Sulphur (gypsum) up to 60 kg /ha did not influence the seed yield of mustard significantly. From similar studies it was observed by Rathore *et al.* (1990) application of gypsum at the rate of 250 kg/ha i.e. 45 kg S/ha produced 2.88 t seed yield per hectare as against 2.69 t/ha obtained from no sulphur treatment.

Narwal *et al.* (1991) observed that application of gypsum increased both seed and oil yield significantly. Naṛang *et al.* (1993) reported that application of 50 kg S/ha through gypsum increased the seed yield of toria variety TL - 15 by 155 kg/ha under Ludhiana agroecological conditions. He also reported 2.4 and 2.6 per cent increase in oil and protein content over no-S application. Dubey and Khan (1993) experimenting under Powerkheda (MP) agroclimatic condition with variety Varuna reported 40, 5.7, 48 and 47.8 per cent increase in seed yield, oil content, oil yield and total N uptake with 50 kg S/ha as gypsum over no-S fertilisation respectively.

Das and Das (1994) reported the seed yield of M-27, 1.26, 1.34, 1.40, 1.55 t/ha with the application of 0, 15, 30 and 45 kg S/ha as gypsum respectively. Sharma (1994) observed increase in seed, stover and oil yield by 68.5, 78.7 and 73.9 per cent respectively with 60 kg S/ha but 4.28 per cent reduction in oil content. The net income was observed up to Rs.6270.00 with 60 kg S/ha from Rs 2940.50 per hectare with no S-application. Tripathy and Sharma (1995) have also reported an increase in seed yield and seed oil content upto 40 kg S/ha, while seed protein content was highest with 80 kg S/ha taking gypsum as the source. From similar studies Arora *et al.* (1994) with cultivar Varuna under alluvial soil of Gwalior (MP) recorded 7 per cent more oil content. This result was corroborated by Singh and Kumar (1996) and Mohan and Sharma (1992) with 40 kg S/ha.

2.5 EFFECT OF IRRIGATION ON MUSTARD

Irrigation is the most crucial input which contributes maximum towards output.

2.5.1 Growth parameters

Begum and Paul (1993) reported that irrigation with 110 mm of water along with 15 mm of precipitation resulted an increase in plant height, total dry matter production per unit area, leaf area index (LAI), crop growth rate (CGR), net assimilation rate (NAR) as compared to unirrigated plots. Samui *et al.* (1986) have also observed application of 2 irrigations to mustard crop increased the number of branches/plant by 26 per cent as compared to the unirrigated treatments. On the contrary to this, Saran and Giri (1988) in New Delhi condition with variety Pusa Bold reported no significant variation with respect to the growth parameters.

On siltyloam soils of Pantnagar, Sharma and Kumar (1993) observed more number of branches and higher LAI with increased number of irrigations. Similar results have been reported by Yadav *et al.* (1994) and Bikram *et al.* (1994) from Hissar.

2.5.2 Yield and yield attributing characters

Shrivastav *et al.* (1989) observed that irrigation either at the preflowering or seed development or at both the stages gave seed yields of 0.86, 0.74 or 0.78 t/ha and oil yields of 0.23, 0.27 or 0.31 t/ha respectively as compared to the seed yield of 0.73 and oil yield of 0.25 t/ha under rainfed conditions. From a similar study Uppal *et al.* (1990) observed a seed yield of 0.76 t/ha with no irrigation while irrigation produced 1.46-1.72 t/ha seed yield. They also found that applying two irrigations at flowering and pod development stage resulted the highest seed yield, oil yield and water use efficiency. On the other hand, Rana *et al.* (1991) with variety Pusa Bold at Barant (UP) reported decrease in seed oil content with irrigation but increase in uptake of N in seed and straw.

From an irrigation trial, Sharma (1991) observed an increase in seed yield with irrigation. He

reported 20.6, 19.8 and 19.7 per cent seed protein content and 38.2, 38.4 and 39.3 per cent seed oil content with no irrigation, one irrigation at 20 days after sowing (DAS) and two irrigations at 30 and 50 DAS, respectively. Similar study conducted by Tomer *et al.* (1992) revealed that irrigation at flowering, flowering and fruiting or without irrigation obtained seed yields of 1.18, 1.45 and 0.83 t/ha and oil content of 38.97, 39.47 and 38.15 per cent respectively with variety Varuna in Gurukulnarsan, UP. Jadhav and Singh (1991) reported that irrigation increased the seed yield of variety Pusa Bold by 27.9 per cent over no irrigation. Irrigation at flowering, flowering and branching, branching and seed development stages in mustard produced seed yield of 0.71, 0.8 and 0.97 t/ha respectively against 0.49 t/ha under rainfed condition (Ghatak *et al.* 1992). Branching and flowering were regarded as the critical stages of irrigation variety B-54 at Jhargram, WB (Zaman *et al.* 1992), where as flowering and pod formation i.e. 30 and 60 days after sowing were emphasized as critical stages by Kumar and Shaktawat (1992) at Udaipur. At Sriganganagar, Rajasthan from similar study Siag *et al.* (1993) highlighted branching and siliqua development as critical stages.

Begum and Paul (1993), however, reported that the number of seeds per pod, harvest index remain unaffected but the seed yield, oil content of seeds increased with irrigations. Irrigations at flowering and siliqua formation stages obtained higher yield than either of the stages or no irrigation as reported by Rohtash *et al.* (1993). Bikram *et al.* (1994) reported seed yield of 1.25 t/ha without irrigation, whereas it was 1.51 and 1.59 t/ha with one irrigation at 50 per cent flowering and two irrigations at 50 per cent flowering and 50 per cent siliqua development stages respectively under the agro-climatic conditions of Hissar, Haryana. Delaying the first irrigation decreased the seed yield considerably as has been reported by Sidhu *et al.* (1995).

2.6 EFFECT OF AZOTOBACTER INOCULATION IN MUSTARD

Azotobacter, a free living heterotrophic nitrogen fixing bacteria plays an important role in easy access of nitrogen to the plant and reduces the cost of chemical fertilizers. It reduces the cost of plant protection having ability to produce anti-fungal, anti biotic compounds against pathogens like Fusarium, Alternaria etc.

2.6.1 Growth parameters

Prabhjeet and Bhargava (1994) reported higher number of primary branches, number of siliquae per plant, higher leaf area index (LAI) particularly at pod filling stage and a faster growth rate of the *ISN-129* with inoculation of *Azotobacter* over no inoculation plots.

2.6.2 Yield and yield attributing characters

Voros and Szegi (1990) reported that *Azotobacter* inoculation in mustard increased the seed yield above their levels with N, P, K alone under yellow soil condition. An increase in seed yield of 35-40 per cent due to inoculation of *Azotobacter* over no inoculation along with recommended dose of 40 kg N/ha in variety Kranti was observed by Narula *et al.* (1993). Prabhjeeta and Bhargava (1994) have also reported that the response to *Azotobacter* inoculation was greatest in the absence of N-fertilizer while highest seed yield was obtained from 40 kg N + inoculation.

Azotobacter inoculation along with N-fertilizer increased the seed yield and oil yield by 31 per cent and 30.1 per cent respectively, as against the increases of 19.8 per cent and 16.9 per cent respectively due to application of N-fertilizer alone over the control (Vivek and Kumar, 1994). They further reported that the response of *Azotobacter* inoculation was more in sandy loam soil with the yield of 731 kg/ha due to lower nutrient status and that in clay loam soil was 601 kg/ha in the year 1994 at Hissar. They also reported in 1995 that *Azotobacter* inoculation not only increased the seed yield but also lowered the disease incidence like Alternaria blight and white rust in all the five *Brassica juncea* cultivars tried.

On the other hand, Sharma *et al.* (1995) from Hissar reported no significant effect of *Azotobacter* inoculation on flower and siliqua initiation or physiological maturity but the yield was highest when inoculated along with 60 kg N/ha in 3 varieties of mustard tried (*TCH-2*, *RH-30* and *RH-819*). However, Chauhan *et al.* (1995) reported that the variety *RH-30* under Gurgaon condition recorded higher seed yield with *Azopirillum* inoculation as compared to inoculation with *Azotobacter*.

2.7 EFFECT OF METHOD OF SOWING ON MUSTARD

Method of sowing determines the optimum plant population maintaining proper balance for demand of space, nutrients, water and light thereby plays an important role in production.

Bhagat *et al.* (1989) reported that the line sowing of mustard resulted the mean seed yield of 0.75 t/ha with 29.27 per cent oil as compared to 0.62 t/ha with 2.5 per cent oil in broadcasted crop. Line showing significantly increased number of branches / plant, siliquae / plant, length of siliqua, seed yield and estimated oil yield /ha over broad casting under agro-climatic conditions of Jorhat (Assam) in the variety M-27. On the otherhand, plant height, number of seeds/siliqua, 1000 seed weight and oil content were not influenced significantly by method of sowing (Kurmi and Kalita, 1992).

Darby *et al.* (1994), on the contrary, reported higher seed yield from the broadcasted plots than the drilled treatments. They observed fewer winter loss in broadcasted plots than the drilled plots which in turn reduced the plant population in drilled plots.

2.8 EFFECT OF DIRECTION OF SOWING ON MUSTARD

Direction of sowing with varying interception of solar radiation affect the leaf characteristics mostly ultimately affecting the yield.

Kaur *et al.* (1993) reported increase in LAI, pods/plant, seeds /pod, seed weight/pod 20, 7.6, 12.5,8.8 per cent respectively in bidirectional sowing at Ludhiana with toria cultivar over N-S sowing. Studying the effect of direction of sowing Kaur *et al.* (1992) observed higher seed yield from cross sowing as compared to N-S or E-W sowing in case of variety *TL-15* under Ludhiana agroclimatic conditions. Dry matter yield of plant was increased in bidirectional sowing but the total N-uptake remained unaffected.

Dhingra *et al.* (1990) with Indian mustard variety *RLM 619* observed 8-12 per cent higher yield in N-S sowing over E-W sowing under agro-ecological conditions of Ludhiana. On the other hand while trying with toria from Ludhiana, Kaur *et al.* in 1992 reported 17.2 per cent higher seed yield in bidirectional sowing over the N-S sowing. The oil yield was also reported to be increased by 13.9 per cent even though the oil content remained low by 2.9 per cent on the bi-directional sowing.

2.9 EFFECT OF THINNING ON MUSTARD

The intercultural operations like thinning maintains proper plant population reducing competitions and providing optimal conditions for plant growth.

Experimenting on the effect of thinning under agroclimatic conditions of Kanpur in case of variety *T-9*, Verma *et al.* (1990) observed significantly higher yield where proper thinning was done as compared to no thinning treatment. The growth and yield parameters were found to be more in the treatments with thinning.

CHAPTER - III

MATERIALS AND METHODS

MATERIALS AND METHODS

To study the effect of various low monetary agrotechniques on the growth, yield and yield attributing characters of mustard, a field trial was conducted using the materials and following the methods as described in this chapter.

3.1 EXPERIMENTAL SITE

The field experiment was conducted during *rabi* (winter) season of 1995-96 in the 'A' block of the Central Research station of the Orissa University of Agriculture and Technology, Bhubaneswar to study the effect of low monetary agro-techniques on mustard (*Brassica juncea* L.). The experimental site was situated in a levelled piece of land with uniform soil.

3.2 SOIL CHARACTERISTICS

Before lay-out of the field a composite soil sample was drawn from a number of randomly selected spots up to a depth of 15 cm. After processing, the soil was used for mechanical and chemical analyses. The data pertaining to mechanical constituents and chemical composition of the soil are given in the Tables 1 a and b.

Table 1(a). **Mechanical composition of the soil (0-15cm).**

Mechanical constituents	Composition (Per cent)	Method employed
Sand	76.7	Bouyoucos
Silt	7.9	Hydrometer method
Clay	15.4	(Piper, 1950)

Table 1(b).Chemical composition of the soil (0-15cm).

Chemical Constituents	Composition	Methods employed
p ^H	5.9	Glass eletorade Beckman's P ^H meter with 1:2.5::Soil:Water. (Jackson, 1967)
Organic Carbon (%)	0.62	Walkley and Black's Wet digestion method (Jackson,1967)
Available Nitrogen (Kg/ha)	282	Alkaline KMnO ₄ method (Subbiah & Asija, 1956)
Available Phosphorus (Kg/ha)	32.7	Bray's extraction method, (Jackon,1967)
Available Potassium (Kg/ha)	185.3	Ammonium acetate extraction and Flame Photometric method (Jackson, 1967)
Available Sulphur (Kg/ha)	5.6	Turbemetric method (Massoumi and Cornfield, 1963)

The soil of the experimental site was sandyloam in texture of alluvial origin (Ustochrept) with medium in organic matter, low in available nitrogen and medium in both available phosphorus and potash.

3.3 CROPPING HISTORY OF THE EXPERIMENTAL FIELD

The experimental plot was put under following crops in different seasons for the last two years preceding the year of experimentation as has been presented in Table 2.

Table 2. Cropping history of the experimental field.

Year	Season		
	Kharif	Rabi	Summer
1993-94	Rice bean	Mustard	Sunflower
1994-95	Maize	Mustard	Sesamum
1995-96	Maize	Mustard (Experiment under report)	

3.4 CLIMATE AND WEATHER CONDITIONS

Geographically, the Central Research Station of the Orissa University of Agriculture and Technology, Bhubaneswar is situated at 20° 15' N latitude and 85° 52' E longitude with an elevation of 25.9m above the mean sea level and at 64km West of the Bay of Bengal. The place is characterised by warm and moist climate with hot and humid summer and short and mild winter.

It receives a mean annual rainfall of about 1615 mm (average of preceding 10 years i.e, from 1985 to 1994). The monsoon sets towards 10-15th June and ceases by 15th October. The distribution of rainfall is erratic and uneven. Nearly 80 per cent of the total annual rainfall is received during the months of June (213.2mm), July (372.6mm), August(409mm), September (241.5mm), and October (138.2mm). The rest 20 per cent of total rainfall is received from November to May. The rainfall code of the place is $D_1E_3 (B_1A_2B_1) C_1D_1E_2$ (Lenka, 1975).

The mean annual average temperature ranges from 21.8° C to 31.7°C. The mean maximum temperature in the hottest month of May was 36.7° C and the mean minimum temperature in the coldest month of December was 14.9° C.

The mean monthly meteorological data for the cropping season i.e., from November 1995 to February 1996 along with their corresponding averages of the preceding ten years (1985-86 to 1994-95) recorded at the meteorological observatory of the Central Research Station of the Orissa University of Agriculture and Technology, Bhubaneswar has been presented in Table 3 and illustrated in figure 1a to 1f.

3.4.1 Rainfall

The total rainfall received during the cropping season (November-February) was 271.6mm which was 168.5mm more than the normal i.e., 103.1 mm (average of preceding 10 years data) for the same period. The months November and January received 120.8 and 68.4 mm more rain, while the month of February had 19 mm less than normal. There was no rainfall during December. Thus, the excess amount of rainfall during the cropping season was 170.2mm. The total number of rainy days was also more than normal.

3.4.2 Air temperature

The mean maximum and mean minimum temperatures during the cropping season are given below.

Month	Temperature(° C)	
	Mean Maximum	Mean Minimum
November	29.2	19.0
December	28.9	14.7
January	29.1	16.9
February	30.9	18.3

Table 3. Meteorological data of the Central Research Station, O.U.A.T, Bhubaneswar for the cropping season (November, 1995 to February,1996).

Months	Particulars	Rainfall (mm)	Number of rainy day	Temperature(^o C)		Relative humidity (%)		Mean Evaporation (mm)	Bright Sunshine hours/day
				Maximum	Minimum	Morning	Afternoon		
November	Current	183.5	7	29.2	19.0	90	58	3.2	7.8
	Normal	62.7	3	30.3	18.8	88	50	3.4	7.6
	Deviation	+120.8	+4	-1.1	+0.2	+2	+8	-0.2	+0.2
December	Current	0	0	28.9	14.7	92	44	3.0	9.0
	Normal	1.7	1	28.7	14.9	98	64	3.2	8.4
	Deviation	-1.7	-1	+0.2	-0.2	-6	-20	-0.2	+0.6
January	Current	83.5	2	29.1	16.9	93	51	3.4	8.1
	Normal	15.1	2	28.6	15.7	89	42	3.4	8.4
	Deviation	+68.4	0	+0.5	+1.2	+4	+9	0	-0.3
February	Current	4.6	2	30.9	18.3	96	46	4.2	9.4
	Normal	23.6	3	31.6	18.6	91	42	4.4	8.8
	Deviation	-19.0	-1	-0.7	-0.3	+5	+4	-0.2	+0.6

Normal- Average of preceding 10 years (1985 to 1994).

Deviation - Increase or decrease from the normal.

Fig. 1.a. Rainfall

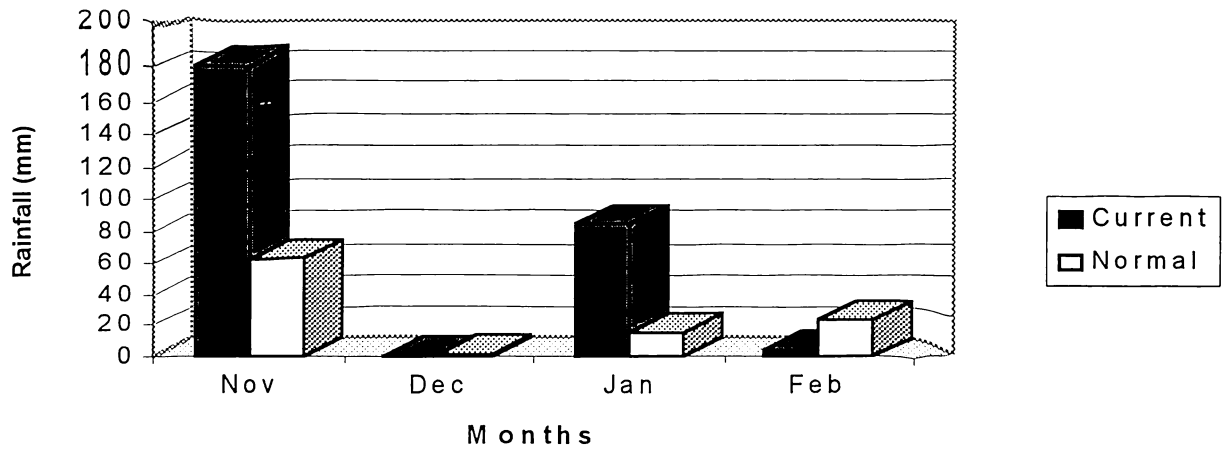


Fig.1.b. Rainy days

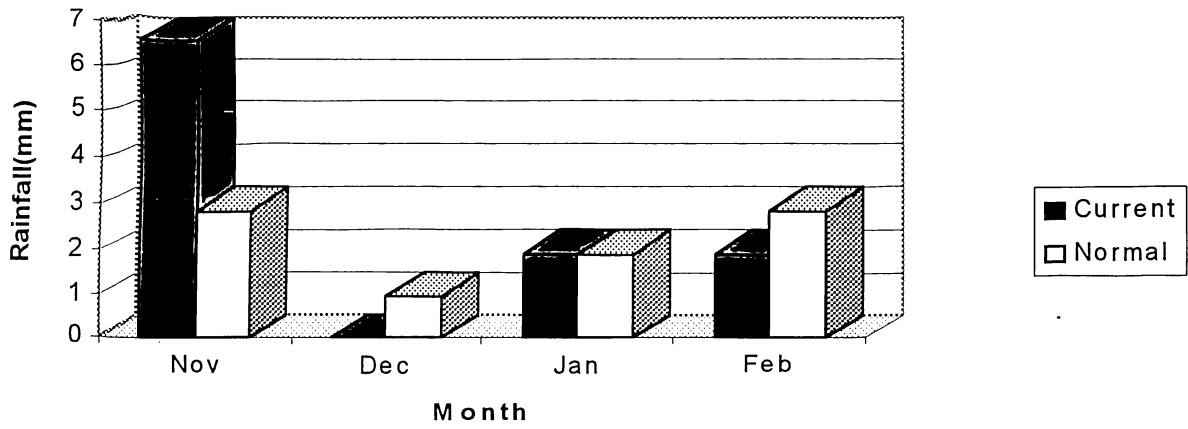


Fig. 1c. Temperature

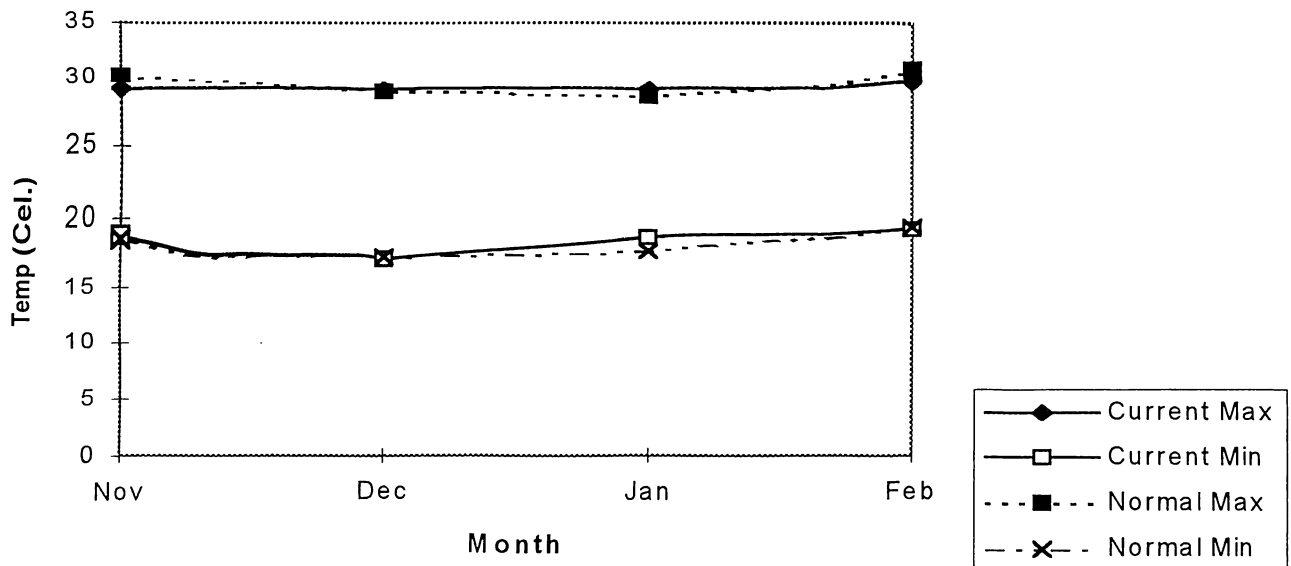


Fig. 1.a. Rainfall

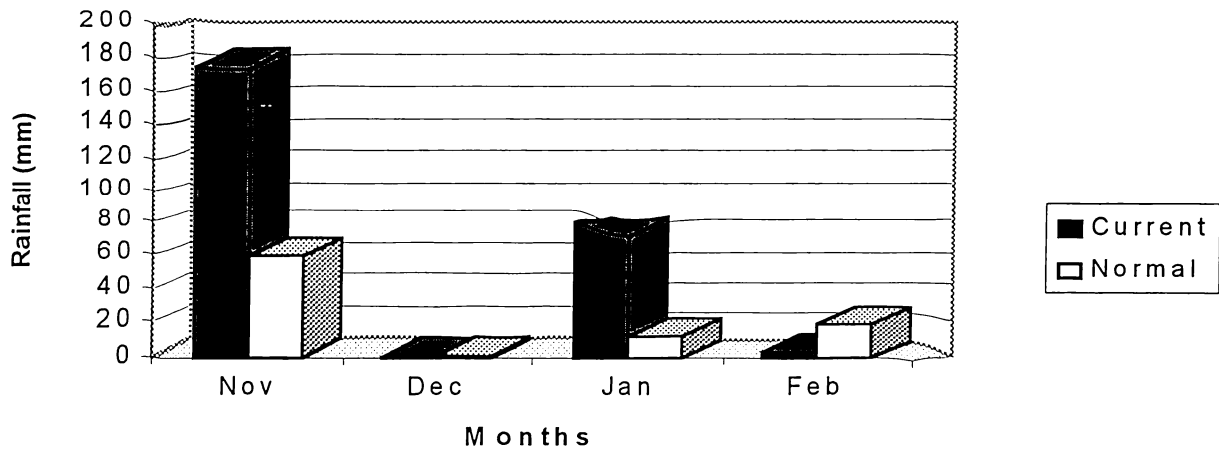


Fig.1.b. Rainy days

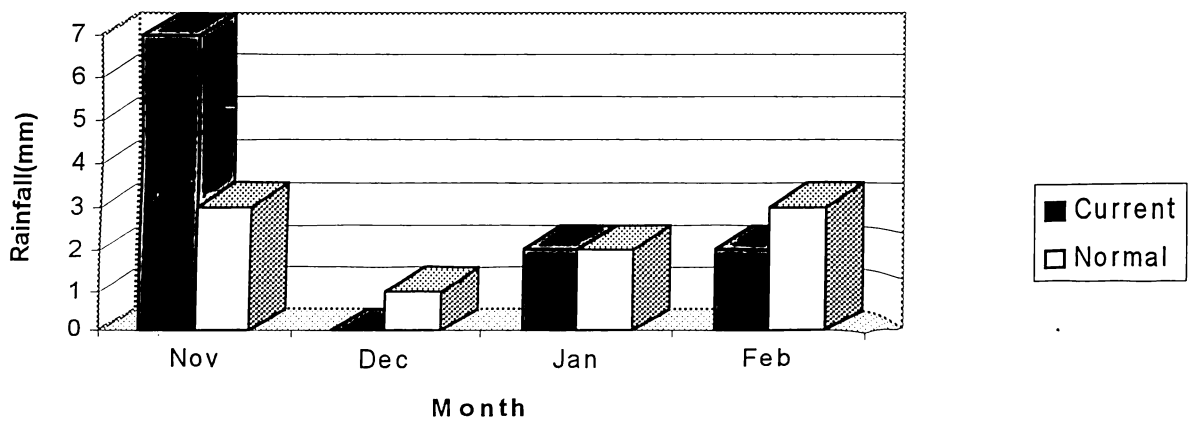


Fig. 1c. Temperature

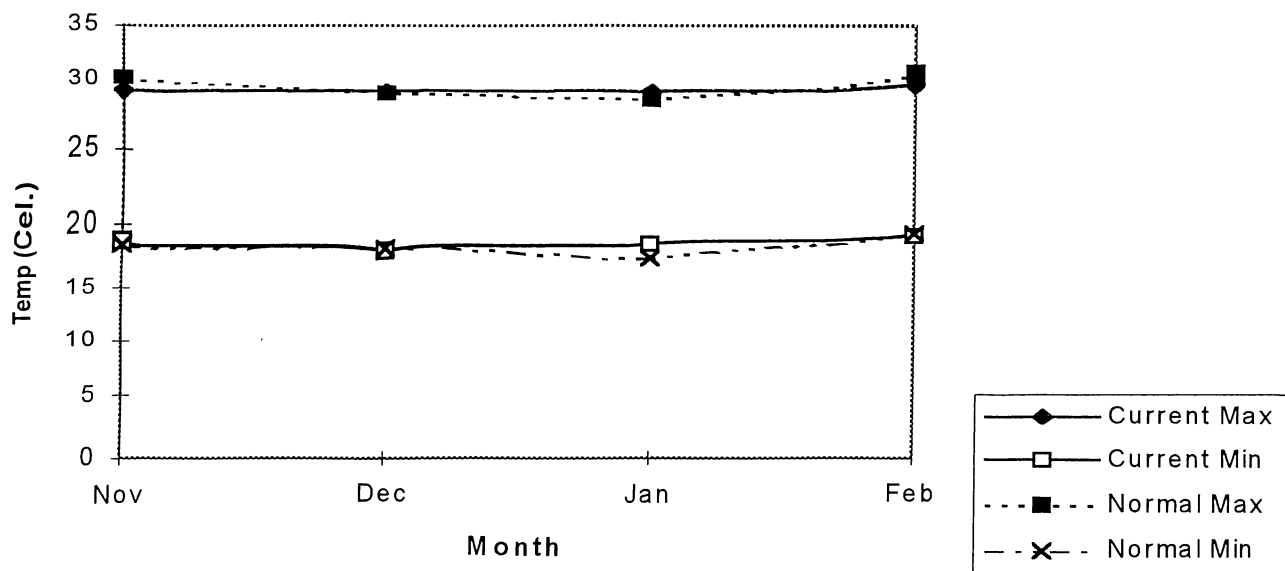


Fig. 1.d. Relative Humidity

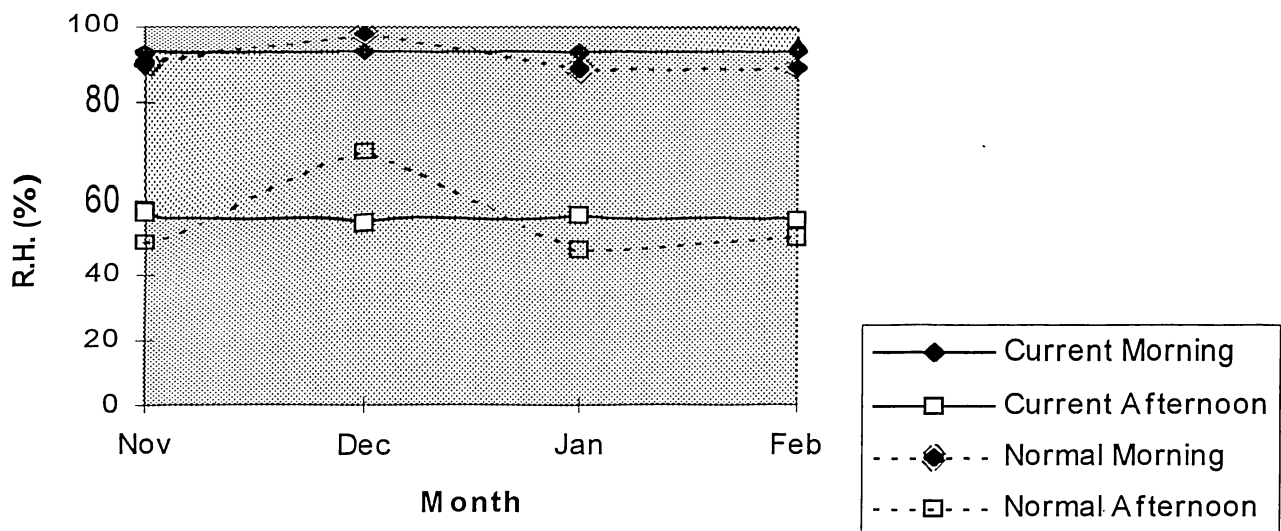


Fig. 1.e. Mean Evaporation

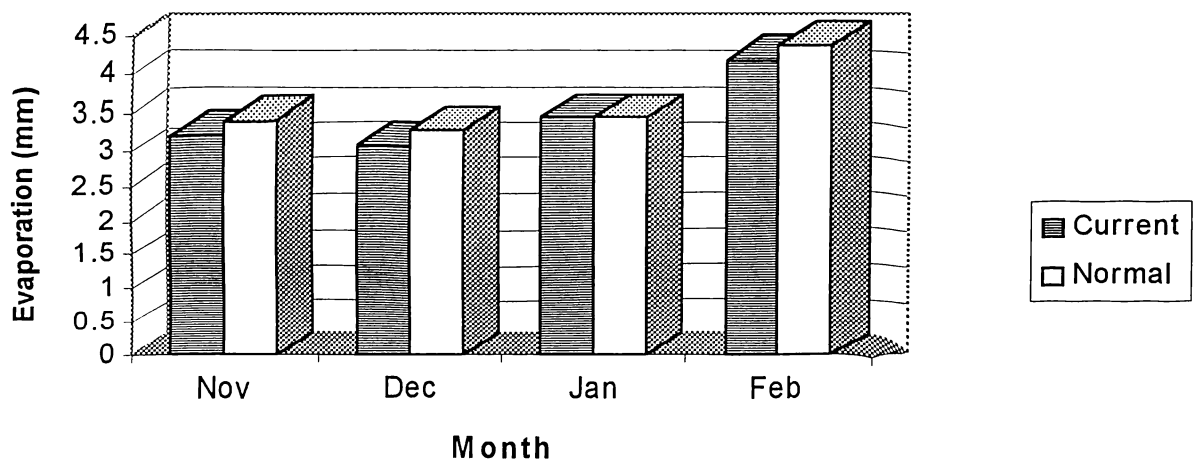
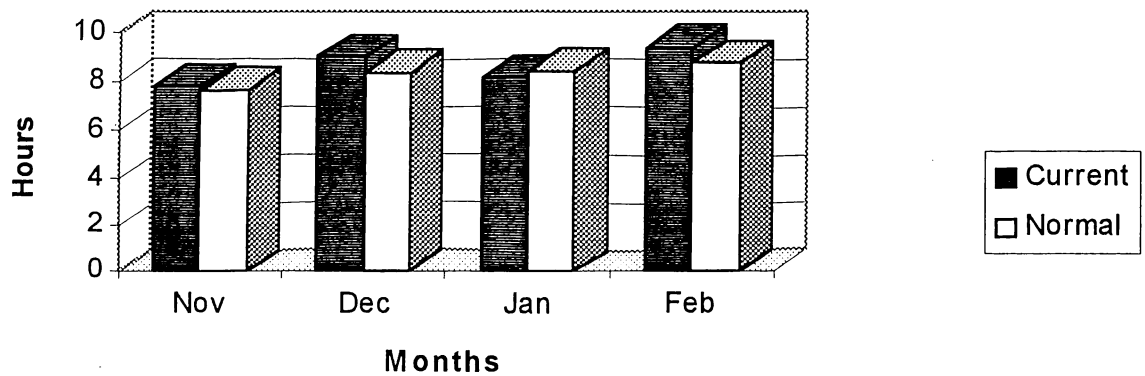


Fig. 1.f. BSH/day



December was the coldest month with mean daily temperature of 21.8° C (28.9° C mean maximum and 14.7° C mean minimum) and February was moderate with mean daily temperature of 24.6° C (30.9° C mean maximum and 18.3° C mean minimum). During the cropping season, November and February were comparatively cooler than the normal and January was comparatively hotter. During the cropping season, the mean monthly maximum temperature was 0.27° C less and the mean monthly minimum temperature was 0.2° C more than the normal.

3.4.3 **Relative humidity**

The mean monthly relative humidity in the morning and afternoon was 92.75 and 49.75 per cent as against the normal of 91.5 and 49.5 per cent respectively during the cropping season. The average values were more than normal in the months of November, January and February and it was less in the month of December.

3.4.4 **Bright Sunshine Hours**

The mean daily bright sunshine hours during the cropping season was 8.6 hours/day as against the normal of 8.3 hours/day. It was more than the normal in the months of November and February, same as normal in December and less than normal in January.

3.4.5 **Evaporation**

During the cropping season, the mean daily evaporation was 3.5mm as against the normal of 3.6mm.

3.5 **EXPERIMENTAL DETAILS**

3.5.1 **Design and Layout**

The experiment was laid-out in randomised block design (RBD) with ten treatments allocated over three replications. The treatments were allocated to different plots following the random number table of Fischer and Yates (1957). The plan of field layout alongwith the details of treatments is shown in Figure2.

3.5.2 Particulars of field layout

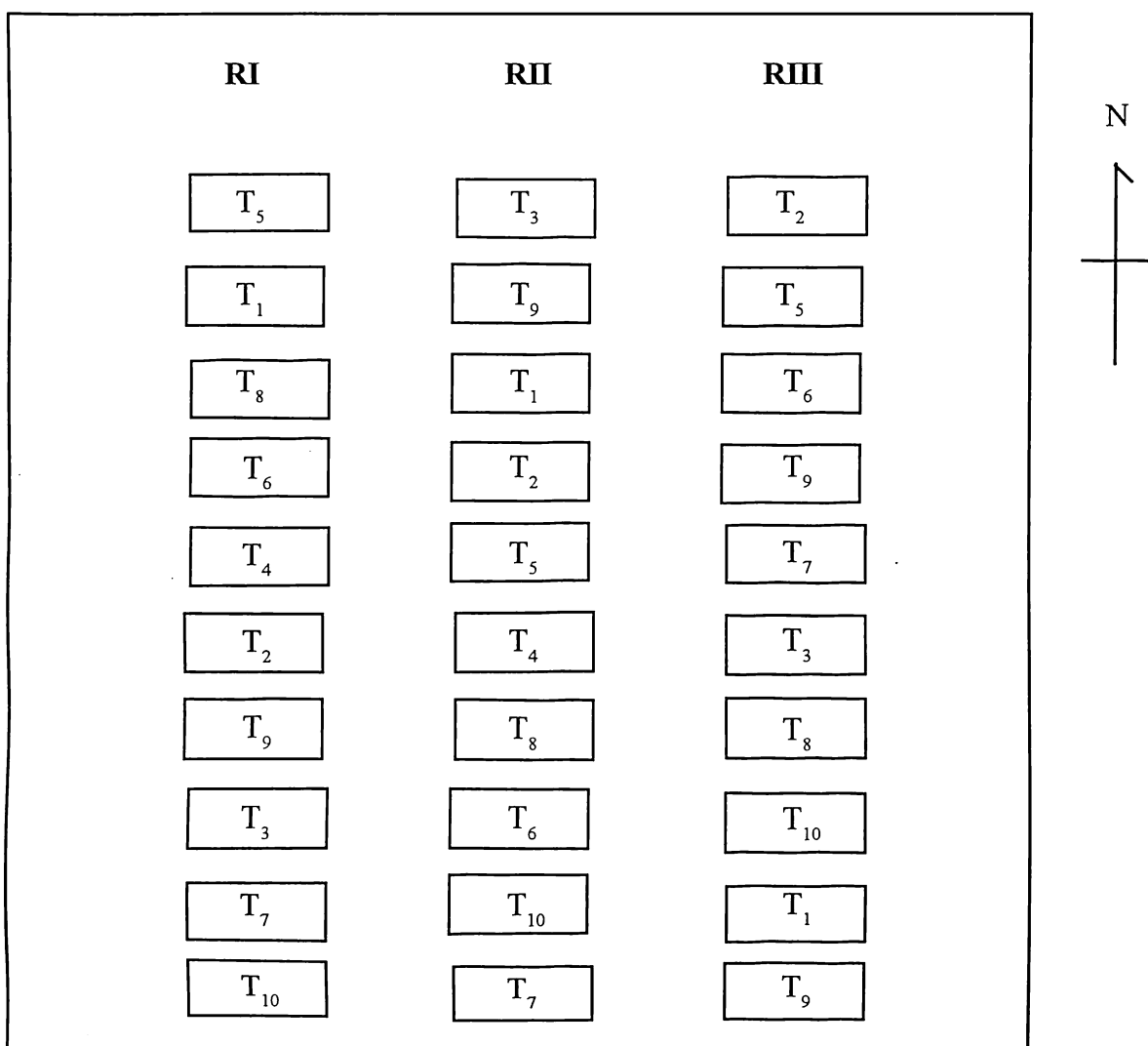
Design	:	Randomised Block Design (RBD)
Number of treatments	:	10
Number of replications	:	3
Total number of plots	:	30
Gross plot size	=	5.5X3.6 = 19.8m ²
Net plot size	=	5X3 = 15m ²
Variety - i) Pusa Bahar		(Improved)
ii) Pusa Bold		(Local Check)
Spacing	:	30 X 10 cm

3.5.3 Details of Treatment

The experiment was conducted with 10 treatments comprising of different low monetary agro-techniques alongwith one local practice and one recommended practice. Details of the treatments of the experiment are given below.

Treatment	Details
T ₁	Local practice (Broad-casting, with 30:15:15 N:P:K. Kg/ha. limited irrigations and sprays)
T ₂	Recommended practice (E-W sowing, No gypsum, No thinning)
T ₃	Recommended practice with thinning at 15 and 25 days of crop age.
T ₄	Recommended practice with thinning and North-South sowing.
T ₅	Recommended practice with thinning and application of Gypsum @ 250 Kg lha.
T ₆	Recommended practice with thinning and 60 per cent N topdressed (No Basal)
T ₇	Recommended practice with thinning and limited irrigations at initial stage.
T ₈	Recommended practice with thinning and <u>Azotobacter</u> inoculation.
T ₉	Recommended practice with thinning, inoculation and 50 per cent N topdressed without any basal N.
T ₁₀	Local practice with <u>Azotobacter</u> inoculation.

Fig. 2 PLAN OF LAYOUT



TREATMENTS

Design - R.B.D

No. of Replications-3

Gross plot size=(5.5 X 3.6)m²

Net Plot size=(5 X 3)m²

Variety i) Pusa Bahar

ii) Pusa Bold

- | | | |
|-----------------|---|---|
| T ₁ | : | Local Practice |
| T ₂ | : | Recommended Practice |
| T ₃ | : | T ₂ + Thinning |
| T ₄ | : | T ₃ + N -S sowing |
| T ₅ | : | T ₃ + Gypsum @ 250 Kg/ha. |
| T ₆ | : | T ₃ + 60% N top dressed (no basal) |
| T ₇ | : | T ₃ + Limited irrigations at initial stage |
| T ₈ | : | T ₃ + <u>Azotobacter</u> inoculation |
| T ₉ | : | T ₃ + Inoculation + 50% N topdressed
(no basal) |
| T ₁₀ | : | T ₁ + Inoculation |

A uniform spacing of 30cm X 10cm was maintained between rows and plants for all the treatments excepting treatment 1 and 10, where broadcasting was followed. In these treatments, plant population of about 4,40,000/ha was maintained.

3.5.4 Description of the variety

i) **PUSA BAHAR (Improved)** : Pusa Bahar (CDIR-247) was the test variety which was released in 1991 in view of its overall superiority by the Central Variety Release Committee for cultivation in the rainfed regions in the eastern zone. Pusa Bahar has been developed by pedigree method of selection from (“Pusa Rai 28” X “Varuna”) X (“Pusa Rai 30” X “T 6342”). Its seed is medium bold (4.5-5.0g/1000 seed). The variety attains a height of 140-150 cm. It has a strong stem and green foliage. The first flower is usually initiated when the crop is about 35 days old. It matures in 108 days in the eastern zone and in 135 days in the western zone. The blackish brown shining seeds contain 42-43 per cent oil. The siliqua is medium long with uneven and beaded surface. The variety is resistant to seed shattering. The yield potential of the variety is around 26 quintals per hectare.

ii) **PUSA BOLD (Local Check)** : Pusa Bold was released in 1984 from a cross of ‘Varuna’ and ‘BIC 1780’. It matures in 105-110 days. The variety attains a height of 170-180cm with a semi compact branching. It is suitable for growing in the coastal belt under irrigated condition. The plants bend on maturity due to heavily laddened pods. Leaves are medium size, medium green in colour with varying number of lobes, terminal lobe being acute. The siliqua is 5cm to 7cm long and each contains 13 to 18 seeds. The seeds are bold, round and blackish brown in colour having around 42 per cent oil. It has the yield potential of 15-18 q per hectare.

3.6 CULTURAL OPERATIONS

The field operations undertaken at various stages of crop growth on different dates are presented in Table - 4.

3.6.1 Field preparation

The experimental field was ploughed twice after the harvest of the previous crop to bring the soil into fine tilth. The weeds and the stubbles of the previous crop were removed. After final ploughing, laddering was done to level the field. Experimental plots were laid-out according to layout plan.

Table 4. Calendar of field operations

Sl.No.	Particulars of operations	Date
1	Ploughing (First)	2.11.95
2	Ploughing (Second)	3.11.95
3	Final Ploughing and laddering	3.11.95
4	Collection of soil sample	4.11.95
5	FYM application	4.11.95
6	Pre-sowing irrigation	5.11.95
7	Layout	6.11.95
8	Basal application of fertilizers in the lines (furrows) before sowing seeds	6.11.95
9	Seed inoculation with <u>Azotobacter</u>	6.11.95
10	Sowing of seed	6.11.95
11	Light irrigation	7.11.95
12	Drainage of excess rain water due to heavy shower after sowing.	8.11.95
13	Resowing /gap filling	13.11.95
14	Irrigation (Second)	25.11.95
15	Light hoeing, thinning and weeding	26.11.95
16	Spraying of pesticides	4.12.95
17	Topdressing with urea	6.12.95
18	Third irrigation	7.12.95
19	Hoeing and weeding	10.12.95
20	Spraying of pesticides	20.12.95
21	Fourth irrigation	22.12.95
22	Spraying of fungicides	10.1.96
23	Fifth irrigation	13.1.96
24	Spraying fungicides	27.1.96
25	Sixth irrigation	28.1.96
26	Harvesting and carrying to threshing floor	20.2.96 & 21.2.96
27	Sundrying	22.2.96 to 25.2.96
28	Threshing and cleaning	26.2.96
29	Seed drying and weighing	27.2.96

3.6.2 Application of manures and fertilizers.

Well decomposed farm yard manure (FYM) was applied uniformly at the rate of 5 tonnes per hectare at the time of land preparation. Fertilizers were applied at the recommended rate of 60:30:30kg for Pusa Bahar and 30:15:15 kg N, P₂O₅, K₂O per hectare for Pusa Bold in the form of urea, DAP and muriate of potash respectively. Half of nitrogen and whole of phosphate and potash were applied as basal in all the treatments but the basal application of N was skipped in T₆ and T₉. The rest 50 per cent nitrogen was top-dressed at the time of intercultural operation in all cases including T₉, but excepting in treatment six. In treatment number six and nine, the nitrogen was top-dressed at the rate of 60 and 50 per cent of the recommendation without any basal application. Gypsum was applied in treatment number five at the rate of 250 kg. per hectare at the time of sowing. The biofertilizer (Azotobacter) was applied at the rate of 10 kg per ha in T₈, T₉ and T₁₀ at the time of sowing. The bio-fertilizer slurry was prepared with water, mixed with the seed and dried in shade. Then the biofertilizer wet seeds were sown in the field.

3.6.3 Seeds and sowing

The seeds at the rate of 7.5 kg per hectare were shown on 6th November, 1995 in lines drawn manually with a row spacing of 30 cm in all the plots except the broad cast ones and the furrows were covered with soil after sowing. Resowing was done in all the line shown treatments one week after sowing as there was heavy rain-fall just after sowing which caused rotting of several seeds.

3.6.4 Thinning of the crop

Thinning was done 15 days after sowing maintaining 10cm spacing between the plants to have a uniform plant stand.

3.6.5 Interculture and weed control

Hoeing and weeding were done simultaneously twice at 15 and 25 days after sowing (DAS) manually.

3.6.6 Irrigation

At initial pre-sowing irrigation was given to facilitate germination. Later a light irrigation was given after sowing. Subsequently, five irrigations were given at desired intervals depending on the need of the crop.

3.6.7 Plant protection measures

BHC 10 per cent dust was applied to the soil at the rate of 25 kg/ha at the time of sowing to protect the seeds and the crop from whiteants and termites. Quinalphos and Endosulfan at the rate of 1 lit./acre were sprayed twice alternately to protect the crop from insect pests like aphids, cabbage leaf webber etc. To protect the crop from fungal wilt in mid crop growth stage and white rust in later stage Indofil M-45 and Bavistin were sprayed twice at the rate of 2.5 kg/ha and at 0.15 per cent conc. respectively.

3.6.8 Harvesting and threshing

The crop was harvested when 80 to 90 per cent of the siliquae turned yellow. One row from each side and five plants from each end of the row were removed to eliminate the border effect and then net plots were harvested. The plants of each plot were bundled separately and carried to the threshing floor for sun drying.

Threshing was done separately for each plot by beating the plants with sticks. The seed and stover were separated. The yield of seed and stover were recorded separately in kg per plot and later converted to kg per hectare.

3.7 BIOMETRIC OBSERVATIONS

3.7.1 SAMPLING TECHNIQUE

Leaving one row from each side and five plants from each end of the row ten plants were selected randomly from the central rows and were marked by pegs and tagged. The sample plants were

harvested treatmentwise and kept separately to record the post-harvest observations. The growth characters were studied at 15 days intervals commencing from 30 days after sowing till harvest. Random sampling technique was adopted to study various plant characters such as plant population, plant height, leaf number, leaf area, leaf area index (LAI), number of primary and secondary branches per plants number of siliquae per plant, length of siliqua, number of seeds per siliqua, 1000 seed weight, dry matter production etc.

3.7.2 PRE-HARVEST OBSERVATIONS

3.7.2.1 Plant population

The total number of plants per m² area were counted at the time of recording the biometric observations treatmentwise.

3.7.2.2 Plant height

The height of the main shoot was measured from the ground level up to the base of the apical bud during vegetative growth stage and upto the base of the topmost floret during the reproductive stage. The height of ten randomly selected and tagged plants from each plot was recorded and the mean plant height was determined.

3.7.2.3 Leaf number

The number of photosynthetically active leaves per plant was counted and the average of ten sample plants for each treatment was found out.

3.7.2.4 Number of branches

The number of primary branches per plant was counted and the average of ten sample plants for each treatment was determined.

3.7.2.5 Leaf area

Five average sized leaves (third leaf from the top) from sample plants of each treatment were collected. The apparent leaf area was calculated by multiplying the maximum length and breadth of the leaf. The actual leaf area was calculated by leaf area meter (systronics 211). The leaf area coefficient was calculated by using the following formula :-

$$\text{Leaf Area Coefficient (LAC)} = \frac{\text{Actual leaf area}}{\text{Apparent leaf area}}$$

The apparent leaf area from the sample plants, LAC and the number of leaves per plant were multiplied to get the total leaf area per plant. This was again multiplied by the number of plants per m² to get the total leaf area per m².

3.7.2.6 Leaf Area Index (LAI)

Leaf area index is the ratio of the total leaf area to the ground area occupied by the plants. LAI for each treatment was determined by using the following formula -

$$\text{LAI} = \frac{\text{Total leaf area}}{\text{Unit land area}} = \frac{\text{Apparent leaf area} \times \text{LAC} \times \text{Average number of leaves/Plant} \times \text{Number of Plants/ m}^2}{\text{m}^2}$$

3.7.2.7 Dry matter production

Five plant samples were collected at random from each plot from the destructive rows and the roots were separated from the base portion. These plants were initially dried under the Sun after taking the fresh weight and then oven-dried at 80°C for 24 hours or till a constant weight was achieved. The dry matter accumulation per plant was expressed on oven-dry basis.

3.7.3 POST- HARVEST OBSERVATIONS

3.7.3.1 Number of siliquae per plant

Number of siliquae of each of the ten sample plants were counted and the average for each treatment was determined.

3.7.3.2 Number of siliquae on main stalk

Number of siliquae on the main stalk of ten sample plants were counted and averaged out separately for each treatment.

3.7.3.3 Length of siliqua

Ten siliquae from each sample plant were collected and the length was measured for each. Then the average length of siliqua for each treatment was determined.

3.7.3.4 Number of seeds per siliqua

Number of seeds in each of the siliqua selected for length study were counted and averaged out to get the number of seeds per siliqua for each treatment.

3.7.3.5 Test weight (1000 seed weight)

After mixing seeds of all the ten sample plants of each treatment, 1000 seeds were counted randomly and weighed to get the test weight.

3.7.4 YIELD STUDIES

3.7.4.1 Seed yield

The seed yield was recorded net plot-wise after the produce was dried under the sun for 3 days. The seed yield per hectare was estimated by multiplying it with the hectare factor.

3.7.4.2 Stover yield

Stover yield of each plot was found-out separately after drying sticks under sun for 5 to 6 days and the corresponding stover yields were recorded in quintals per hectare by multiplying with the hectare factor.

3.7.4.3 Harvest Index (HI)

The harvest index was calculated by dividing the seed yield by the total biological yield which was expressed on percentage basis.

Harvest Index = Seed yield (qha⁻¹) / Biological yield (qha⁻¹) X 100

Biological yield is the sum of seed and stover yield.

3.7.4.4 Seed : stover ratio

Seed : stover ratio for individual treatment was found out by dividing the seed yield with the corresponding stover yield.

3.7.4.5 Oil content of seeds

Seed samples from each treatment were kept separately and their oil content was determined by the ether extraction method.

3.8 PLANT ANALYSIS

The plant samples collected for the determination of dry matter were used for nutrient uptake study. The samples were oven dried at 80^oc to a constant weight and finely ground in an electric grinder and then passed through a 2mm sieve. Then the samples were analysed for determination of different nutrients. The methods employed are given in the Table. 5.

Table 5. **Methods employed for plant analysis**

Serial No	Nutrient	Methods employed
1	Nitrogen	Micro Kjeldahl steam distillation method (Jackson, 1967)
2	Phosphorus	Di-acid digestion method and colorimetric determination. (Piper, 1950)
3	Potassium	Di-acid digestion and Flame photometric determination (Piper, 1950)
4	Sulphur	Di-acid digestion and turbidity method (Massoumi and Cornfield, 1963)

3.9 ECONOMICS OF PRODUCTION

The economics of production for different treatments were calculated on hectare basis by taking into account the cost of various inputs and the value of produce as per the prevailing market price. The net profit for each treatment was calculated by deducting the total cost of cultivation from the gross return value. Net return per rupee invested was worked out by dividing the net profit by the total cost of cultivation.

3.10 STATISTICAL ANALYSIS

3.10.1 Analysis of variance

The data obtained on various growth, yield and yield attributes were analysed statistically as per the method appropriate for randomised block design for analysis of variances. The variances were tested at 5 per cent level of significance (Cochran and Cox, 1957). The standard error of means [SE(m) ±] were calculated in all cases and the critical differences (CD) were calculated for comparing the treatment means wherever 'F' test was significant.

The SE(m) and CD were calculated as per the formulae given below :

$$SE(m)\pm = \sqrt{\frac{\text{Error mean square}}{r}}$$

$$CD = SE(m) \times \sqrt{2} \times t_{(0.05)} \text{ at error df}$$

where, r- number of replications

df- degrees of freedom

3.10.2 Correlation studies

Correlation between different growth characters, yield and yield attributes were studied. The correlation coefficient (r) was calculated by using the following formula (Panse and Sukhatme, 1967).

$$r = \frac{\text{Cov}(x,y)}{\sqrt{V(x) \cdot V(y)}}$$

$$= \frac{\Sigma XY - \frac{\Sigma X \Sigma Y}{n}}{\sqrt{\left[\left\{ \Sigma X^2 - \frac{(\Sigma X)^2}{n} \right\} \cdot \left\{ \Sigma Y^2 - \frac{(\Sigma Y)^2}{n} \right\} \right]}}$$

- where,
- r - correlation coefficient
 - x - independent variable
 - y - dependent variable
 - V(x) - variance of X
 - V(y) - variance of Y
 - Cov(x,y) - covariance of XY
 - n - number of observations

For test of significance of the correlation co-efficient the following formula was used.

$$t = \frac{r}{\sqrt{1-r^2}} \times \sqrt{n-2}$$

where, r - correlation coefficient

n - number of pairs of observations

If this ratio exceeds the 't' value for p= 0.05 at n-2 degrees of freedom we have reason to believe that the sample indicates a real correlation between the two variates.

CHAPTER - IV

EXPERIMENTAL FINDINGS

EXPERIMENTAL FINDINGS

The experimental findings of the present investigation conducted to study the impact of low monetary agrotechniques on the growth and yield of mustard have been presented in this chapter. During the course of investigation, observations on different growth parameters, yield and yield attributing characters and uptake of different nutrients as influenced by different treatments were recorded at different stages of growth and analysed statistically to study the effect of various low monetary agrotechniques on mustard variety Pusa Bold (local check) and Pusa Bahar (improved). The results have been described here with appropriate figures.

4.1 PRE-HARVEST STUDIES

4.1.1 Plant Population

The data in respect of plant population at initial stage was counted and have been presented in Table 6.

Table 6. Plant population/m² at initial stage as affected by low monetary agro-techniques.

	Treatment	Plant population/m ²
T ₁	Local Practice	65
T ₂	Recommended Practice	54
T ₃	T ₂ + thinning	40
T ₄	T ₃ + N-S sowing	42
T ₅	T ₃ + Gypsum	48
T ₆	T ₃ + 60 % N topdressed (no basal)	44
T ₇	T ₃ + limited Irrigations	40
T ₈	T ₃ + <i>Azotobacter</i>	47
T ₉	T ₈ + 50 % N topdressed (no basal)	46
T ₁₀	T ₁ + <i>Azotobacter</i>	63
	SE (m) ±	3.75
	CD (0.05)	11.14

The data would indicate that plant stand remained practically uniform in line sown plots except the treatment number two i.e. without thinning. T_2 had 24.33 per cent more plant population than mean of plots with thinning (T_3 - T_9). In broadcast plots the plant population was significantly more than the line sown plots, but was at par with that of the line sown plot without thinning. The plant population was recorded per square metre area basis. The mean plant population of the broadcast plots (T_1 and T_{10}) was 43 per cent higher than that of line sown plots (T_2 - T_9).

4.1.2 Plant height

The plant height gives an indication of the growth of a crop. The observations on mean plant height recorded during successive stages of growth at 15 days interval commencing from 30 DAS have been presented in Table 7 and illustrated in Fig. 3.

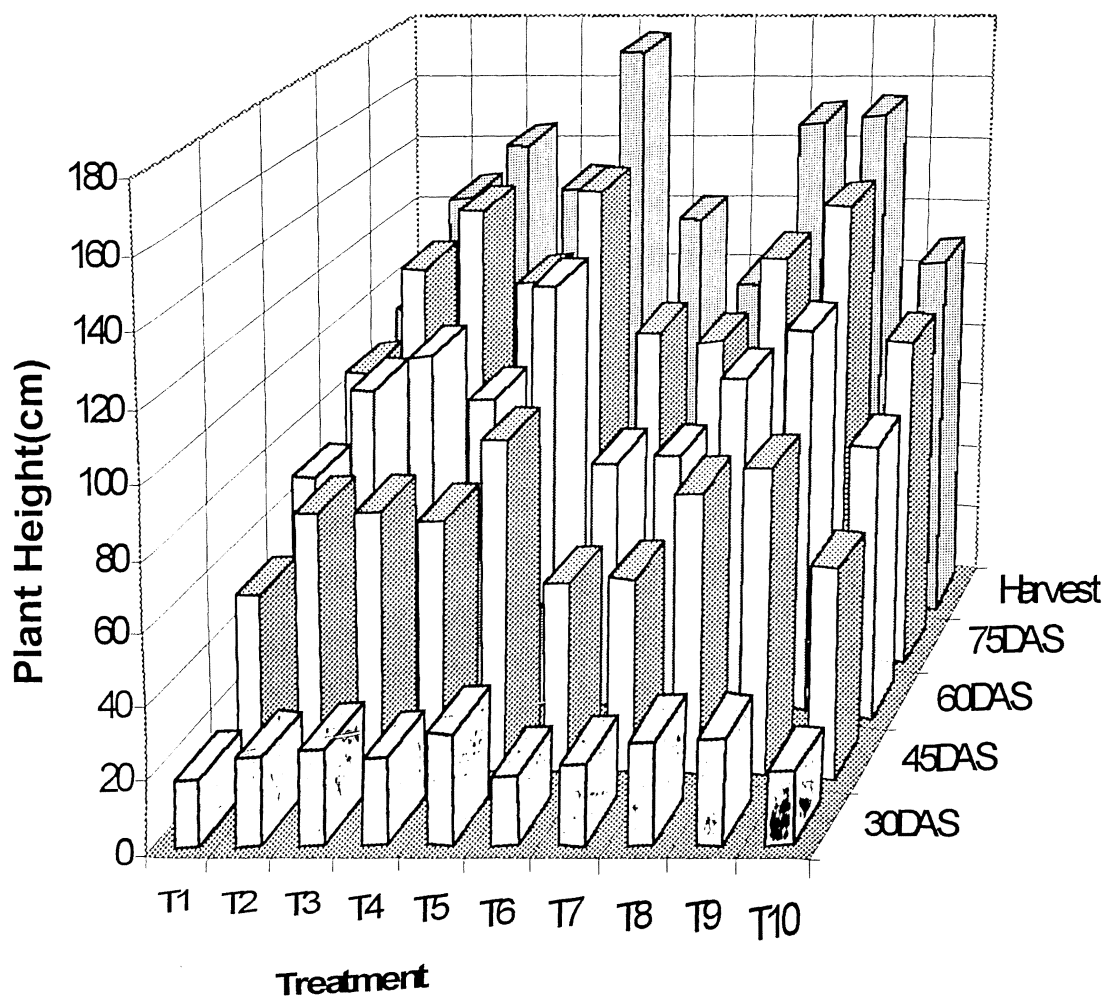
The data presented in Table 7 indicated that the height of the plants increased progressively with time and attained the maximum at harvest in all the treatments studied. However, the rate of growth was maximum between 30 to 45 DAS (3.09 cm per day) and minimum between 75 DAS to harvest (0.601 cm per day). The treatment number five (Recommended practice + thinning + 250 kg gypsum/ha) recorded maximum plant height among all the treatments tried and T_1 (local practice) had the minimum irrespective of stages of growth. At harvest, the recommended practice (T_2) registered significant increase in plant height by 39.14 per cent over the local practice (T_1). Thinning (T_3) enhanced the plant height by 39.39 per cent over no thinning (T_2) in recommended practice. N-S direction of sowing (T_4) showed marginal depression in plant height over the E-W sowing (T_3). The maximum plant height was attained by T_5 with the application of gypsum (175.43 cm) which enhanced the height by 20.43 per cent over no gypsum treatment (T_3). Split application of N fertilizer (50% basal + 50% topdressing) was found superior to only topdressing with 60 per cent N without any basal application and registered 19.73 per cent increase in plant height. Application of limited irrigations (T_7) reduced the plant height by 30.99 per cent over the normal practice (T_3) but was at par with T_1 . *Azotobacter* inoculation enhanced the plant height significantly (109.83cm) by 18.95 per cent in case of recommended practice. There was no significant difference between the mean plant heights of T_8 and T_9 .

Average plant heights of Pusa Bold were 19.62 , 55.8, 74.25, 92.33 cm and that of Pusa Bahar were 25.46, 74.36, 97.51, 120.85 cm at 30, 45, 60 and 75 DAS respectively. The variety Pusa Bahar registered 138.95 cm plant height at harvest which was 37.46 per cent more than the variety Pusa Bold (101.08cm) at harvest.

Table 7. Plant height (cm) at successive stages of growth as affected by low monetary agro-techniques.

Treatment	Days after sowing				At harvest
	30	45	60	75	
T ₁ Local Practice	17.73	50.93	68.67	86.43	92.33
T ₂ Recommended Practice	23.43	74.67	95.43	118.56	128.47
T ₃ T ₂ + thinning	25.83	75.53	105.57	136.47	145.67
T ₄ T ₃ + N-S sowing	23.53	72.53	92.53	114.33	131.53
T ₅ T ₃ + Gypsum	30.46	95.17	126.33	142.63	175.43
T ₆ T ₃ + 60 % N topdressed (no basal)	19.40	53.77	72.93	98.73	121.67
T ₇ T ₃ + limited Irrigations	22.67	55.53	75.20	95.67	100.53
T ₈ T ₃ + <i>Azotobacter</i>	28.83	80.20	98.73	121.77	152.83
T ₉ T ₈ + 50 % N topdressed (no basal)	29.53	87.50	113.37	138.67	155.50
T ₁₀ T ₁ + <i>Azotobacter</i>	21.50	60.67	79.83	98.23	109.83
SE (m) ±	2.73	5.45	5.95	5.31	5.47
CD (0.05)	8.12	16.19	17.67	15.78	16.26

Fig.3. Plant Height



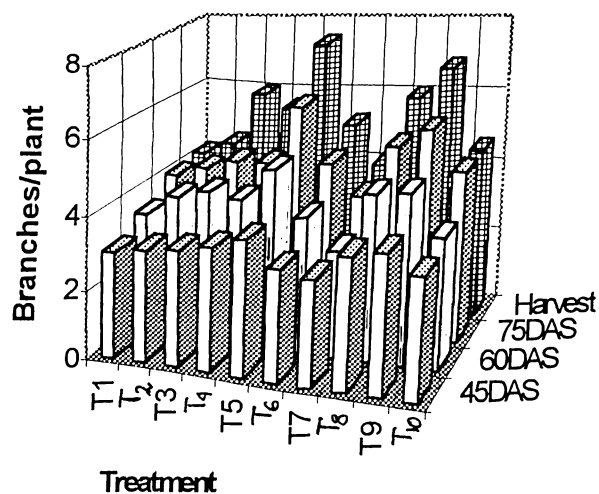
4.1.3 Number of primary branches per plant

The branches which came out directly from the main stalk were taken as the primary branches. The data on number of primary branches per plant recorded at successive stages of growth at 15 days intervals commencing from 45 DAS have been presented in Table 8 and depicted in Fig. 4.

Table 8. Number of primary branches per plant at successive stages of growth as affected by low monetary agro-techniques.

	Treatment	Days after sowing			At Harvest
		45	60	75	
T ₁	Local Practice	3.03	3.46	4.01	4.12
T ₂	Recommended Practice	3.21	4.07	4.33	4.52
T ₃	T ₂ + thinning	3.32	4.33	4.64	6.01
T ₄	T ₃ + N-S sowing	3.51	4.23	4.68	5.67
T ₅	T ₃ + Gypsum	3.83	5.13	6.26	7.52
T ₆	T ₃ + 60 % N topdressed (no basal)	3.13	3.83	4.73	5.23
T ₇	T ₃ + limited Irrigations	2.91	2.95	3.81	4.11
T ₈	T ₃ + <i>Azotobacter</i>	3.57	4.53	5.23	6.05
T ₉	T ₈ + 50 % N topdressed (no basal)	3.73	4.60	5.72	6.88
T ₁₀	T ₁ + <i>Azotobacter</i>	3.26	3.52	4.62	4.63
	SE (m) ±	0.32	0.39	0.35	0.49
	CD (0.05)	NS	1.15	1.04	1.46

Fig.4. Primary Branches per plant



The data in Table 8 would reveal that the number of primary branches per plant exhibited an increasing trend up to harvest. However, the rate of increases was more between 45 and 60 DAS and later declined attaining minimum between 75 DAS and harvest. The treatment with recommended practice + thinning and application of gypsum (T_3) recorded maximum number of primary branches per plant and T_7 with limited irrigations in the recommended practice and thinning recorded minimum in all the growth stages observed. All the treatments recorded more number of primary branches per plant than that in T_1 . At harvest, the recommended practice (T_2) did not record any significant increase in number of primary branches per plant over the local practice (T_1), whereas thinning with recommended practice (T_3) increased the number by 32.96 per cent over no-thinning (T_2). N-S direction (T_4) of sowing had slightly reduced the number of primary branches per plant but was at par with the E-W sowing (T_3). T_5 recorded significantly higher number of primary branches per plant (7.52) which was 25.12 per cent more than T_3 and was at par with T_9 . Application of N in two equal splits (50 % basal + 50 % topdressing), T_3 registered slightly higher number of primary branches per plant than that with top dressing of 60 per cent N without any basal application (T_6). Limited irrigations (T_7) reduced the number of branches by 31.61 per cent than the recommended practice (T_3). *Azotobacter* inoculation increased the number of primary branches per plant marginally over the local practice and recommended practice. But when 50 per cent basal N was skipped (T_9) inoculation resulted further increase in the number of primary branches per plant.

The improved variety, Pusa Bahar recorded 3.4, 4.21, 4.93, 5.75 primary branches per plant while the local check, Pusa Bold had 3.38, 3.62, 4.32, 4.38 at 45, 60, 75 DAS and harvest respectively.

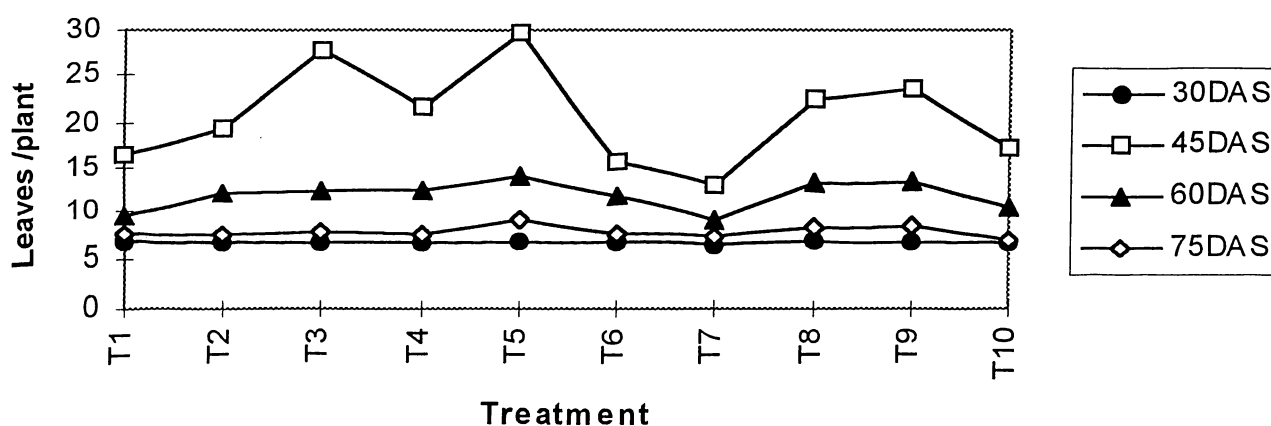
4.1.4 Number of functional leaves per plant

The green leaves which were unfolded completely and took active part in photosynthesis were taken as the functional leaves. The data of mean number of functional leaves per plant recorded at successive stages of growth starting from 30 DAS have been presented in Table 9 and illustrated in Fig.5.

Table 9. Number of functional leaves per plant at successive stages of growth as affected by low monetary agro-techniques.

	Treatment	Days after sowing			
		30	45	60	75
T ₁	Local Practice	6.53	16.33	9.53	7.47
T ₂	Recommended Practice	6.90	19.23	12.47	7.87
T ₃	T ₂ + thinning	7.33	27.83	12.83	8.47
T ₄	T ₃ + N-S sowing	7.27	21.50	12.63	8.13
T ₅	T ₃ + Gypsum	7.37	29.82	14.47	9.83
T ₆	T ₃ + 60 % N topdressed (no basal)	6.80	15.60	11.93	7.77
T ₇	T ₃ + limited Irrigations	6.40	12.67	8.80	7.17
T ₈	T ₃ + <i>Azotobacter</i>	7.37	22.50	13.56	8.87
T ₉	T ₈ + 50 % N topdressed (no basal)	7.37	23.72	13.83	9.27
T ₁₀	T ₁ + <i>Azotobacter</i>	7.27	17.20	10.93	7.53
	SE (m) ±	0.06	2.10	1.13	1.06
	CD (0.05)	0.18	6.24	3.36	NS

Fig.5. Functional Leaves per plant



In general, the number of leaves per plant increased progressively upto 45 DAS and declined thereafter due to senescence of older leaves. It was also observed that irrespective of treatments almost all the leaves have dropped from the plants at maturity. The maximum number of leaves per plant was observed in T₅ comprising of recommended practice and thinning with gypsum while T₇ i.e. the recommended practice and thinning with limited irrigations recorded minimum number of leaves per plant at all the stages of growth. All the treatments except T₇ recorded more number of leaves per plant as compared to the local practice (T₁). At 45 DAS, the maximum leaf number stage, there was no significant difference between leaf number in local practice and recommended practice. Thinning (T₃) recorded significantly more (44.72%) leaves than no-thinning (T₂). N-S sowing (T₄) exhibited a depressive effect and produced significantly less (29.44%) leaves than E-W sowing (T₃). Application of gypsum (T₅) recorded largest number of leaves (29.82) with marginal increment over T₃ and T₉. Topdressing with 60 per cent N alone without any basal application (T₆) reduced the leaf number drastically (78.4%) over the recommended practice of split application of the whole N (T₃). Limited irrigations (T₇) also reduced the number of leaves significantly by 119 per cent over normal practice (T₃). *Azotobacter* inoculation did not show any significant difference in leaf number over both the local and recommended practice, whereas inoculation with 50 per cent N topdressing (T₉) increased the leaf number slightly over T₈.

The local check, Pusa Bold recorded 16.77 and Pusa Bahar recorded 21.61 leaves showing 28.86 per cent increase in number of leaves per plant over the former at 45 DAS.

4.1.5 Leaf Area per plant

The data on mean leaf area determined at different stages of growth commencing from 30 DAS have been presented in Table 10 and illustrated in Fig. 6.

It would be evident from the data that the mean leaf area per plant increased progressively upto 60 DAS and declined thereafter. The rate of increase in leaf area was maximum between 30 to 45 DAS. The treatment number five (recommended practice and thinning plus gypsum application) recorded maximum leaf area at 30 and 75 DAS where as T₃ (Recommended practice plus thinning) recorded

maximum at 45 and 60 DAS. The local practice (T₁) recorded minimum leaf area at each stage of growth. At 60 DAS, the maximum leaf area stage, the recommended practice (T₂) obtained significantly more (91.04%) leaf area than the local practice (T₁). Thinning (T₃) proved to be superior over no thinning (T₂) with 39.6 per cent advantage in leaf area. The N-S direction of sowing (T₄) reduced the leaf area marginally over E-W sowing (T₃). T₃ registered maximum leaf area of 971.63 cm² without gypsum which was marginally higher than that in the gypsum applied plot (T₅). There was no significant difference between leaf area of T₃ and T₆ with 60 per cent N topdressing. Limited irrigation reduced the leaf area significantly by 43.26 per cent over normal practice (T₃). There was no significant influence

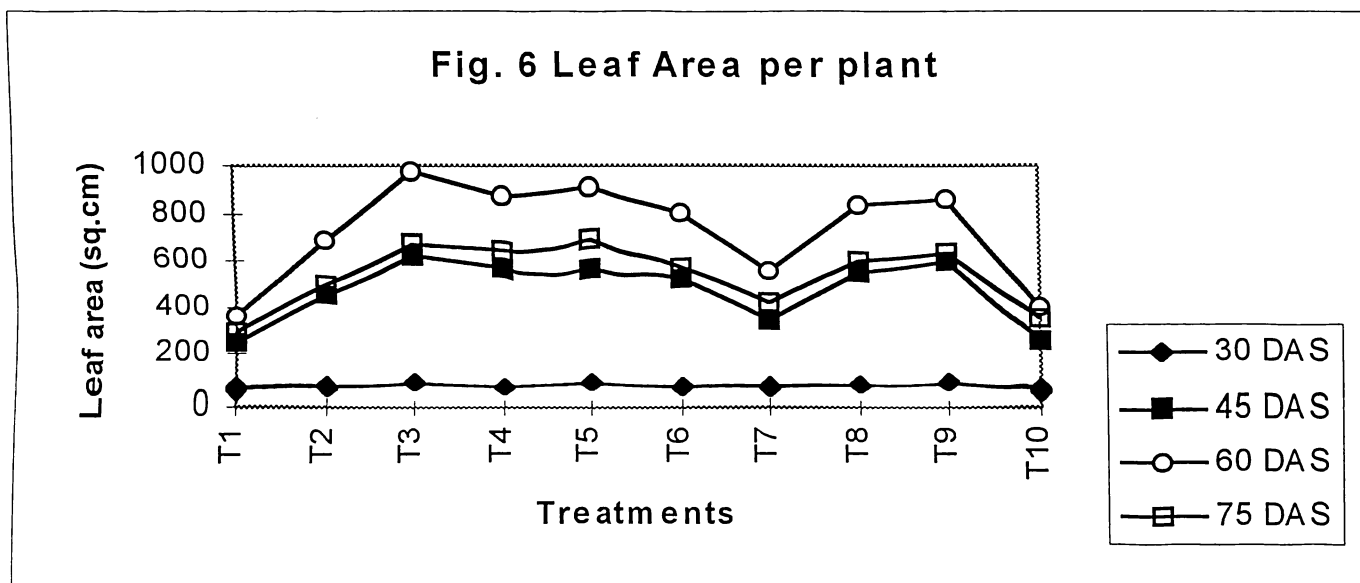
Table 10. Leaf area per plant (cm²) at successive stages of growth as affected by low monetary agro-techniques.

Treatment		Days after sowing			
		30	45	60	75
T ₁	Local Practice	53.80	242.20	364.33	294.67
T ₂	Recommended Practice	77.83	462.77	696.03	512.11
T ₃	T ₂ + thinning	127.47	653.80	971.63	702.07
T ₄	T ₃ + N-S sowing	107.14	600.00	888.09	678.57
T ₅	T ₃ + Gypsum	131.33	606.97	915.57	726.50
T ₆	T ₃ + 60 % N topdressed (no basal)	93.18	527.27	802.27	565.91
T ₇	T ₃ + limited Irrigations	77.53	351.27	551.33	417.37
T ₈	T ₃ + <i>Azotobacter</i>	114.87	563.00	837.3	607.03
T ₉	T ₈ + 50 % N topdressed (no basal)	126.13	605.87	865.93	635.03
T ₁₀	T ₁ + <i>Azotobacter</i>	60.33	258.13	389.87	344.87
	SE (m) ±	5.82	37.80	64.89	43.37
	CD (0.05)	17.29	112.29	192.78	128.84

of *Azotobacter* inoculation though there was marginal increase in both the practices. When from the recommended practice 50 per cent N was skipped at sowing and inoculated with *Azotobacter* the increase was marginal over T_8 .

The improved variety, Pusa Bahar recorded leaf area of 816.02 cm² and the local check, Pusa Bold had 377.1 cm² showing 116.39 per cent increase over the latter at the maximum leaf expansion stage (60 DAS).

Fig. 6 Leaf Area per plant



4.1.6 Leaf area index (LAI)

The leaf area indices computed at different stages of growth have been presented in Table-11 and depicted in Fig. 7.

The leaf area index increased progressively upto 60 DAS and declined thereafter. The rate of increase in LAI was maximum between 30 to 45 DAS. Inclusion of different low monetary agro-techniques improved the leaf area index over the local practice in all cases except in treatment number 7 with limited irrigations along with the recommended practice and thinning which had minimum LAI at all the stages of growth. The treatment with recommended practice and thinning along with gypsum application (T_3) recorded the maximum LAI at each stage of growth. At 60 DAS, the recommended practice (T_2) recorded significantly higher leaf area index (53.39%) over local practice (T_1) where as

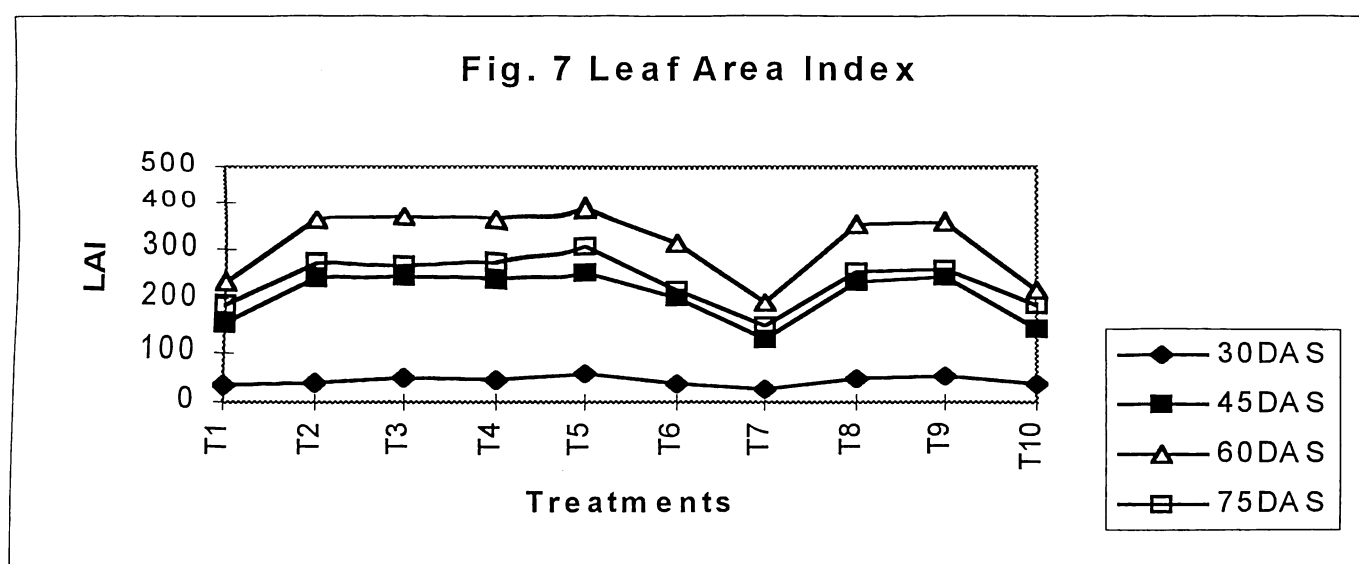
Table 11. Leaf area index(LAI) at successive stages of growth as affected by low monetary agro-techniques.

Treatment		Days after sowing			
		30	45	60	75
T ₁	Local Practice	0.35	1.57	2.36	1.91
T ₂	Recommended Practice	0.42	2.48	3.62	2.74
T ₃	T ₂ + thinning	0.51	2.61	3.85	2.81
T ₄	T ₃ + N-S sowing	0.45	2.52	3.73	2.85
T ₅	T ₃ + Gypsum	0.63	2.85	4.28	3.43
T ₆	T ₃ + 60 % N topdressed (no basal)	0.41	2.32	3.53	2.49
T ₇	T ₃ + limited Irrigations	0.31	1.38	2.18	1.65
T ₈	T ₃ + <i>Azotobacter</i>	0.54	2.64	3.92	2.86
T ₉	T ₈ + 50 % N topdressed (no basal)	0.58	2.78	3.98	2.91
T ₁₀	T ₁ + <i>Azotobacter</i>	0.38	1.61	2.49	2.11
	SE (m) ±	0.04	0.18	0.18	0.28
	CD (0.05)	0.12	0.54	0.54	0.83

all the stages of growth. The treatment with recommended practice and thinning along with gypsum application (T₅) recorded the maximum LAI at each stage of growth. At 60 DAS, the recommended practice (T₂) recorded significantly higher leaf area index (53.39%) over local practice (T₁) where as the former with thinning showed marginal increase in LAI over (T₂). Both the E-W (T₃) and N-S (T₄) directions of showing were at par with regard to LAI. Application of gypsum (T₅) increased LAI

significantly over T_3 without gypsum application by 11.17 per cent. T_6 with no basal but topdressing with 60 per cent N showed marginal increase over T_3 with two equal split applications (50% basal + 50% topdressed). T_7 with limited irrigation reduced the LAI significantly over T_3 with normal practice by 43.38 per cent. *Azotobacter* inoculation did not influence the LAI much against the local (T_{10}) as well as the recommended practice with inoculation (T_8). However, when 50 per cent basal N application was skipped in T_9 , there was marginal increase in LAI over T_8 .

The variety Pusa Bahar (3.64) was found superior to Pusa Bold (2.43) registering 49.79 per cent more LAI at 60 DAS.



4.1.7 Dry matter accumulation (DMA) per plant

The weight of the plant after being oven dried was taken as the DMA in that plant. The data on dry matter accumulation determined at successive stages of growth have been presented in Table 12 and depicted in Fig. 8.

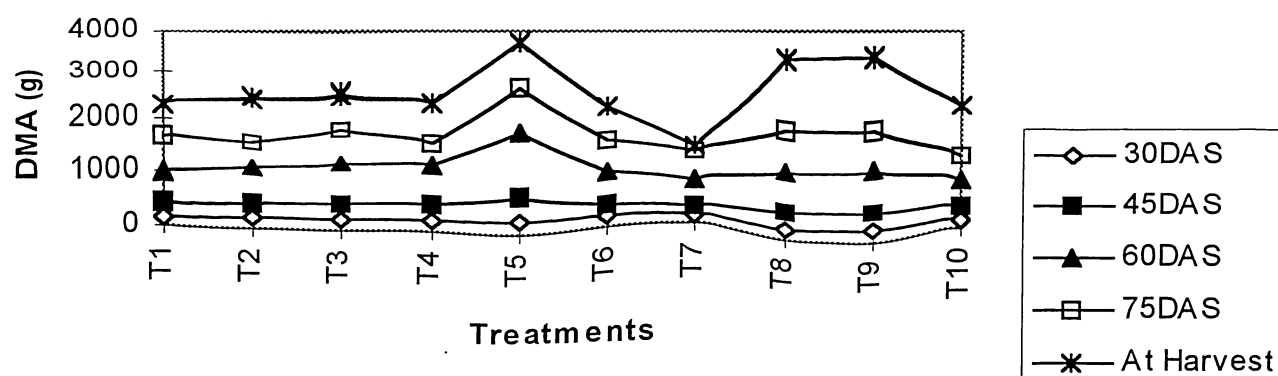
It may be revealed from the data in Table 12 that the dry matter accumulation increased remarkably from 30 DAS up to harvest. However, the rate of increase in DMA was highest between 45-60 DAS. There was no significant difference between the treatments with regard to DMA at 30 DAS. The recommended practices with thinning and gypsum application (T_5) produced largest amount of dry matter, whereas the recommended practice with thinning and limited irrigations produced the least at each stage of growth till harvest. At harvest, the recommended practice (T_2) recorded 23.42 per cent

higher dry matter over the local practice (T₁). Thinning (T₃) enhanced the DMA marginally over no-thinning (T₂) while N-S sowing (T₄) reduced the DMA significantly by 15.82 per cent over E-W sowing (T₃). T₅ produced the highest (37.86 g) DM closely followed by T₉ (*Azotobacter* inoculation and 50% N topdressing) producing 35.77 g/plant. T₆ with no basal but topdressing with 60 per cent N reduced the DMA significantly by 20.26 per cent. Whereas limited irrigations (T₇) reduced it by 96.5 per cent over normal practice (T₃). There was marginal enhancement in DMA with *Azotobacter* inoculation in local practice (T₁₀) as well as in the recommended practice (T₈). When 50 per cent basal N was skipped with inoculation (T₉), there was significant increase in DMA by 15.95 per cent over T₃, whereas T₈ and T₉ were at par with each other.

Table 12. Dry matter accumulation per plant (g) at successive stages of growth as affected by low monetary agro-techniques.

	Treatment	Days after sowing				At harvest
		30	45	60	75	
T ₁	Local Practice	1.87	4.33	9.66	16.33	22.50
T ₂	Recommended Practice	2.10	4.83	12.26	17.83	27.77
T ₃	T ₂ + thinning	2.23	5.60	15.03	22.87	30.85
T ₄	T ₃ + N-S sowing	2.13	5.26	12.96	17.63	25.97
T ₅	T ₃ + Gypsum	2.50	7.40	20.23	28.83	37.86
T ₆	T ₃ + 60 % N topdressed (no basal)	2.03	4.43	11.00	17.50	24.60
T ₇	T ₃ + limited Irrigations	1.80	3.23	8.90	14.70	15.70
T ₈	T ₃ + <i>Azotobacter</i>	2.43	5.97	14.97	22.33	35.23
T ₉	T ₈ + 50 % N topdressed (no basal)	2.47	6.80	15.62	22.80	35.77
T ₁₀	T ₁ + <i>Azotobacter</i>	1.90	4.33	9.80	14.97	25.22
	SE (m) ±	0.49	0.51	1.48	1.49	1.64
	CD (0.05)	NS	1.52	4.40	4.43	4.87

Fig. 8 Dry Matter Accumulation



The average dry matter accumulation in *Pusa Bahar* per plant were 2.21, 5.44, 13.87, 18.72, 29.22 and those in *Pusa Bold* were 1.89, 4.33, 9.73, 15.65, 23.86 g at 30, 45, 60, 75 DAS and harvest respectively. In *Pusa Bahar*, the rate of dry matter accumulation was 0.45 g / day / plant which was 21.62 per cent higher over the local check, *Pusa Bold* with DMA 0.37 g/day/plant.

4.2 POST-HARVEST STUDIES

4.2.1 Number of Siliquae per plant

The data on mean number of siliquae per plant has been statistically analysed and presented in Table 13 and illustrated in Fig. 9.

Fig. 9 Siliquae/Plant & Siliquae/Main Stalk

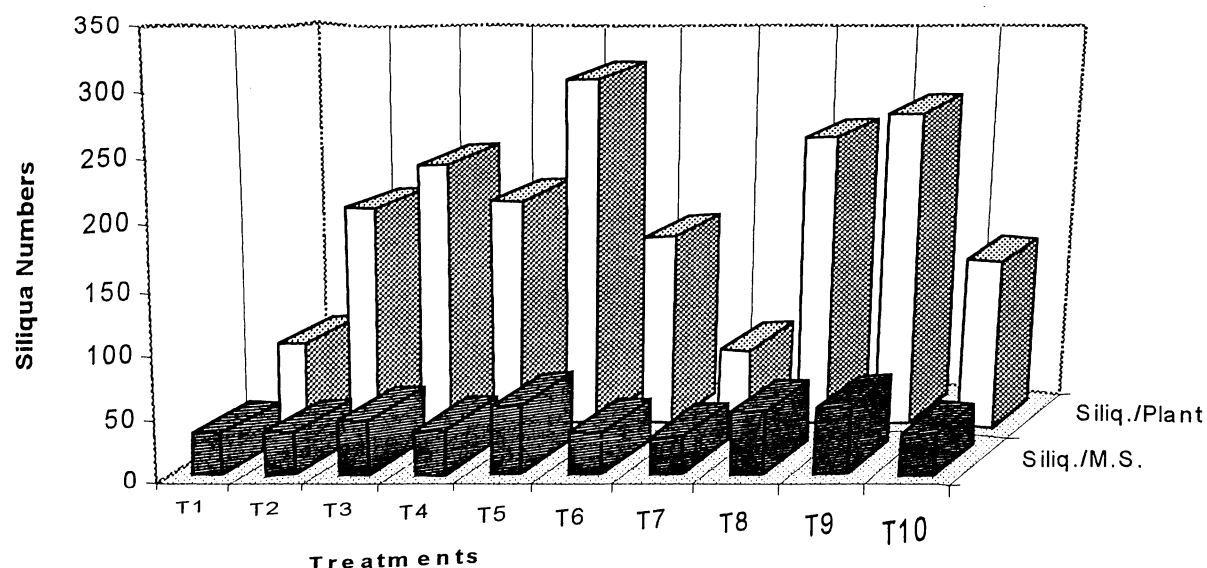


Table 13. Number of siliquae per plant and number of siliquae on main stalk per plant as affected by low monetary agro-techniques.

	Treatment	Siliquae/Plant	Siliquae on main stalk /Plant
T ₁	Local Practice	73.90	35.23
T ₂	Recommended Practice	201.43	38.33
T ₃	T ₂ + thinning	245.30	48.77
T ₄	T ₃ + N-S sowing	208.57	38.83
T ₅	T ₃ + Gypsum	320.50	60.23
T ₆	T ₃ + 60 % N topdressed (no basal)	174.40	36.67
T ₇	T ₃ + limited Irrigations	67.93	33.47
T ₈	T ₃ + <i>Azotobacter</i>	265.60	54.87
T ₉	T ₈ + 50 % N topdressed (no basal)	288.7	58.77
T ₁₀	T ₁ + <i>Azotobacter</i>	155.40	35.83
	SE (m) ±	13.84	3.22
	CD (0.05)	41.12	9.57

It would be evident from the data that the mean number of siliqua per plant were significantly higher in all the treatments except in T₇ (recommended practice with thinning and limited irrigations) as compared to the local practice. The per cent increase in number of siliqua per plant was maximum in the gypsum treated plot with recommended practices and thinning (333.69 %) and minimum in T₁₀ i.e. the local practice + *Azotobacter* inoculation (110.28%) over the local practice. The recommended practice (T₂) recorded 172.57 per cent more siliqua per plant over the local practice, where as the recommended practice with thinning recorded 21.78 per cent increase over T₂. The E-W sowing (T₃) was found to be superior than N-S sowing (T₄) with 17.61 per cent more number of siliqua per plant. Gypsum application(T₅) augmented the siliqua number by 30.60 per cent over no-gypsum treatment (T₃). With 60 per cent N topdressing without any basal application together with recommended prac-

tice and thinning (T_6) there was 40.65 per cent reduction in number of siliquae per plant over the recommended practice with N-application in two equal splits (T_3). Limited irrigations (T_7) reduced the siliqua number by 72.3 per cent over T_3 but was at par with local practice (T_1). *Azotobacter* inoculation enhanced the number significantly in local practice (T_{10}) but not in recommended practice (T_8). When the latter was supplied with 50 per cent topdressing, without any basal application of N (T_9), the number of siliqua increased significantly by 17.69 per cent over T_3 but was at par with T_8 . The variety, Pusa Bahar recorded on an average 221.55 siliquae per plant which was 93.24 per cent more than the number of siliqua obtained by the local check, Pusa Bold (114.65).

4.2.2 Number of siliquae on main stalk per plant

The data on mean number of siliquae on main stalk per plant have been furnished in Table 13 and depicted in Fig. 9.

It would be evident from the data that the mean number of siliquae on main stalk per plant were higher in all the treatments except the treatment with limited irrigations (T_7). The gypsum treatment (T_5) was found superior to all other treatments in respect of number of siliquae/main stalk. This treatment obtained 70.96 per cent more siliquae on main stalk (60.23), the maximum increase over local practice closely followed by T_9 (58.77). T_{10} with *Azotobacter* inoculation in local practice recorded marginal (1.7%) increase of siliquae on main stalk per plant over the latter. There was no significant difference between the local practice and recommended practice (T_2) with respect to the siliquae number on main stalk. Thinning (T_3) proved itself better to the non thinning treatment (T_2) with 27.24 per cent increase in the number of siliquae on main stalk per plant. N-S sowing (T_4) showed 25.6 per cent decrease in number of siliquae on main stalk over the E-W sowing (T_3). Gypsum application recorded significant increase in number of siliqua (23.5%) on main stalk over no-gypsum treatment (T_3). Recommended practice with two equal split applications of nitrogen (T_3) was found superior to that with 60 per cent top dressing only (T_6) as the former had 33 per cent more siliquae on the main stalk. The *Azotobacter* inoculation along with top dressing of 50 per cent N skipped at basal (T_9) recorded 20.5 per cent more siliquae per plant and main stalk over T_3 but was at par with the inoculation with the

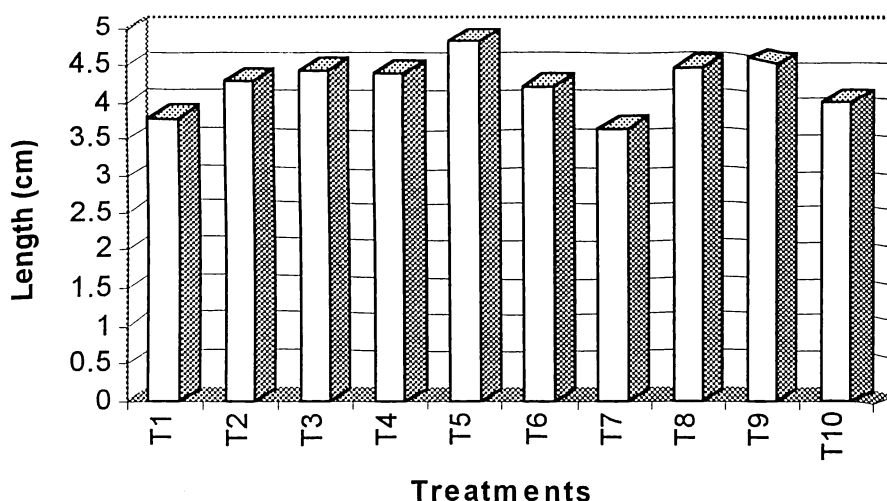
recommended practice and thinning (T_8). On the other hand, the inoculation had no significant effect on local practice (T_{10}). Pusa Bahar, the improved variety proved itself more efficient bearing 17.84 per cent more siliquae (41.85) on main stalk per plant than the local check, Pusa Bold (35.53).

4.2.3 Length of siliqua

The data on mean length of siliqua as influenced by various treatment combinations have been presented in Table 14 and depicted in Fig. 10.

The perusal of data revealed that there was no significant difference among the treatments with respect to the length of siliqua. However, gypsum application over and above the recommended practice and thinning (T_5) ensured largest siliqua (4.83 cm) closely followed by *Azotobacter* inoculation with 50 per cent N topdressing without any basal application. (4.63 cm) in T_9 . T_5 recorded 27.1 per cent increase in siliqua length as compared to the local practice (T_1 , 3.8 cm). Recommended practice with thinning and limited irrigations (T_7) had the smallest siliqua (3.67 cm) which was 3.42 per cent smaller than the local practice. The variety Pusa Bahar recorded 10.08 per cent more towards the mean length of siliqua over the local check, Pusa Bold.

Fig. 10 Siliqua Length



4.2.4 Number of seeds per siliqua

The data on mean number of seeds per siliqua have been presented in Table 14 and depicted in Fig. 11.

It would be revealed from the data that the number of seeds per siliqua was influenced significantly with the inclusion of various low monetary agrotechniques. All the treatments except the treatment with limited irrigations along with recommended practice and thinning (T_7) were superior to the local practice. The gypsum treatment with recommended practice and thinning (T_5) was the most efficient one in relation to number of seeds per siliqua (18.17) closely followed by *Azotobacter* inoculation with 50 per cent N topdressing, T_9 (18.10) and inoculation with recommended practice and thinning, T_3 (17.27). Gypsum treatment (T_5) ensured 45.7 per cent and the *Azotobacter* inoculation in local practice (T_{10}) 7.22 per cent more seeds per siliqua, the maximum and the minimum respectively over the local practice (T_1). Thinning (T_3) proved itself superior to no-thinning (T_2) with 9.76 per cent more seeds / siliqua. It was observed that all other practices remaining same, N-S sowing (T_4) showed marginal increase in number of seeds/ siliqua over E-W sowing (T_3). Gypsum application (T_5) enhanced the seed number per siliqua slightly over no-gypsum treatment (T_3). Split application of N fertilizer (50% basal + 50% topdressed), T_3 was found superior to the single application (60% N as topdressing), T_6 with 18.62 per cent more seeds per siliqua. Limited irrigations (T_7) in recommended practice thinning caused 28.49 per cent reduction in seed number per siliqua over normal practice (T_3). *Azotobacter* inoculation had slight enhancing effect in seed number per siliqua in both local practice (T_{10}) and recommended practice (T_8) when basal application of 50 per cent N was skipped from T_8 the increase was further enhanced. Between the two varieties, Pusa Bahar recorded 15.64 per cent more seeds per siliqua (16.27) over Pusa Bold (14.07).

4.2.5. Test weight (1000 Seed weight)

The data on the test weight of seeds (g) as influenced by various low monetary agrotechniques have been presented in Table 14 and shown in Fig. 12.

Table 14. Length of silliqua, Number of seed per silliqua and Test weight as affected by low monetary agro-techniques.

	Treatment	Length of silliqua(cm)	Number of seeds/silliqua	Test weight (gm)
T ₁	Local Practice	3.80	12.47	4.25
T ₂	Recommended Practice	4.30	15.67	4.54
T ₃	T ₂ + thinning	4.43	17.20	4.75
T ₄	T ₃ + N-S sowing	4.40	16.97	4.65
T ₅	T ₃ + Gypsum	4.83	18.17	5.39
T ₆	T ₃ + 60 % N topdressed (no basal)	4.23	14.50	4.29
T ₇	T ₃ + limited Irrigations	3.67	12.30	3.92
T ₈	T ₃ + <i>Azotobacter</i>	4.47	17.27	5.18
T ₉	T ₈ + 50 % N topdressed (no basal)	4.63	18.10	5.21
T ₁₀	T ₁ + <i>Azotobacter</i>	4.13	13.37	4.28
	SE (m) ±	0.29	0.49	0.15
	CD (0.05)	NS	1.46	0.46

The data would reveal that the test weight was influenced significantly by inclusion of different agro-techniques. Test weight of seeds in all the treatments except T₇ (Recommended practice + thinning+limited irrigations) was more than that of local practice. Test weight of seeds increased to the tune of 26.82 per cent in case of gypsum applied treatments with the recommended practice and thinning (T₅) and minimum in T₁₀ with very slight (2.35%) increase over local practice (T₁). There was almost no significant difference between the recommended practice (T₂) and local practice (T₁),

thinning (T_3) and no-thinning (T_2). N-S sowing showed marginal reduction in test weight over E-W sowing. T_5 obtained significantly higher 1000 seed weight by 13.47 per cent than that in no gypsum treatment (T_3). Single application of 60 per cent N as topdressing (T_6) caused 9.68 per cent reduction in test weight as against the two equal split application of recommended dose with thinning (T_3). Limited irrigations (T_7) reduced the test weight pronouncedly by 17.47 per cent over normal practice (T_3). *Azotobacter* inoculation resulted very slight increase in test weight in both the local and recommended practice but when the latter was skipped from 50 per cent N at basal then also there was further increase in the test weight at the edge. The average test weight of seeds in case of variety Pusa Bahar was 4.27 g as against 4.3 g obtained by the local check, Pusa Bold.

Fig. 11 Seeds per Siliqua

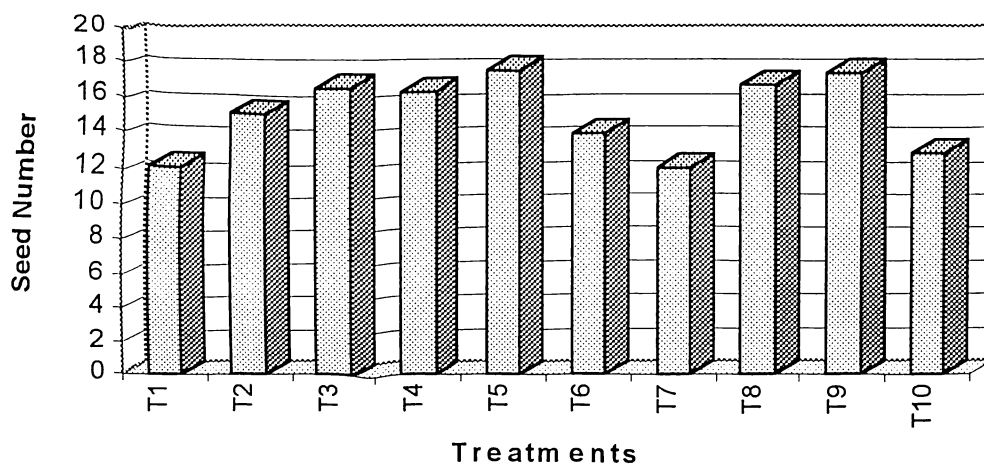
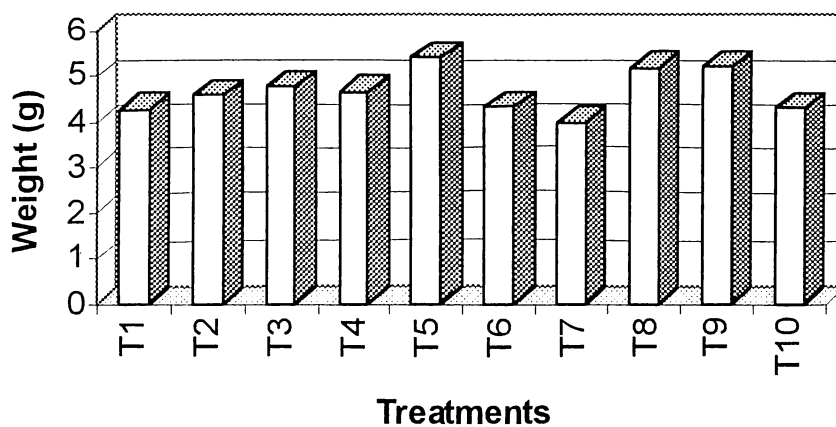


Fig. 12 Test Weight



4.2.6 Seed yield

The data on seed yield as influenced by various low monetary agrotechniques have been statistically analysed and presented in Table 15 and illustrated in Fig. 13.

It would be evident from the data that the seed yield was significantly influenced by the various treatments. All the treatments recorded significantly higher seed yield than the local practice except the treatment with limited irrigations over and above recommended practice and thinning (T_7) which registered significantly lower yield than the local practice. The gypsum treatment (T_5) was the highest yielder (18.76 q/ha) showing an increase of 88.73 per cent over the local practice (T_1). Thinning (T_3) had an advantage of 11.13 per cent over no-thinning (T_2), while N-S sowing (T_4) had a reduction of 8.12 per cent in yield over the E-W sowing (T_3). T_5 was found superior to all the treatments and recorded 22.77 per cent higher seed yield than the no-gypsum treatment in recommended practice (T_3). Split application of N-fertilizer (50% basal + 50% top dressing), T_3 obtained 19.1 per cent higher yield over the single application of 60 per cent N as top dressing (T_6). Recommended practice with limited irrigations (T_7) reduced the seed yield profoundly over the normal practice by 46.79 per cent. *Azotobacter* inoculation increased the seed yield significantly by 14.66 per cent over recommended practice (T_8) and 22.33 per cent over the local practice (T_{10}). When in the former the basal 50 per cent N was skipped (T_9) there was 18.85 per cent increase in seed yield over T_3 . The improved variety, Pusa Bahar recorded mean seed yield of 14.81 q/ha where as the local check, Pusa Bold produced 11.05 q/ha. The increase with the improved variety was 28.6 per cent over the local check.

Fig. 13 Seed Yield

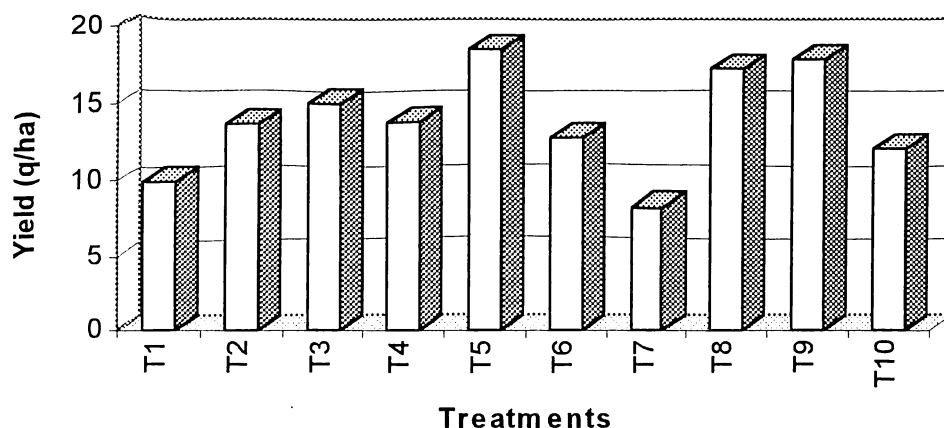


Table 15. Seed yield and stover yield as influenced by various
low monetary agro-techniques.

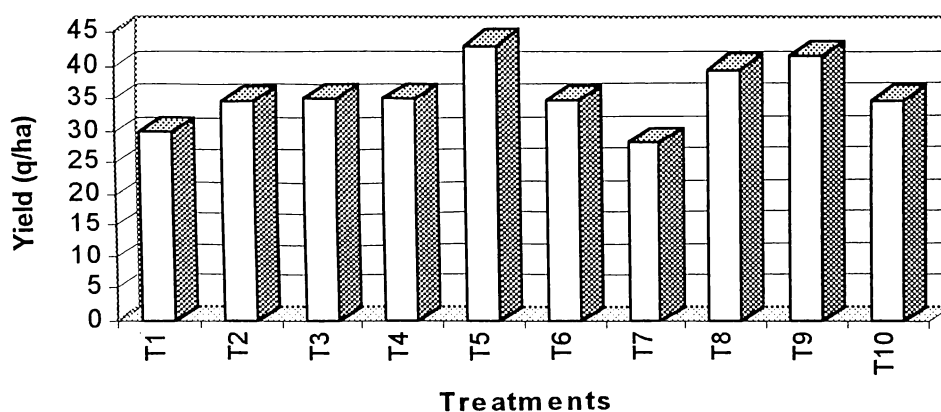
Treatment		Seed Yield (q/ha)	Stover Yield (q/ha)
T ₁	Local Practice	9.94	29.83
T ₂	Recommended Practice	13.75	34.77
T ₃	T ₂ + thinning	15.28	35.17
T ₄	T ₃ + N-S sowing	14.04	35.07
T ₅	T ₃ + Gypsum	18.76	43.00
T ₆	T ₃ + 60 % N topdressed (no basal)	12.83	34.60
T ₇	T ₃ + limited Irrigations	8.13	28.00
T ₈	T ₃ + <i>Azotobacter</i>	17.52	39.33
T ₉	T ₈ + 50 % N topdressed (no basal)	18.16	41.37
T ₁₀	T ₁ + <i>Azotobacter</i>	12.16	34.50
	SE (m) ±	0.21	1.76
	CD (0.05)	0.62	5.23

4.2.7 Stover yield

The data on mean stover yield as influenced by different treatments have been respresented in Table 15 and depicted in Fig. 14.

It would be evident from the data that the stover yields of mustard were significantly influenced by different low monetary agrotechniques tried as against the local practice. Among all the treatments, application of gypsum with recommended practice and thinning (T_5) recorded maximum stover yield of 43 q/ha which was about 44 per cent more than the local practice (T_1). However, it was at par with T_9 , i.e. *Azotobacter* inoculation with 50 per cent nitrogen top-dressing and T_8 (recommended practice including thinning and inoculation) with the stover yields of 41.37 and 39.33 q/ha respectively. T_7 produced lowest stover yield (28.0 q/ha) which was at par with the local practice (T_1). The recommended practice (T_2) showed a marginal increase in stover yield over local practice (T_1). There was no significant difference between thinning (T_3) and no-thinning (T_2), N-S sowing (T_4) and E-W sowing (T_3). Topdressing 60 per cent N without any basal (T_6) reduced the stover yield marginally over the normal practice (50% basal + 50% topdressing). Limited irrigation (T_7) caused 20.4 per cent reduction in stover yield over normal irrigations in T_3 . *Azotobacter* inoculation increased the stover yield marginally in both the local practice and recommended practice whereas inoculation with no basal but 50 per cent N top dressed (T_9) increased the stover yield significantly by 17.63 per cent over the T_3 . The Pusa Bahar recorded a mean stover yield of 36.41 q/ha as against the local check, Pusa Bold with 32.17 q/ha.

Fig. 14 Stover Yield



4.2.8 Harvest index (HI)

The data on harvest index have been analysed statistically and presented in the Table 16 and illustrated in the Fig. 15.

The results revealed existence of significant difference in the harvest indices among various treatments tried. The treatment with recommended practice, thinning and *Azotobacter* inoculation (T_8) registered the maximum harvest index of 30.82 per cent which was 22.64 per cent more over the local practice (T_1). The treatment with recommended practice, thinning and limited irrigation (T_7) had the lowest harvest index (22.5%) which was at par with the local practice (T_1). Recommended practice (T_2) recorded significantly higher harvest index by 12.77 per cent over T_1 (local practice). Thinning (T_3) had no significant difference over no-thinning (T_2). N-S sowing (T_4) had smaller HI than E-W sowing (T_3) but the difference was non-significant. The gypsum treatment (T_5) did not differ significantly from the no-gypsum treatment (T_3). Split application of N-fertilizer (50% basal + 50% topdressing), T_3 was found superior to only top dressing of 60 per cent N in T_6 by 11.98 per cent which was at par with T_2 , T_4 and T_{10} . Limited irrigations (T_7) reduced the HI by 25.72 per cent over normal practice (T_3) with harvest index of 22.5 per cent. *Azotobacter* inoculation marginally increased in the HI in both the local practice (T_{10}) as well as recommended practice, but 50 per cent N skipped at sowing in T_9 reduced the HI slightly over T_8 . T_5 having the maximum harvest index was at par with no-gypsum treatments T_2 , T_3 , T_4 and inoculation treatments T_8 and T_9 . However, T_8 had little edge over the others as it exhibited the maximum (30.82%). The improved variety, Pusa Bahar registered 28.56 per cent harvest index, while the local cheek, Pusa Bahar recorded 25.68 per cent.

Fig 15. Harvest Index

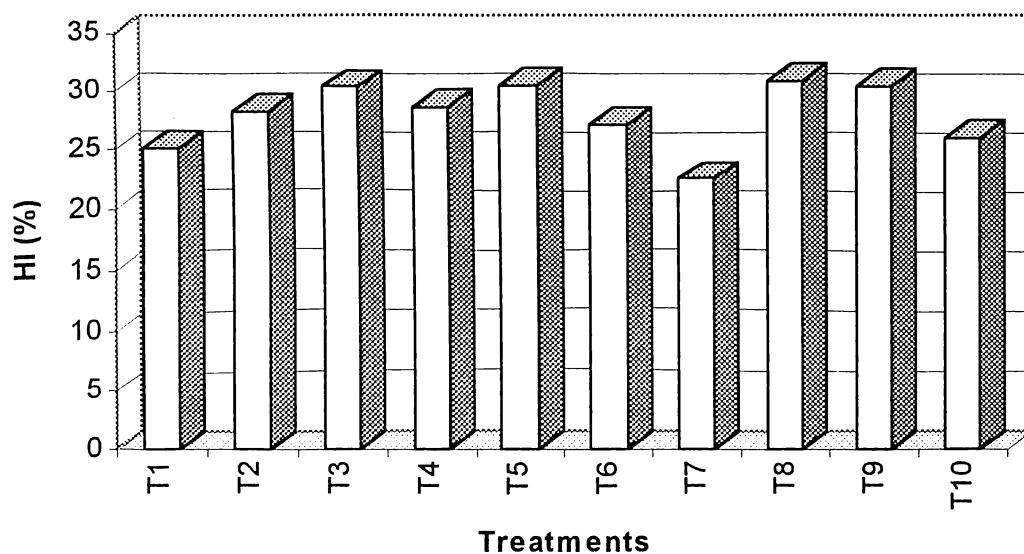


Table 16. Harvest Index and Seed: Stover ratio as affected by low monetary agro-techniques.

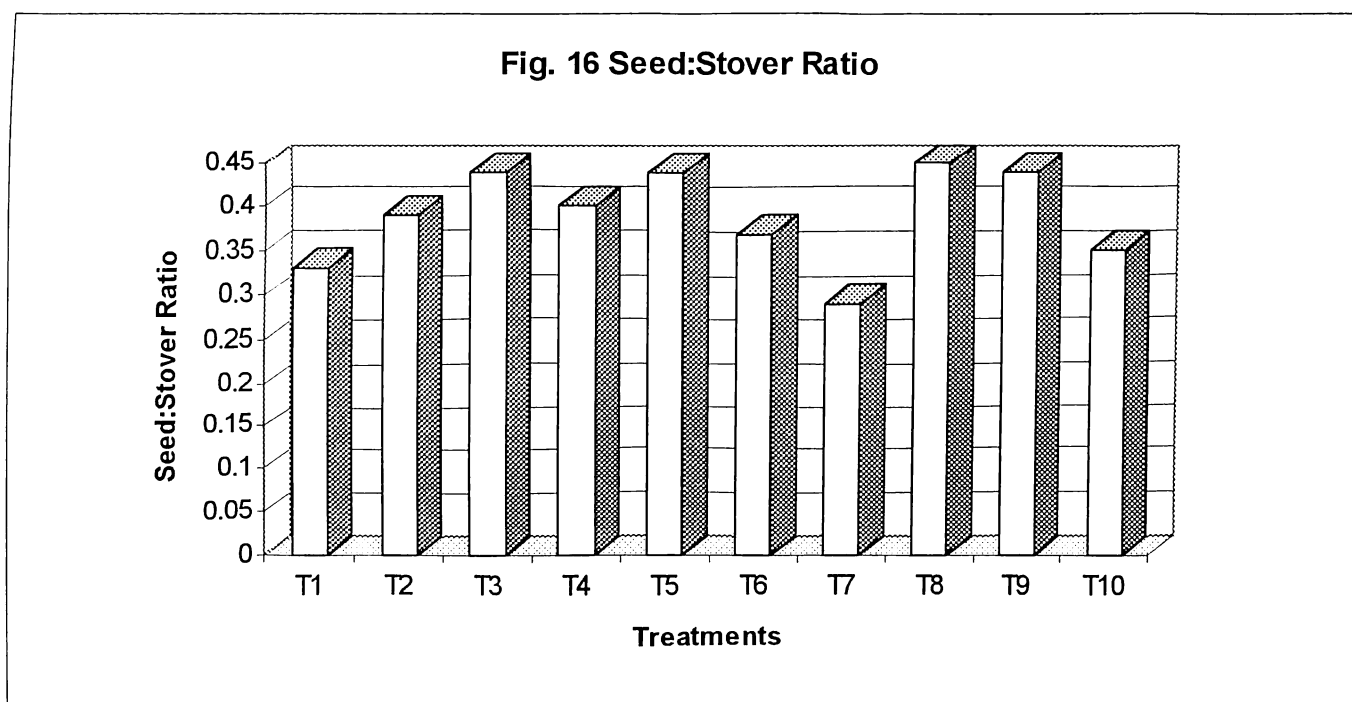
Treatment		Harvest Index (%)	Seed: Stover (ratio)
T ₁	Local Practice	25.13	0.33
T ₂	Recommended Practice	28.34	0.39
T ₃	T ₂ + thinning	30.29	0.44
T ₄	T ₃ + N-S sowing	28.59	0.40
T ₅	T ₃ + Gypsum	30.38	0.44
T ₆	T ₃ + 60 % N topdressed (no basal)	27.05	0.37
T ₇	T ₃ + limited Irrigations	22.50	0.29
T ₈	T ₃ + <i>Azotobacter</i>	30.82	0.45
T ₉	T ₈ + 50 % N topdressed (no basal)	30.50	0.44
T ₁₀	T ₁ + <i>Azotobacter</i>	26.06	0.35
	SE (m) ±	0.94	0.02
	CD (0.05)	2.79	0.06

4.2.9 Seed: Stover ratio

The data on seed:stover ratio have been presented in Table 16 after being statistically analysed and depicted in Fig. 16.

It was evident from the data that *Azotobacter* inoculation along with recommended practice and

thinning (T_8) recorded maximum seed : Stover ratio (0.45) which was at par with inoculation and 50 per cent N topdressing (T_3), gypsum treatment (T_5) recommended practice with N-S sowing (T_4). The recommended practice (T_2) recorded 24.24 per cent higher seed : stover ratio over the local practice (T_1). Thinning (T_3) showed marginal but positive effect over no-thinning (T_2), both remaining at par with each other. There was marginal reduction in seed: stover ratio by N-S sowing (T_4) over E-W sowing (T_3). The gypsum treatment (T_5) obtained significantly higher ratio (33.33%) of seed and stover over the local practice (T_1). Split application of N-fertilizer (50% basal+ 50% to dressing), T_3 increased the seed : stover ratio significantly by 18.92 per cent over the T_6 with 60 per cent N used for topdressing only. Limited irrigations (T_7) retarded the seed : stover ratio by 34.1 per cent over the normal practice (T_3). *Azotobacter* inoculation did not count for any significant increase in seed: stover ratio in local practice (T_{10}) and recommended practice (T_8). Still T_8 had an edge over T_9 in terms of the seed: stover ratio. Pusa Bahar, the improved variety recorded seed : stover ratio of 0.4 where as the local check Pusa Bold had the ratio of 0.34.



4.2.10 Oil content

The data on oil content as influenced by different treatments have been analysed statistically and presented in Table 17 and depicted in Fig. 17.

It was observed from the data that the oil content increased remarkably in all the treatments over the local practice (T_1) having significantly lower oil content (28.21 %). The gypsum treatment with recommended practice and thinning (T_5) recorded significantly higher oil content (39.21%) than others. The recommended practice (T_2) had 22.47 per cent more oil content than that of local practice (T_1). Thinning (T_3) and no-thinning showed no much difference in the oil content. Direction of showing did not influence the oil content much. However, the E-W sowing (T_3) improved the oil content over the N-S sowing (T_4) slightly (about 3%). T_5 recorded 12.51 per cent more oil content than the no-gypsum treatment (T_3). With all other practices remaining same, the oil content of seed was not influenced either with the two equal split application or 60 per cent N as topdressing (T_6), whereas both of them were at par with T_7 given limited irrigations. *Azotobacter* inoculation increased the oil content significantly by 6.31 and 10.85 per cent in recommended practice (T_8) and local practice (T_{10}) respectively whereas with the 50 per cent N skipped at sowing in the former (T_9) the oil content reduced slightly over T_8 . The improved variety, Pusa Bahar contained 35.41 per cent oil while the Pusa Bold, the local check had 29.74 per cent oil their seeds.

Fig. 17 Oil Content

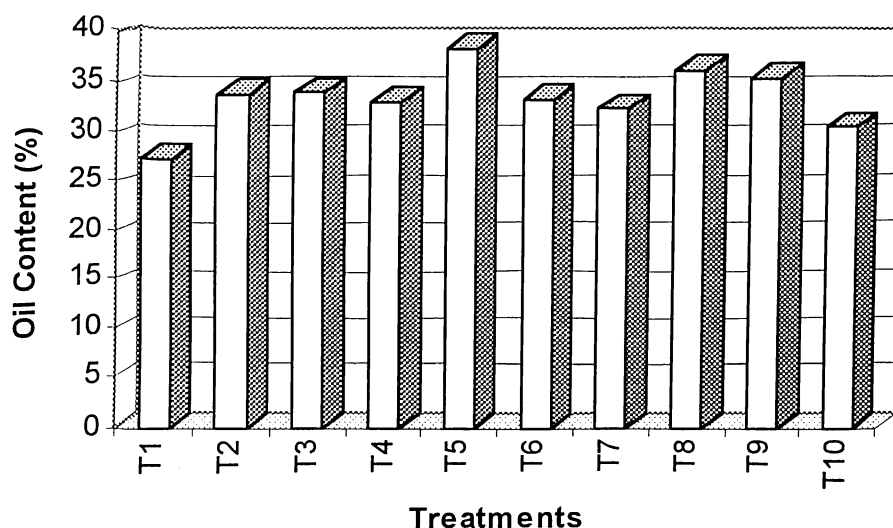


Table 17. Oil content and Oil yield as affected by low monetary agro-techniques.

Treatment	Oil Content (%)	Oil Yield (q / ha)
T ₁ Local Practice	28.21	2.81
T ₂ Recommended Practice	34.55	4.75
T ₃ T ₂ + thinning	34.85	5.32
T ₄ T ₃ + N-S sowing	33.85	4.75
T ₅ T ₃ + Gypsum	39.21	7.37
T ₆ T ₃ + 60 % N topdressed (no basal)	34.24	4.39
T ₇ T ₃ + limited Irrigations	33.23	2.69
T ₈ T ₃ + <i>Azotobacter</i>	37.05	6.72
T ₉ T ₈ + 50 % N topdressed (no basal)	36.28	6.11
T ₁₀ T ₁ + <i>Azotobacter</i>	31.27	3.80
SE (m) ±	0.70	0.29
CD (0.05)	2.09	0.86

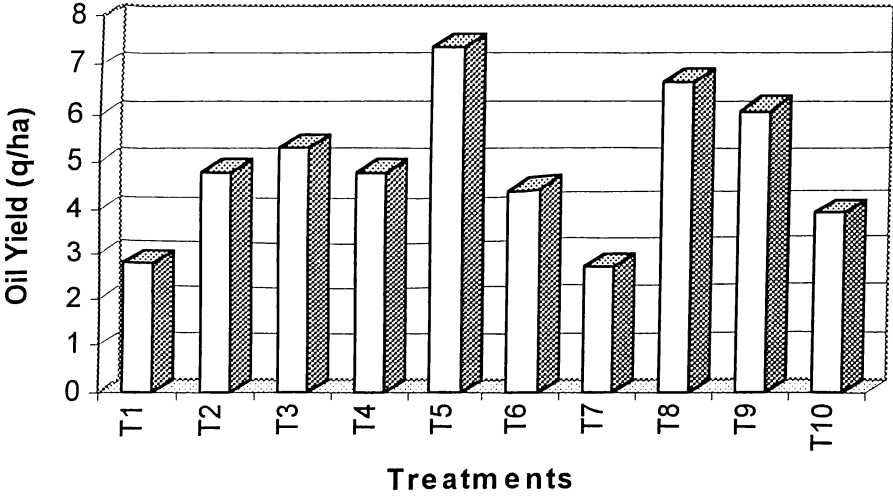
4.2.11 Oil yield

The data on oil yield was analysed stastically and have been presented in Table 17, depicted in Fig. 18.

The data in the Table 17 revealed that all the treatments recorded significantly more oil yield than the local practice (T₁) except the treatment with recommended practice, thinning and limited irrigations

(T₇). Both of them were at par with each other. The gypsum treatment (T₅) recorded significantly higher oil yield of 7.37 q/ha over other treatments excepting T₈ with *Azotobacter* inoculation skipping 50 per cent basal N in recommended practice and thinning (6.72q/ha) which was at par with the former. The recommended practice (T₂) obtained 69 per cent higher oil yield than the local practice (T₁). Thinning and direction of sowing had no significant effect on oil yield. However, thinning (T₃) had slight positive and N-S sowing (T₄) had slight negative effect on oil yield over no thinning and E-W sowing respectively. Application of 60 per cent N in topdressing alone (T₆) reduced the oil yield by 17.48 per cent over the two equal split applications of the recommended dose in (T₃). *Azotobacter* inoculation in recommended practice and thinning (T₈) increased the oil yield significantly by 26.32 per cent over no inoculation (T₃) but when 50 per cent N was skipped at sowing (T₉) the increase was by 14.85 per cent over T₃. T₈ and T₉ were at par with each other. *Azotobacter* inoculation increased the oil yield by 35.23 per cent over the local practice. The variety, Pusa Bahar recorded the oil yield of 5.27 q/ha where as Pusa Bold, the local check recorded 3.31 q/ha. The former showed 59.21 per cent higher oil yield than the latter.

Fig. 18 Oil Yield



4.3 NUTRIENT UPTAKE

4.3.1 Uptake of Nitrogen

The data on N-content of seed and stover and its uptake at harvest have been analysed statistically and presented in Table 18 is illustrated in Fig 19.

It may be revealed from the data that the gypsum application with recommended practice and thinning (T_5) ensured maximum amount of nitrogen in seed (4.83 %) as well as stover (0.79 %) closely followed by *Azotobacter* inoculation along with topdressing of 50 per cent N only without basal (T_9) and (T_8) i.e. inoculation in recommended practice and thinning. The local practice (T_1) had minimum N-content both in seed (3.12 %) and stover (0.35 %). There was no significant difference among T_2 , T_6 and T_{10} . All were at par and had slightly higher N content than T_1 . Thinning (T_3) and no-thinning E-W and N-S direction (T_4) of sowing, 60 per cent N topdressing (T_6) as against 50 per cent basal and 50 per cent topdressing did not cause any significant difference between them. T_3 , T_4 and T_6 were at par with T_{10} i.e., *Azotobacter* inoculation in local practice and T_7 (Recommended practice with thinning and limited irrigations) in relation to N-content.

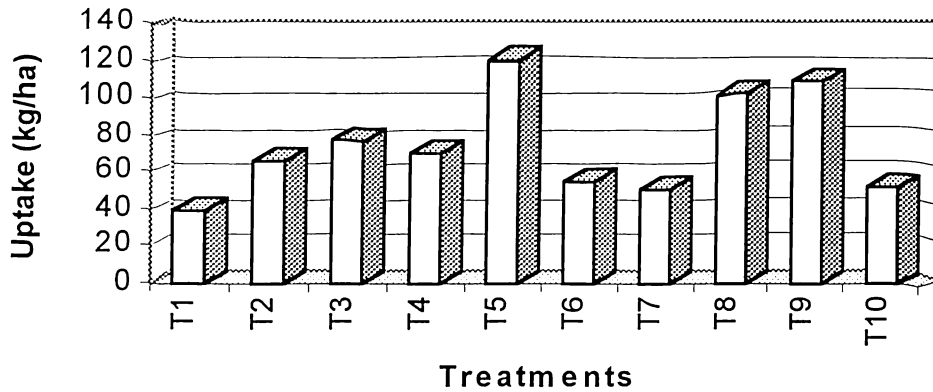
The total uptake was highest (124.71 kg/ha) in gypsum applied treatment (T_5) and lowest (41.46 kg/ha) in the local practice (T_1). The recommended practice (T_2) recorded 66.43 per cent higher uptake over T_1 . Thinning (T_3) was found superior to no-thinning (T_2) resulting 17.59 per cent higher N-uptake. N-S direction of sowing (T_4) exhibited a depressive effect on N-uptake in seed and stover by 11.26 and 2.48 per cent over E-W sowing (T_3). Topdressing with 60 per cent nitrogen without basal application (T_6) reduced the uptake by 33.78 and 14.51 per cent in seed and stover respectively over split application of the whole N fertilizer (50 % basal and 50 % topdressed). Limited irrigations along with recommended practice and thinning (T_7) reduced the N-uptake by 34.16 per cent over the normal practice (T_3). *Azotobacter* inoculation with only topdressing of 50 per cent N-fertilizer (T_9) ensured higher uptake of N both in seed and stover (5.03 % and 12.61 %) over inoculation with recommended

practice and thinning (T_8), whereas both of them registered 38.69 and 29.57 per cent increase in N-uptake over normal practice respectively. *Azotobacter* inoculation increased the total N-uptake by 27.28 per cent in local practice and 29.57 per cent in recommended practice. When 50 per cent N was skipped from the basal (T_9), N-uptake was enhanced further by 38.69 per cent. Pusa Bahar, the improved one ensured an uptake of 87.61 kg N/ha as against the local check, Pusa Bold having 47.12 kg N/ha as its uptake.

Table 18. N-content and its uptake at harvest as affected by low monetary agro-techniques.

Treatment		N- Content (%)		N-Uptake (kg/ha)		
		Seed	Stover	Seed	Stover	Total
T_1	Local Practice	3.12	0.35	32.02	10.44	41.46
T_2	Recommended Practice	3.95	0.42	54.40	14.60	69.00
T_3	T_2 + thinning	4.23	0.47	64.61	16.53	81.14
T_4	T_3 + N-S sowing	4.14	0.46	58.07	16.13	74.20
T_5	T_3 + Gypsum	4.83	0.79	90.74	33.97	124.71
T_6	T_3 + 60 % N topdressed (no basal)	3.72	0.41	42.78	14.19	56.97
T_7	T_3 + limited Irrigations	4.39	0.38	35.69	10.64	53.42
T_8	T_3 + <i>Azotobacter</i>	4.42	0.71	77.21	27.92	105.13
T_9	T_8 + 50 % N topdressed (no basal)	4.61	0.76	81.09	31.44	112.53
T_{10}	T_1 + <i>Azotobacter</i>	3.23	0.39	39.31	13.46	52.77
	SE (m) \pm	0.41	0.032			
	CD (0.05)	1.22	0.09			

Fig. 19 . Nitrogen Uptake



4.3.2 Uptake of Phosphorus

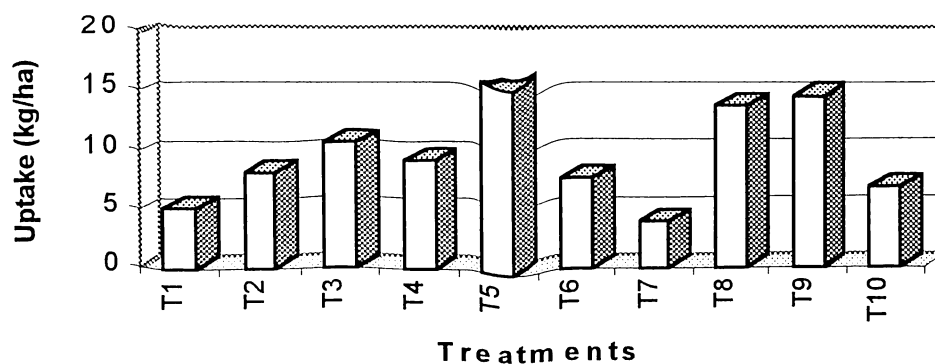
The data on phosphorus content in seed and stover have been analysed and its uptake has been calculated. The data have been presented in the Table 19 and depicted in Fig. 20.

There was no significant difference among the seed P-content unlike stover P-content. The P-content and its uptake both in seed and stover was maximum in the gypsum applied treatment (T_5) and was minimum in (T_7) i.e., recommended practice and thinning with limited irrigations. There was no significant difference among the P-content of stover in T_5 , T_8 (Recommended practice and thinning with *Azotobacter* inoculation) and T_9 (T_8 with 50 % N topdressed). The local practice (T_2) with regard to P-content, but the latter had 58.66 per cent more up take (both by seed and stover) over the former. Thinning (T_3) exhibited slight increase in P-content and its uptake (27.35 % more) over no-thinning. Similarly N-S sowing (T_4) showed slight decline in P-uptake (15.06 %) and its content over E-W sowing. The treatment with topdressing of 60 per cent N with no basal N(T_6) had 38.37 per cent less uptake as well as slight lesser content of P than the recommended practice of N application. Inoculation with 50 per cent nitrogen topdressing (T_9) increased the P-uptake and content marginally over the recommended practice, thinning and *Azotobacter* inoculation (T_8). *Azotobacter* inoculation (T_{10}) increased the uptake over the local practice by 30.73 per cent though its P-content was marginally higher. The phosphorus uptake was to the extent of 10.8 and 6.2 kg/ha in Pusa Bahar and Pusa Bold respectively.

Table 19. P-content and its uptake at harvest as affected by low monetary agro-techniques.

Treatment	P- Content (%)		P-Uptake (kg/ha)		
	Seed	Stover	Seed	Stover	Total
T ₁ Local Practice	0.42	0.12	4.17	1.20	5.37
T ₂ Recommended Practice	0.45	0.17	6.19	2.33	8.52
T ₃ T ₂ + thinning	0.47	0.24	7.18	3.67	10.85
T ₄ T ₃ + N-S sowing	0.46	0.21	6.46	2.97	9.43
T ₅ T ₃ + Gypsum	0.56	0.35	10.51	6.53	17.04
T ₆ T ₃ + 60 % N topdressed (no basal)	0.45	0.16	5.77	2.07	7.84
T ₇ T ₃ + limited Irrigations	0.38	0.13	3.09	1.03	4.12
T ₈ T ₃ + <i>Azotobacter</i>	0.51	0.29	8.94	5.07	14.01
T ₉ T ₈ + 50 % N topdressed (no basal)	0.52	0.31	9.44	5.57	15.01
T ₁₀ T ₁ + <i>Azotobacter</i>	0.44	0.14	5.35	1.67	7.02
SE (m) ±	0.05	0.02			
CD (0.05)	NS	0.06			

Fig. 20 Phosphorus Uptake



4.3.3 Uptake of Potassium

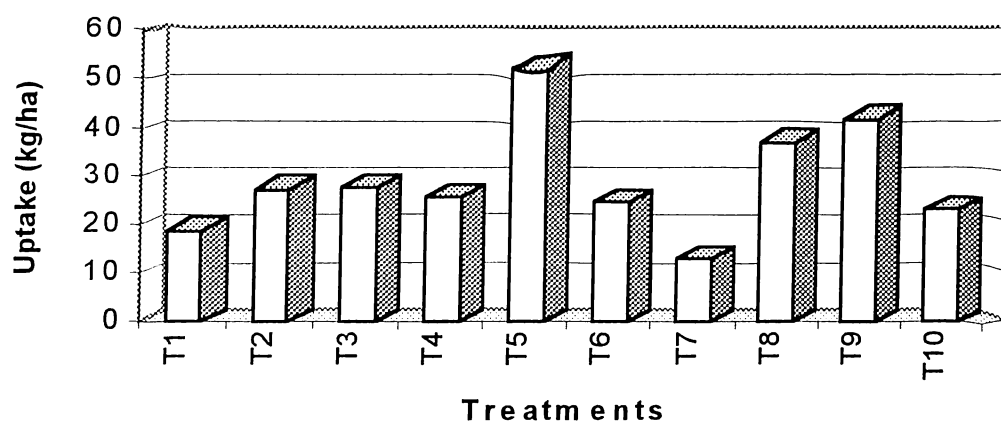
The data on K-content have been analysed, the uptake has been calculated and presented in Table 20 illustrated in Fig. 21.

The gypsum treatment with recommended practice and thinning (T_5) showed significantly higher K-content in seed as well as stover K-content over all the treatments. The total K-uptake was also found to be the highest with T_5 . The treatment with limited irrigations in recommended practice and thinning (T_7) showed the minimum K content in seed (0.52 %) and stover (0.33%) finally the total K-uptake (13.47 kg/ha). The recommended practice (T_2) recorded 45.64 per cent K-uptake with significantly higher seed and stover K-content over the local practice (T_1). Thinning (T_3) recorded significantly lower K-content in seed but higher in stover ultimately with about 1.5 per cent higher K-uptake. The N-S direction of sowing (T_4) reduced marginally the K-content of seed but significantly that of stover over E-W sowing (T_3). The uptake was 7.4 per cent less in T_4 than that of T_3 . The gypsum treatment (T_5) recorded 90.34 per cent more K-uptake as compared to no gypsum treatment (T_3) with significantly higher seed and stover K-content. T_6 with no basal but 60 per cent N-topdressed registered slightly higher seed K-content but significantly lower stover K-content over the normal N-fertilizer management practice, (50 % basal + 50 % topdressed), T_3 . T_6 recorded 11.22 per cent lower K-uptake as compared to T_3 . Limited irrigations in recommended practice and thinning (T_7) recorded significantly lower K-content in seeds but marginally lesser K-content in stover over the normal practice (T_3). T_7 registered 53.21 per cent lower K-uptake over T_3 . *Azotobacter* inoculation enhance the seed K-content significantly but marginally in stover in both local as well as recommended practice. The uptake was enhanced to the tune of 33.24 and 22.54 per cent in the recommended and local practice respectively due to this inoculation. When 50 per cent basal N-fertilizer application was skipped from the recommended practice and thinning, the content was further increased enhancing the uptake by 51.27 per cent over the recommended practice and thinning (T_3). The K-content of seed and stover was 0.62 and 0.42 per cent in Pusa Bold and the uptake was to the tune of 21.68 kg/ha. In case of Pusa Bahar the respective values were 0.91 and 0.49 per cent and 25.3 kg/ha.

Table 19. K-content and its uptake at harvest as affected by low monetary agro-techniques.

Treatment	K- Content (%)		K-Uptake (kg/ha)		
	Seed	Stover	Seed	Stover	Total
T ₁ Local Practice	0.61	0.45	6.06	13.42	19.48
T ₂ Recommended Practice	0.90	0.46	12.38	15.99	28.37
T ₃ T ₂ + thinning	0.71	0.51	10.85	17.94	28.79
T ₄ T ₃ + N-S sowing	0.70	0.48	9.83	16.83	26.66
T ₅ T ₃ + Gypsum	1.50	0.62	28.14	26.66	54.80
T ₆ T ₃ + 60 % N topdressed (no basal)	0.86	0.42	11.03	14.53	25.56
T ₇ T ₃ + limited Irrigations	0.52	0.33	4.23	9.24	13.47
T ₈ T ₃ + <i>Azotobacter</i>	1.00	0.53	17.52	20.84	38.36
T ₉ T ₈ + 50 % N topdressed (no basal)	1.10	0.57	19.97	23.58	43.55
T ₁₀ T ₁ + <i>Azotobacter</i>	0.63	0.47	7.66	16.22	23.88
SE (m) ±	0.06	0.01			
CD (0.05)	0.18	0.03			

Fig. 21 Potassium Uptake



4.3.4 Uptake of Sulphur

The data on S-content of seed and stover were analysed, the uptake values were calculated and have been presented in Table 21 and illustrated in Fig. 22.

The data would reveal that the sulphur content was highest in the gypsum applied treatment (T_3) both in seed and stover and so also was its uptake. On the other hand, the S-content of seed was minimum in case of the local practice (T_1) whereas that of stover was minimum in T_7 , i.e., the treatment with limited irrigations along with recommended practice and thinning. This treatment (T_7) had also the lowest uptake of sulphur (10.14 kg/ha) which was even 12.81 per cent less than S-uptake of the local practice (T_1). Unlike the S-content of seed that of stover showed significant difference among the treatments. In all treatments, the uptake of sulphur in stover was found to be more than that of seed. The recommended practice (T_2) recorded 41.62 per cent more S-uptake than the local practice. Thinning recorded 17.8 per cent higher uptake of S over no thinning. N-S sowing (T_4) exhibited slight decline trend with respect to the S-content and its uptake over the E-W sowing which had 9.79 per cent higher uptake than the former. The S-content of stover did not differ significantly among T_5 , T_9 and T_8 , however, the total uptake were 50.85, 27.41, 16.95 per cent higher respectively over the recommended practice with thinning (T_3). Topdressing of 60 per cent N fertilizer without any basal application (T_6) reduced the S-content by 8.62 and 16.67 per cent in seed and stover respectively and also by 20.4 per cent in the total uptake over the normal practice of N-fertilization in T_3 . *Azotobacter* inoculation had marginal increasing trend in both local and recommended practice. The S-uptake in inoculated treatments were augmented by 21.58 and 37.83 per cent in local practice (T_{10}) and recommended practice (T_8) due to increase in S-content in seeds. Topdressing only with 50 per cent N without basal application in the inoculated trial of recommended practice (T_9) had marginal increase in S-content and uptake over inoculation in recommended practice and thinning (T_8).

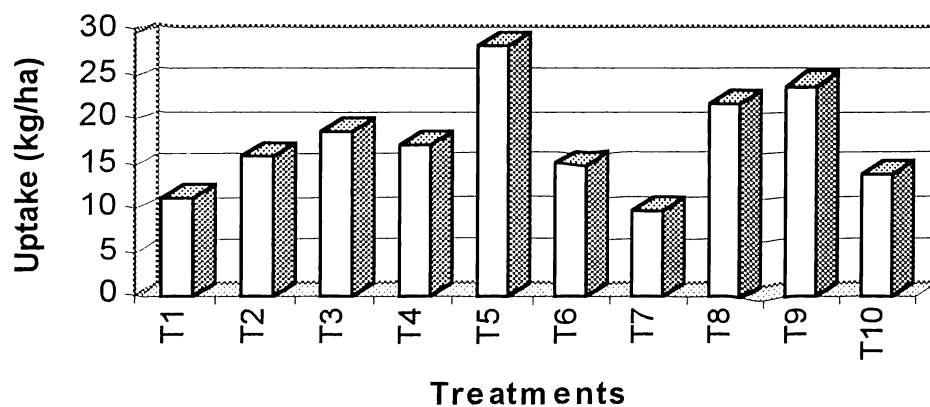
The improved variety, Pusa Bahar showed 0.58 and 0.29 per cent S in seed and stover as against 0.5 and 0.23 per cent in the local check, Pusa Bold. The former recorded total uptake of 19.48 kg S/ha while the latter had 12.89 kg S/ha.

Table 21.

**S-content and its uptake at harvest as affected by low
monetary agro-techniques.**

Treatment		S- Content (%)		S-Uptake (kg/ha)		
		Seed	Stover	Seed	Stover	Total
T ₁	Local Practice	0.48	0.23	4.70	6.86	11.63
T ₂	Recommended Practice	0.54	0.26	7.43	9.04	16.47
T ₃	T ₂ + thinning	0.58	0.30	8.86	10.55	19.41
T ₄	T ₃ + N-S sowing	0.56	0.28	7.86	9.82	17.68
T ₅	T ₃ + Gypsum	0.69	0.38	12.94	16.34	29.28
T ₆	T ₃ + 60 % N topdressed (no basal)	0.53	0.25	6.80	8.65	15.45
T ₇	T ₃ + limited Irrigations	0.49	0.22	3.98	6.16	10.14
T ₈	T ₃ + <i>Azotobacter</i>	0.60	0.31	10.51	12.19	22.70
T ₉	T ₈ + 50 % N topdressed (no basal)	0.61	0.33	11.08	13.65	24.73
T ₁₀	T ₁ + <i>Azotobacter</i>	0.51	0.23	6.20	7.94	14.14
SE (m) ±		0.07	0.02			
CD (0.05)		NS	0.06			

Fig. 22 Sulphur Uptake



4.4 CORRELATION STUDIES

Correlation studies were undertaken to determine the nature and degree of relationship between the plant characters, oil yield and seed yield. The data have been presented in Table 22.

It would be revealed from the data that the plant characters like plant height and number of primary branches per plant at harvest, leaf characters like leaf number (45 DAS) leaf area and leaf area index (60 DAS), dry matter production per plant (at harvest) number of siliquae/plant, number of siliquae on main stalk/plant, number of seeds/siliqua and 1000 grain weight had a positive and significant correlation with seed yield both at 5 per cent and 1 per cent level. The seed yield had an positive and significant correlation with oil yield at 5 per cent and 1 per cent level.

Table 22. Correlation of seed yield with plant characters and oil yield

	Character(X)	Y	Correlation coefficient(r)
1.	Plant height	Seed yield	0.963 **
2.	Primary branches per plant at harvest	Seed yield	0.927 **
3.	Leaf number (45 DAS)	Seed yield	0.865 **
4.	Leaf area (60 DAS)	Seed yield	0.756 **
5.	Leaf area index (60 DAs)	Seed yield	0.737 **
6.	Dry matter production per plant at harvest	Seed yield	0.984 **
7.	Number of siliquae per plant	Seed yield	0.987 **
8.	Number of siliquae on main stalk/plant	Seed yield	0.926 **
9.	Number of seeds/siliqua	Seed yield	0.948 **
10.	Test weight	Seed yield	0.975 **
11.	Oil yield	Seed yield	0.978 **

** Significant at 1 per cent level.

Correlation studies were undergone to determine the degree of association between uptakes of nutrients N, P, K and biological yield. The 'r' values have been presented in Table 23. The data would reflect that there was a significant and positive correlation between the uptakes and total biological yield.

Table 23. Correlation of biological yield with nutrient uptake.

	Nutrient uptake (X)	Y	Correlation co-efficient (r)
1.	N	Biological yield	0.923 **
2.	P	Biological yield	0.945 **
3.	K	Biological yield	0.962 **
4.	S	Biological yield	0.933 **

** Significant at 1 per cent level.

4.5 ECONOMICS

The inclusion of various low monetary agro-techniques to enhance the seed as well as oil yield is practically feasible only when the net profits are remunerative to the farmers. Therefore, in the present investigation, the cost of cultivation, gross returns, net profit, net return per rupee invested and benefit cost ratio for various treatments have been worked out. Taking in to consideration the cost of cultivation and the value of the economics of production as influenced by various combinations of low monetary agro inputs have been presented in Table 24.

4.5.1 Cost of cultivation

It would be evident from the data (Table 24) that the cost of cultivation of all the treatments were more than the local practice irrespective of any limitation and inclusions.

In general, the cost of cultivation was more due to the higher dose of fertilizer and inclusion of biofertilizer, more number of irrigation and plant protection measures in other treatments than the local practice (T₁). The cost of cultivation was highest in the gypsum applied plot (T₅) with Rs. 9189 per hectare followed by the *Azotobacter* inoculation along with the recommended practice and thinning (T₉) i.e. Rs.8774 per hectare. The minimum cost was involved in local practice i.e. Rs.7294 per hectare.

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Table 24. Economics of production as affected by low monetary agro-techniques.

Treatment	Cost of cultivation(Rs/ha)	Gross return (Rs/ha)			Net return (Rs/ha)	Net return per rupee cost ratio investment	Benefit: cost ratio
		Seed	Stover	Total			
T ₁ Local Practice	7294	13916	585	14501	7207	0.98	1.98
T ₂ Recommended Practice	8564	19250	695	19945	11381	1.33	2.33
T ₃ T ₂ + thinning	8684	21392	703	22095	13411	1.54	2.54
T ₄ T ₃ + N-S sowing	8564	19656	701	20357	11793	1.38	2.38
T ₅ T ₃ + Gypsum	9189	26264	860	27124	17935	1.95	2.95
T ₆ T ₃ + 60 % N topdressed (no basal)	8475	17962	692	18654	10179	1.20	2.20
T ₇ T ₃ + limited Irrigations	8324	11382	560	11942	3618	0.43	1.43
T ₈ T ₃ + <i>Azotobacter</i>	8774	24528	787	25315	16541	1.89	2.89
T ₉ T ₈ + 50 % N topdressed (no basal)	8437	25424	827	26251	17814	2.11	3.11
T ₁₀ T ₁ + <i>Azotobacter</i>	7544	17024	690	17714	10170	1.35	2.35

Cost of produce as per prevailing market price

1. Seed: Rs.1400.00 per quintal
2. Stover : Rs.20.00 per quintal

Cost of inputs

1. Gypsum 250 kg/ha @ Rs.2.50 per kg.
2. *Azotobacter* 10 kg/ha @ Rs. 25.00 per kg.

4.5.2 **Gross Return**

Highest gross return (Rs. 27,124 / ha) was obtained in the gypsum applied plot (T₅) followed by treatment nine (*Azotobacter* inoculation with 50 % N topdressed without any basal N (Rs.26,251 /ha).

The return was lowest in the treatment with limited irrigation (T_7) i.e. Rs.11,942 per hectare.

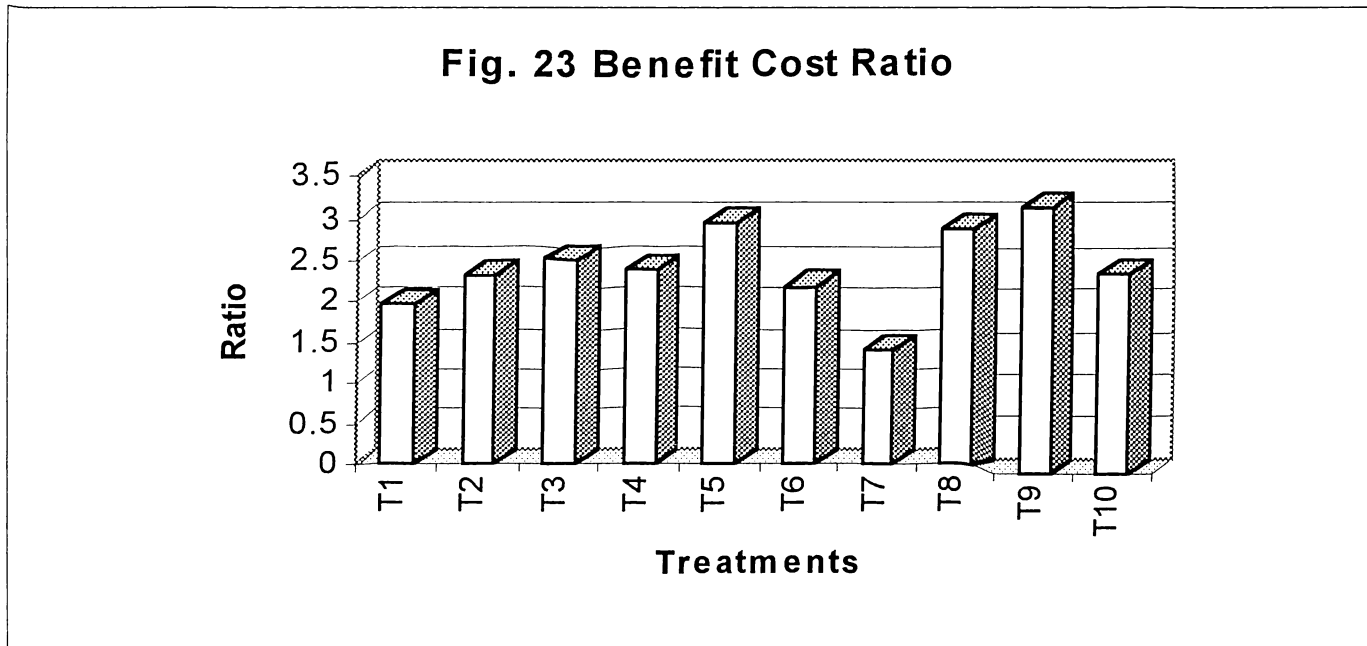
4.5.3 Net return and Net return per rupee invested

The highest net return of Rs.17,935 per hectare was obtained when gypsum was applied with recommended practice and thinning (T_5) closely followed by T_9 i.e., *Azotobacter* inoculation with 50 per cent N topdressed (Rs.17,814 per hectare). The net return was lowest (Rs. 3,618 /ha) in T_7 i.e. recommended practice and thinning with limited irrigations.

The net return per rupee invested was highest (2.11) in treatment 9, (*Azotobacter* inoculation and 50 % N topdressed but no basal) and it was the lowest (0.43) in T_7 i.e. the recommended practice and thinning with limited irrigations.

4.5.4 Benefit: Cost Ratio

The benefit cost ratio as obtained in different treatments have been presented in Table.24 and illustrated in Fig. 22. The highest benefit : cost ratio (3.11) was obtained from T_9 i.e. *Azotobacter*



inoculation, no basal but 50 per cent N topdressing followed by the gypsum treatment (T_5) with the ratio of 2.95. Recommended practice with the limited irrigations T_7 had the smallest ratio (1.43) among all the treatments tried.

CHAPTER - V

DISCUSSION

A field experiment was conducted in the Central Research station of the Orissa University of Agriculture and Technology, Bhubaneswar during *rabi*, 1995-96 to study the effect of low monetary agrotechniques on growth, yield and yield attributes of mustard. The data regarding various growth parameters, yield and yield attributes, uptake of nutrients and economics have been presented in the preceding chapter. In this chapter, an attempt has been made for a critical assessment of the extent of variations among different treatments and assign possible reasons for the same.

5.1 GROWTH

Growth of plants result from the combined effect of their inherited genetic potential and the environmental conditions in which they grow. The reproductive performance and finally the economic yield (seed and oil yields) is profoundly influenced by the degree of vegetative growth the plant attains. In the present study, the contributory growth characters like plant height, number of primary branches per plant, leaf characteristics like number of functional leaves and leaf area per plant, LAI and dry matter accumulation per plant were vividly studied to help in interpreting the reproductive ability of mustard in different treatments.

5.1.1 Plant height and Branch number

Vegetative growth is primarily influenced by height of the plant and number of branches per plant. These two characters are the visible manifestation of genetic behaviour of crop plant along with the environmental influences. A definite increase in these growth parameters were observed by different low monetary agrotechniques. The plant height increased progressively at successive stages of growth, and so also the primary branches per plant but the primary branches appeared from 45 DAS in the varieties tried i.e. Pusa Bold and Pusa Bahar. The more appreciable increase in case of plant height occurred between 30 and 45 DAS, while in case of primary branches it was between 45 and 60 DAS which coincided with the cell division, cell expansion and stem elongation stage (30-60 DAS) of mus-

Inclusion of different low monetary agro-techniques increased the plant height and number of primary branches over the local practice. The perusal of data (Table 7 and 8) envisaged that among all the treatments the gypsum application in addition to the recommended practice and thinning (T_5) showed its superiority in terms of plant height and number of branches per plant in all the stages of growth. With a visible rise in these parameters T_5 recorded the tallest plants (175.43 cm) and maximum number of primary branches (7.52) per plant at harvest. This might be attributed to increased uptake of N, P, K and S and a better nutritional environment for plant growth (Giri and Saran, 1985). This could also be attributed to increased cell division, cell elongation due to S-fertilization (Sharma, 1994). The recommended practice (T_2) recorded significantly taller plants over the local practice at each stage excepting 30 DAS which could be due to better nutritional environment in the rhizosphere. Similar increase in growth attribute under fertility condition were observed by Samui *et al.*, 1986, Kumar and Shaktawat, 1992 and Tomer *et al.*, 1996. It might also be due to uniform spacing with optimum plant population in case of line sowing over broadcasting (T_1) (Kurmi and Kalita, 1992). With regard to number of branches per plant no significant differences were observed between T_1 and T_2 . Thinning (T_3) had a significant contribution resulting 13.39 and 32.96 per cent increase in plant height and number of primary branches per plant respectively over no thinning (T_2). This showed that thinning resulted optimum plant stand reducing the competition among themselves for nutrients, solar radiation and space for free and accelerated branching pattern and growth. This result corroborates the findings of Verma *et al.* (1990). N-S direction of sowing (T_4) did not have any significant effect on plant height and number of primary branches /plant rather it caused slight reduction in plant height and number of primary branches as against E-W sowing. This could be due to lesser interception of light by the former. Application of N-fertilizer in two equal splits i.e. 50 per cent basal and 50 per cent topdressed 30 days after sowing (T_3) enhanced the plant height and number of primary branches at each stage of growth over no basal but 60 per cent N topdressing (T_6). This might be due to higher and sustained supply of N to the crop in T_3 . The results corroborated with the findings of Jasinka, 1993 and Tomar and Mishra, 1991. Limited irrigations at initial stage (T_7) reduced the plant height and the number of primary branches. Significantly over normal irrigation practice (T_3) by 30.99 and 31.61 per cent respectively at harvest. Similar results have been

reported by Darange *et al.* 1995, which could be due to lesser utilization of nutrients under limited water supply reducing cell division, cell elongation and other biochemical processes in plant affecting the important growth parameters. *Azotobacter* inoculation (T_{10}) increased the plant height remarkably over the local practice (T_1) because of easy access of nitrogen resulting its higher uptake that enhanced the growth. But inoculation improved the plant height marginally over the recommended practice (T_3). Similar was the trend with respect to number of primary branches/plant. The improved variety Pusa Bahar had taller plants and more number of primary branches than the local check, Pusa Bold due to better nutritional and environmental conditions meted out to the former.

5.1.2 Leaf characters

The leaf characters like number of functional leaves, leaf area, leaf area index (LAI) are the important growth parameters for optimum yield realization. The functional leaves being the base/source of photosynthates have paramount effect on the economic yield.

Inclusion of different low monetary agro-techniques improved the leaf characters over local practice. The leaf number increased starting from 30 DAS to 45 DAS and leaf area and LAI up to 60 DAS and declined there after. The increase of leaf area and LAI were remarkably high between 30 DAS and 45 DAS. Due to senescence of leaves the leaf number decreased and almost all the leaves have dropped towards the latter stage of growth. The perusal of data in the Table 9, 10 and 11 would reveal that in the gypsum treatment (T_5) the leaf number and LAI (29.82 and 4.28) were higher as compared to other treatments irrespective of stages of growth but in case of leaf area/plant, T_5 also recorded maximum of 726.5cm² in the latter stage. The overall performance of gypsum treatment was found better than others which could be due to beneficial effect of S-fertilization which played an important role in various metabolic processes in plant and imparted higher LAI (Tondon, 1986). It was an agreement with the results of Joshi *et al.* (1991). The local practice (T_1) recorded an all time low leaf area probably due to broadcast method of sowing resulting increased competition among the plants lower rate of fertilization, but the treatment with limited irrigations (T_7) recorded lesser number of leaves as well as LAI among all the treatments. This could be due to lower rate of uptake of nutrients and water,

attributing towards retardation of various plant processes like maintaining cell turgidity, cell elongation, cell division, photosynthesis, respiration etc. (Singh *et al.*, 1994). This results confirmed the findings of Khan and Agarwal (1988). The recommended practice (T_2) recorded slight increase in leaf number (17.76%) and pronounced increase in leaf area (91.04%) and LAI (53.39%) over the local practice (T_1). This may be attributed to higher rate of fertilization and optimum plant population owing to line sowing as compared to lower fertilizer dose and broadcast method of sowing in T_1 . Thinning (T_3) had marginal effect on LAI, but profoundly increased leaf area in all stages and leaf number up to 45 DAS due to maintenance of proper plant population and spacing which met the spatial, nutritional, solar radiation and water need of the crop over no-thinning (T_2). Thinning did not influence the leaf number towards the later stages of growth over no thinning probably due to senescence of leaves. The N-S direction of sowing reduced the leaf number, leaf area and LAI slightly over the E-W sowing. Application of N-fertilizer in two equal splits (50% basal + 50% topdressing) increased the leaf number, leaf area and LAI at maximum leaf area stage over no basal but topdressing with 60 per cent N-fertilizer. This could be attributed to sustained nitrogen supply from initiation of growth which resulted higher uptake, accelerated the green growth and better expansion of leaves. Split application (T_3) did not, however, influence other leaf characters like LAI and leaf number significantly over no basal but only 60 per cent nitrogen topdressing (T_6) in later stages. *Azotobacter* inoculation increased the leaf number, leaf area and LAI marginally over the local practice (T_1) only. Its effect over the recommended practice (T_8) were not significant with regard to leaf area or LAI. The variety, Pusa Bahar recorded more number of leaves, leaf area and LAI as compared to the local check, Pusa Bold as it grew under better nutrition, irrigation, plant protection & microenvironment.

5.1.3 Dry matter accumulation (DMA) per plant

Dry matter accumulation signifies the amount of photosynthates accumulated inside the plant. Dry matter accumulation per plant was enhanced by inclusion of various low monetary agrotechniques excepting treatment seven with limited irrigations. The dry matter accumulation per plant increased from 30 DAS to harvest (Table 12). The rate of accumulation was highest between 45 and 60 DAS. There was no significant difference among treatments at the initial stage of growth (30 DAS), but at the

5.2 YIELD ATTRIBUTES

The yield attributing characters play a very important role in determining the seed yield as well as the oil yield. The number of siliquae per plant, number of siliquae on main stalk per plant, length of siliqua, number of seeds per siliqua, test weight (g) are the major attributes having paramount importance in assessing the yielding ability of the crop.

The perusal of data presented in Table 13 and 14 would give an overall view of the trend of different yield attributes. Inclusion of various low monetary agrotechniques influenced the yield attributing characters in positive way over the local practice (T_1). All the yield attributing characters registered their maximum in the gypsum treatment (T_5) and minimum in the treatment with limited irrigations (T_7). The data obtained from the experiment revealed that the yield attributing characters attained their maximum in the gypsum treatment (T_5) closely followed by the treatment with *Azotobacter* inoculation and 50 per cent N topdressed (T_9). The mean number of siliquae/plant, number of siliquae on main stalk/plant, length of siliqua, seeds/siliqua, test weight were 320.5, 60.23, 4.83 cm, 18.17 and 5.39g respectively recorded in T_5 . All the yield attributing characters recorded minimum in T_7 with limited irrigations and were at par with the corresponding values of T_1 with local practice. The recommended practice (T_2) was superior with regard to number of siliquae/plant (201.43) and number of seeds/siliqua (15.67) and had marginally higher number of siliquae on main stalk per plant over local practice (T_1). The variation with regard to length of siliqua and test weight were not significant between T_2 and T_1 . The increase in number of siliquae/plant and seeds/siliqua were also observed by Tomer *et al.* (1996). This increase could be due to better supply of nutrients along with optimum plant density in line sown crop in T_2 . The second reason was in conformity with the findings of Kurmi and Kalita (1992). Thinning was significantly superior to no-thinning in producing more number of siliquae/plant (21.78%) as well as main stalk (27.23%) and also more number of seeds/siliqua (9.76%). The thinning maintained an optimum plant stand there by reduced the degree of competition for nutrients and water and met the optimum requirement of the crop. The siliquae numbers on main stalk was affected mostly by the direction of sowing. Here the N-S sowing had reduction significantly low by 20.38 per cent over E-W sowing but in all other yield attributing characters there were only marginal reduction. This reduction might be attributed to lower rate of light interception resulting lower rate of photosynthesis, dry matter accumu-

tion thereby affecting these yield components. The superiority of gypsum treatment was reflected in most of the yield attributing characters due to S-fertilization which increased the leaf number, LAI, that resulted in increasing photosynthesis, assimilation rates and ultimately resulting improvement in these yield components. The results were in close conformity with that of Sharma (1994). The split application of N in two equal doses (50% basal+ 50% topdressing) increased the number of siliquae/plant, seeds/siliqua and test weight (g) remarkably over the no basal but 60 per cent N topdressed by 40.65, 8.62 and 10.72 per cent respectively. This increment might be attributed to supply of N on a sustainable basis which increased the N-uptake, which influenced the metabolic activities thereby affecting the partitioning of photosynthates to sinks. This corroborated the earlier findings of Jadav *et al* (1995). Limited irrigations (T₁) performed poorly with regard to all the yield attributing characters which could be due to poor performance of the crop under moisture stress condition reducing the uptake of nutrients and water which affected various bio-chemical and physiological processes in the plant. *Azotobacter* inoculation increased the number of siliquae/plant by 110.28 per cent over the local practice. Inoculation of biofertilizer along with application of N at the rate of 50 per cent (topdressed) increased the number of siliquae/plant and per main stalk significantly by 17.69 and 20.5 per cent more than the recommended practice and thinning T₃ could be due to greater bacterial activity ensuring better nitrogen supply which enhanced the uptake for greater metabolic processes that could enhance the siliqua number. The results are in conformity with the earlier findings of Vivek and Kumar, 1994. The variety Pusa Bahar recorded more number of siliqua/plant and per main stalk, improved siliqua length and seeds/ siliqua and test weight than those in Pusa Bold due to better nutritional and environmental conditions prevailing in the field with higher levels of fertilizers, adequate irrigation and optimum plant population as compared to lower fertilizer levels, limited irrigations and broadcast sowing (local practice).

3 YIELD

Yield is the ultimate output of the combined effect of the genetical and environmental characteristics. It is the ultimatum we obtain with implementation of various package of practices.

5.3.1 Seed yield and stover yield

Seed, the economic yield of mustard is the ultimate indicator of superiority or otherwise of a treatment meted out to the crop. Stover yield can be taken as the basis to know the extent of dry matter accumulation in the plant which decides the rate of photosynthesis in the plant. In this study the data obtained on seed and stover yield (Table 15) revealed that the inclusion of various low monetary agrotechniques improved the seed yield remarkably over the local practice except T_7 with limited irrigations which recorded significantly lower yield than the local practice. The gypsum treatment with recommended practice and thinning (T_5) recorded the maximum yield among all other treatments indicating the importance of sulphur nutrition in mustard. This established the fact that sulphur has got its own significance in metabolic activity of the plant being involved in the formation of chlorophyll, glucosinolate and erusic acid and activation of enzymes, it determines the seed and oil yields in mustard. The increase in seed and stover yield by 22.77 and 22.26 per cent over the recommended practice due to Sulphur application could be due to the increased number of siliquae per plant, formation of larger siliqua, more number of seeds per siliqua, bolder seeds with higher accumulation of photosynthates. This corroborated the earlier findings of Saran and Giri (1990). The increase might also be attributed to improvement of bearing capacity i.e. siliqua numbers and photosynthates production efficiency (Narang *et al.* 1993). The yield was minimum (8.13qha^{-1}) in the treatment, the recommended practice with limited irrigations among all the treatments. The lower yield in T_7 could be attributed to limited supply of water which increased the soil strength thereby reducing the root proliferation and retarded the uptake of nutrients, water to the plant and their translocation inside the plant, affecting the biochemical reactions adversely which restricted the development of yield attributes and ultimately reduced the yield. These results are in conformity with that of Tomer *et al.* (1992) and Sharma (1991). The recommended practice T_2 recorded 38.33 and 16.56 per cent seed and stover yield than the local practice (T_1). This might be due to sustained and high level of fertilisation in T_2 which provided a better nutritional environment resulting higher growth and dry matter production with the improvement of the yield components. This corroborated the earlier findings of Sharma (1991), might also be due to the optimum plant density prevailed in T_2 on account of line sowing (T_2) than broadcasting (T_1) reducing the competition and providing optimum environment for growth and yield attributes thereby affecting the yield ultimately. Thinning (T_3) recorded significantly higher yield than the no-thinning treatment (T_4)

with the provision of proper spacing and maintenances of adequate plant stand which reduced the competition for the spacing and maintenance of adequate plant stand which reduced the competition for the space, light and nutrients thereby improved various growth and yield attributing characters affecting the yield (Verma *et al.*, 1990) The N-S direction (T_4) of sowing reduced the yield over the E-W sowing (T_3) probably due to less light interception rate which reduced the rate of photosynthesis which in turn reflected in the yield. Topdressing of N at the rate of 60 per cent without any basal application (T_6) reduced the yield over the application of N in two equal splits (50% basal + 50% topdressing) by 19.09 per cent. This was due to lesser supply of n in T_6 which depressed the growth and development of yield attributes reduced the N-uptake and thereby the yield. These results are in conformity with the findings of Tomar *et al.* (1991), Singh and Srivastava (1986). *Azotobacter* inoculation increased the seed yield significantly over the local practice as well as recommended practice. The percentage of increase in yields were 22.33 per cent and 19.66 per cent respectively due to easy access of N to the crop by the biological fixation affecting various growth and yield parameters and ultimately the yield. When basal 50 per cent N was skipped from the recommended practice with *Azotobacter* inoculation (T_9) enhanced the yield further over inoculation with full dose of N application as in T_8 . This might be attributed to increased rate of activity of the *Azotobacter* in absence of N-fertilizer at the initial stage which accelerated the N-uptake by the plant through biological fixation. The variety Pusa Bahar, the improved one recorded more seed and stover yield as compared to Pusa Bold, due to the better nutritional and environmental conditions meted out to the former as against the latter.

5.3.2 Harvest index (HI) and seed:stover ratio

Harvest index (HI) is the ratio of economic yield to biological yield. In the present study, the HI was maximum in T_8 i.e. *Azotobacter* inoculation along with the recommended practice and thinning closely followed by T_9 . *Azotobacter* inoculation + 50% N topdressed with no basal, T_5 (gypsum with recommended practice and thinning) and T_3 (recommended practice with thinning). The seed:stover ratio was also in the same trend. This result indicated that there was more seed yield in T_8 with respect to the stover and total biomass yield. The HI was minimum in T_7 (recommended practice and thinning with

ited irrigations) so also the seed:stover ratio. The harvest index and seed:stover ratio were higher in the recommended practice as compared to the local practice (T_1), which indicated higher seed yield. Thinning increased the harvest index and seed:stover ratio over no-thinning showing more seed yield in thinning treatments. The direction of sowing had no significant effect on the harvest index and seed:stover ratio however, N-S sowing showed marginal reduction in HI and seed:stover ratio over the W sowing. This might be due to favourable light interception, higher photosynthesis rate affecting the yield and biomass production. The gypsum application over no-gypsum treatment, split application of whole N- fertilizer over topdressing only with 60 per cent N, normal irrigation practice over limited irrigations, *Azotobacter* inoculation over no inoculation resulted more harvest index and seed:stover ratio thereby indicated significant amount of seed yield in the former over the latter.

3.3 Oil content and oil yield

The oil content and oil yield are the major factors contributing towards the economic yield of the crop. The oil content shows its prime importance affecting the oil yield. The oil content and oil yield were maximum (39.2% and 7.37 of qha⁻¹) in the gypsum applied plots (T_9) indicating the superiority of sulphur in increasing oil content in seeds and oil yield ultimately. Tondon (1986) has also reported that on an average, sulphur application improved the oil content of mustard by 8.5 per cent. This increase in oil content of mustard due to sulphur application which increased the formation of glucosides and glucosinolate compounds of mustard seed. This corroborated the earlier findings of Agrawal and Gupta (1982), Saran and Giri (1990). The higher oil yield was attributed to the higher oil content and oil yield. This study also established the fact that sulphur plays a key role in oil formation synthesis and ultimately the oil yield. It corroborated the earlier findings of Tandon (1990), Mohan and Sharma (1992). The oil content and oil yield were minimum in treatment seven (normal recommendations with limited irrigations). This could be due to lesser photosynthetic area, shorter leaf duration and availability of less photosynthates resulting less oil accumulation in developing seeds (Ichiharra and Noda, 1980). The results are in agreement with the findings of Singh *et al.* (1997). The recommended practice recorded profoundly higher oil content (22.47%) and oil yield (69.04%) as compared to local practice due to higher amount of fertilizer application and line sowing in T_2 which accounted for the balanced nutrition

proper spacing to the plants affecting the crop yield oil content. This corroborated with findings of and Kar (1995). Thinning improved the seed oil content and oil yield marginally over no-thinning direction of sowing did not influence significantly towards oil content or oil yield. However, the oil content in N-S sowing was slightly less than that of E-W sowing probably due to lower rate of photosynthesis owing to lower light interception rate which reduced decreased oil content and oil yield. Split application of N-fertilizer (50% basal +50% topdressing) was found at par with the topdressing with 60 per cent N without any basal application in relation to oil content and oil yield. Recommended practice thinning with limited irrigations (T_7) did not show any significant variation in its oil content as compared to normal practice (T_3), but there was reduction in oil yield over the normal practice. It was directly related to poor seed yield because of restricted growth and reduction in yield parameters. These findings corroborated with the findings of Singh and Singh (1982) and Darange *et al.* (1995). *Sinorhizobium* inoculation (T_{10}) and (T_8) increased the oil content 10 and 6.3 per cent and oil yield by 13 and 26.32 per cent respectively over local practice and recommended practice respectively. Inoculation with 50 per cent N topdressing (T_9) reduced the oil content and oil yield slightly over T_8 . The variety Pusa Bahar ensured higher oil content (35.41%) and oil yield (5.26 q/ha) while local check, Pusa Bahar had 29.74 per cent oil and 3.31 qha⁻¹ of oil yield respectively. This might be due to better nutritional environment owing to higher fertility level and better microenvironment owing to line sowing which reduced the competition for nutrients, water and light.

UPTAKE OF NUTRIENTS

The perusal of data (Table 18-21) would reveal that the content and uptake of different nutrients (N, P, K and S) were influenced significantly by various low monetary agrotechniques. Gypsum application (T_5) had the maximum uptake of N, P, K and S over all the treatments. The S- application ensured better availability of N, P, K and S which is reflected in terms of yield. (Khanpara *et al.*, 1993). Singh and Bairathi (1990) and Rathore and Manohar (1989) also reported similar results. N and S both are closely linked with protein metabolism and their relationship is synergistic (Aulakh and Pasricha, 1983). Hence, with application of sulphur the N-uptake was also enhanced. The minimum content and uptake was observed in case of recommended practice with limited irrigations (T_7). The availability of

P and K is more in higher soil moisture level than in lower soil moisture (Parihar and Tripathi, 1989). Moisture stress has been reported to increase the soil strength, decrease in root growth and its proliferation and in turn N-absorption of crop (Fischer and Mauver, 1978). The results also corroborated with the findings of Sharma and Kumar (1988). The recommended practice (T_2) obtained higher uptake of nutrients over the local practice (T_1) which was clearly due to better availability of nutrients and lower competition among plants in T_2 as compared to T_1 with lower fertilizer dose and broadcast sowing. Thinning was found superior to no-thinning with relation to the nutrients' content and uptake which could be due to lower competition for the availability of nutrients in case of (T_2) with optimum plant stand. The N-S direction of sowing reduced the uptake of different nutrients by the plant as compared to the E-W sowing which could be due to lower photosynthetic and biochemical activity. Application of N-fertilizer in two equal splits (50% basal + 50% topdressing) was found better than the single (60%) application as topdressing. Continuous and sustained supply of N through split applications also helped for higher uptake of K and S. S uptake had synergistic effect with N. *Azotobacter* inoculation increased the nutrient content and uptake due to the biological fixation over no-inoculation treatments when 50 per cent N was skipped from the basal the uptake was improved due to higher biological fixation and easy access of N. Also the uptake of P, K and S were enhanced due to synergistic effect. The variety Pusa Bahar ensured higher uptake of N, P, K and S and higher content of these elements as compared to the local check, Pusa Bold due to better supply of nutrients under favourable micro environment. In general, the S-uptake was found considerable higher in the plant probably due to application of Endosulfan which contains about 0.9 per cent S in it and the varieties tried were the long duration ones getting more time for the nutrient uptake.

5. ECONOMICS

The data on economics of production indicated that the gypsum application along with the recommended practice and thinning (T_2) ensured the highest net return of Rs.17,935/ha with a monetary advantage of around 150 per cent over the local practice (Rs.7,207/ha). This was followed by T_2 , i.e. inoculation with 50 per cent N-topdressing (Rs.17,814/ha) and T_8 i.e.inoculation with recommended dose of N (Rs.16,541/ha). The cost of cultivation was also highest in T_5 (Rs. 9,189/ha) followed by T_8

Azotobacter inoculation with the recommended practice and thinning (Rs.8,774/ha) and T₃ i.e. recommended practice and thinning (Rs.8,684). The higher cost of cultivation in T₅ was due to the full recommended dose of N, P, K and gypsum application. The cost reduced in T₉ to Rs.8,437 as 50 per cent basal N was skipped which reduced the cost. The local practice had the lowest cost of cultivation due to lower dose of fertilizer, limited irrigations and plant protection measures. The net return was more when the yield was more in T₅ and less when that was less in T₇. *Azotobacter* enhanced the cost marginally over the local practice but reduced over the recommended practice. The net return per rupee invested and the benefit: cost ratio appeared to be highest (Rs 2.11 and 3.11 respectively) in T₉. The benefit: cost ratio was 2.95 in case of the highest yielder (T₅). This could be due to low cost of cultivation and appreciable yield return from the treatment.

CHAPTER - VI

SUMMARY AND CONCLUSION

SUMMARY

A field experiment was conducted at the Central Research Station of the Orissa University of Agriculture and Technology, Bhubaneswar during *rabi* season of 1995-96 (November to February) to study the effect of low monetary agrotechniques on mustard (*Brassica Juncea* L.) varieties Pusa Bold (local check) and Pusa Bahar. Ten treatment combinations including one local practice and one recommended practice were tested on a randomised block design with three replications. The results have been furnished and discussed in the preceding chapters. The salient findings and the broad conclusions drawn from the experiment are stated here under.

1. The Plant population per m² was found almost practically uniform (43.9) in the line sown plots but it was more in the non thinned line sown (54) and broadcast plots (64). The optimum plant population in the line sown plots rendered to attain higher values of growth parameters, yield attributes and hence yield as compared to overcrowded population.
2. Gypsum application at the rate of 250 kg/ha along with the recommended practice and thinning (T₅) recorded the maximum plant height of 175.43 cm followed by the treatment with *Azotobacter* inoculation and 50 per cent N topdressing, T₉ (155.5 cm) at harvest. The local practice (T₁) registered an all time low attaining plant height of 92.33 cm at harvest. *Azotobacter* inoculation and thinning had a remarkable effect on plant height. Limited irrigations reduced the plant height by 30.99 per cent over the recommended practice.
3. The gypsum treatment along with the recommended practice and thinning (T₅) resulted maximum number of primary branches per plant (7.52) among all the treatments closely followed by T₉, the inoculated plot with 50 per cent N topdressing (6.88). The treatment with limited irrigations (T₇) reduced the number of primary branches to 4.11 even less than that (4.12) of the local practice (T₁). All the treatments excepting T₇ registered more number of branches than the local practice.

Leaf characters like number of functional leaves per plant, leaf area and leaf area index (LAI) were influenced significantly by various low monetary agrotechniques. All the parameters recorded their maximum in the gypsum treatment along with the recommended practice and thinning (T_5). The minimum leaf number and LAI were observed in the local practice.

Dry matter accumulation per plant was the highest in the gypsum applied treatment at harvest (7.86 g) among all the treatments closely followed by the inoculation treatments T_9 (35.77 g) and T_8 (5.23 g) while the treatment with restricted irrigation (T_7) recorded the least (15.7 g).

Addition of gypsum along with the recommended practice and thinning (T_5) recorded 320.5 siliquae / plant, the highest among all the treatments closely followed by the treatment with *Azotobacter* inoculation and 50 per cent N top-dressing with no basal N (T_9) with 288.7 siliquae/plant. Similar trends also observed with respect to number of siliquae/main stalk 60.23 and 58.77 in T_5 and T_9 , respectively. The treatment with the recommended practice and limited irrigations (T_7) recorded the least number of siliquae/plant (67.93) and on main stalk (33.47). Excepting T_7 , other treatments recorded more number of siliquae than the local-practice (T_1).

In general, sulphur application in terms of gypsum over the recommended practice and thinning (T_5) produced longer siliqua (4.83 cm), whereas the treatment with limited irrigations (T_7) had the shortest one (3.67 cm). All the treatments excepting T_7 obtained larger siliqua than that in local practice.

Sulphur fertilization in the form of gypsum in T_5 registered a remarkable increase in the number of seeds/siliqua over the local practice (T_1). T_5 obtained maximum number of seeds/siliqua (18.17) closely followed by inoculation treatments T_9 (18.1) and T_8 (17.27). The recommended practice with limited irrigations (T_7) recorded lowest number of seeds/siliqua (12.3), marginally lower than that recorded in the local practice (12.47).

9. The test weight (1000 grain weight) was significantly influenced by various low monetary agrotechniques. The maximum test weight of 5.39 g was observed in the gypsum applied plots (T_5) with slight increment over the inoculation treatment, T_9 (5.21g) and T_8 (5.18 g). The limited irrigations in T_7 reduced the test weight marginally from the local practice and recorded the minimum (3.92 g) among the treatments.

10. Seed yield registered a spectacular improvement i.e. 88.73 per cent rise over the local practice, when sulphur was applied in the form of gypsum (250 kg/ha) along with the recommended practice and thinning. It registered seed yield of 18.76 qha⁻¹ which was at par with T_9 in the *Azotobacter* inoculation with 50 per cent N topdressed (18.16 qha⁻¹). Recommended practice with limited irrigations (T_7) reduced the yield drastically to 8.13qha⁻¹ which was less than the local practice which recorded 9.94qha⁻¹ seed yield. *Azotobacter* inoculation increased the seed yield considerably over local as well as recommended practice.

11. Addition of gypsum along with recommended practice and thinning (T_5) increased the stover yield to 43 qha⁻¹, i.e. 44.15 per cent increase over the local practice (T_1). This was slightly higher than that obtained in the *Azotobacter* inoculation treatment with 50 per cent N topdressing (T_9) and also in the inoculation with normal fertilization (T_8). The lowest straw yield of 28 qha⁻¹ was obtained in the T_7 , the recommended practice with limited irrigations closely followed by the local practice (29.83qha⁻¹).

12. *Azotobacter* inoculation in recommended practice and thinning (T_8) showed highest harvest index (30.82%) among all the treatments closely followed by gypsum treatment, T_5 (30.38%), recommended practice with thinning (T_3) and *Azotobacter* inoculation with 50 per cent N topdressing (T_9) treatments. The lowest HI of 22.5 per cent was obtained in the treatment with limited irrigations (T_7), marginally lower than that of local practice (25.13%).

13. The seed:stover ratio was maximum (0.45) in the treatment with *Azotobacter* inoculation in recommended practice and thinning (T_8) and minimum (0.29) in the treatment with limited irrigations (T_7). The seed:stover ratio exhibited the similar trend as in case of HI.

14. Oil content registered a conspicuous rise of 38.99 per cent when gypsum was applied along with the recommended practice and thinning (T_5) over the local practice (T_1). *Azotobacter* inoculation treatments (T_8 , T_9 and T_{10}) also showed higher oil content as compared to other no-inoculation plots. The minimum was obtained in the local practice (T_1) with 28.21 per cent and maximum in T_5 with 39.21 per cent oil.

15. The oil yield was maximum in the gypsum treatment (7.37 q/ha) which was closely followed by the treatment with *Azotobacter* inoculation and 50 per cent N topdressing (T_9) (6.72 q/ha.). The minimum of 2.81 qha⁻¹ oil was obtained in the local practice (T_1) having almost no difference from the treatment with limited irrigations in recommended practice with thinning (T_7).

16. Nitrogen content and its uptake showed an appreciable increase in gypsum treatment (T_5) over the local practice. The uptake was maximum to the tune of 124.71 kg/ha in T_5 followed by the inoculation treatment T_9 (112.53 kg/ha). The uptake was minimum in the local practice (41.96 kg/ha) closely preceded by T_7 with limited irrigation (53.42 kg/ha) and T_6 with 60 per cent N topdressed with no basal application (56.97 kg/ha).

17. Phosphorus content in seeds and stover and its uptake reached its maximum to the extent of 0.56 and 0.35 per cent and 17.04 kg/ha respectively in the gypsum treatment (T_5) closely followed by the inoculation treatments T_9 (15.01 kg/ha) and T_8 (14.01 kg/ha). *Azotobacter* inoculation did not have any significant contribution towards the P-uptake. Recommended practice with limited irrigations (T_7) had the lowest P-uptake of 4.12 kg/ha among all the treatments closely following the local practice (5.32 kg/ha).

18. Potassium uptake was found to the extent of 54.8 kg/ha in the gypsum treatment (T_5) with K-content of seeds and stover at 1.5 and 0.62 per cent respectively. The treatment with *Azotobacter* inoculation with 50 per cent N topdressing was the next best in relation to K-uptake (43.55 kg/ha) with K-content in seed and stover at 1.1 and 0.57 per cent respectively. The uptake was minimum in the

treatment with limited irrigations (T_7 , 13.47 kg/ha) marginally lower than the local practice with 19.48 kg S/ha.

9. Sulphur content in seeds unlike the stover did not have any significant difference among the treatments. The maximum S-content was observed to the tune of 29.28 kg/ha in gypsum treatment followed by T_9 i.e. inoculation with 50 per cent N topdressed and no basal with 24.73 kg S/ha. The S-content of seed and stover was also highest in the same treatment (T_5) at 0.69 and 0.38 per cent respectively. The local practice (T_1) had least uptake (11.63 kg S/ha) than all other treatments excepting T_7 with limited irrigations (10.14 kg S/ha).

20. A positive correlation was established between seed yield and other characters like plant height, primary branches per plant at harvest, number of leaves (45 DAS), leaf area and LAI (60 DAS), dry matter production at harvest, number of siliquae per plant and on main stalk, number of seeds per siliqua, 1000 grain weight both at 5 and 1 per cent levels. The seed yield and oil yield were correlated significantly at both the levels. Between the uptake of nutrients and biological yield, there also existed a significant correlation (0.05 and 0.01 levels).

21. The maximum net return of Rs. 17,935 /ha was obtained from the gypsum applied treatment (T_5) along with recommended practice and thinning due to higher yield and also it involved higher cost of cultivation (Rs. 9189/ha). But the net return for rupee invested was the highest (Rs.2.11) in T_9 i.e. *Azotobacter* inoculation with 50 per cent N-topdressing so also the benefit:cost ratio (3.11). In this treatment the cost of cultivation was Rs. 8,437/ha and the net return was to the extend of Rs.17,814/ha.

CONCLUSION

From the results summarised above, it may be concluded that gypsum application at the rate of 250 kg/ha with the recommended practice and thinning is essential to increase the seed and oil yield of Indian mustard profitably. This practice recorded 18.76 and 7.37 qha⁻¹ of seed and oil yields respectively. The cost of cultivation was highest (Rs.9,189/ha) and also the net return (Rs.17,935/ha) in this treatment. But considering the seed and oil yields and economics as a whole, the *Azotobacter* inoculation with 50 per cent N-topdressing along with the recommended practice and thinning was the most efficient one giving highest benefit:cost ratio (3.11) and net return /rupee invested (Rs.2.11). It also attained a sizeable yield of seed and oil 18.16 and 6.11 qha⁻¹ respectively with the variety Pusa Bahar under the agro-climatic condition of Bhubaneswar. However, for confirmation of results the experiment needs repetition for at least one or two more seasons.

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2. Gypsum application at the rate of 250 kg/ha along with the recommended practice and thinning (T₅) recorded the maximum plant height of 175.43 cm followed by the treatment with *Azotobacter* inoculation and 50 per cent N topdressing, T₉ (155.5 cm) at harvest. The local practice (T₁) registered an all time low attaining plant height of 92.33 cm at harvest. *Azotobacter* inoculation and thinning had a remarkable effect on plant height. Limited irrigations reduced the plant height by 30.99 per cent over the recommended practice.
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4. Leaf characters like number of functional leaves per plant, leaf area and leaf area index (LAI) were influenced significantly by various low monetary agrotechniques. All the parameters recorded their maximum in the gypsum treatment along with the recommended practice and thinning (T_5). The minimum leaf number and LAI were observed in the local practice.
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8. Sulphur fertilization in the form of gypsum in T_5 registered a remarkable increase in the number of seeds/siliqua over the local practice (T_1). T_5 obtained maximum number of seeds/siliqua (18.17) closely followed by inoculation treatments T_9 (18.1) and T_8 (17.27). The recommended practice with limited irrigations (T_7) recorded lowest number of seeds/siliqua (12.3), marginally lower than that obtained in the local practice (12.47).

9. The test weight (1000 grain weight) was significantly influenced by various low monetary agrrotechniques. The maximum test weight of 5.39 g was observed in the gypsum applied plots (T_5) with slight increment over the inoculation treatment, T_9 (5.21g) and T_8 (5.18 g). The limited irrigations in T_7 reduced the test weight marginally from the local practice and recorded the minimum (3.92 g) among the treatments.

10. Seed yield registered a spectacular improvement i.e. 88.73 per cent rise over the local practice, when sulphur was applied in the form of gypsum (250 kg/ha) along with the recommended practice and thinning. It registered seed yield of 18.76 qha⁻¹ which was at par with T_9 in the *Azotobacter* inoculation with 50 per cent N topdressed (18.16 qha⁻¹). Recommended practice with limited irrigations (T_7) reduced the yield drastically to 8.13qha⁻¹ which was less than the local practice which recorded 9.94qha⁻¹ seed yield. *Azotobacter* inoculation increased the seed yield considerably over local as well as recommended practice.

11. Addition of gypsum along with recommended practice and thinning (T_5) increased the stover yield to 43 qha⁻¹, i.e. 44.15 per cent increase over the local practice (T_1). This was slightly higher than that obtained in the *Azotobacter* inoculation treatment with 50 per cent N topdressing (T_9) and also in the inoculation with normal fertilization (T_8). The lowest straw yield of 28 qha⁻¹ was obtained in the T_7 , the recommended practice with limited irrigations closely followed by the local practice (29.83qha⁻¹).

12. *Azotobacter* inoculation in recommended practice and thinning (T_8) showed highest harvest index (30.82%) among all the treatments closely followed by gypsum treatment, T_5 (30.38%), recommended practice with thinning (T_3) and *Azotobacter* inoculation with 50 per cent N topdressing (T_9) treatments. The lowest HI of 22.5 per cent was obtained in the treatment with limited irrigations (T_7), marginally lower than that of local practice (25.13%).

13. The seed:stover ratio was maximum (0.45) in the treatment with *Azotobacter* inoculation in recommended practice and thinning (T_8) and minimum (0.29) in the treatment with limited irrigations (T_7). The seed:stover ratio exhibited the similar trend as in case of HI.

4. Oil content registered a conspicuous rise of 38.99 per cent when gypsum was applied along with the recommended practice and thinning (T_5) over the local practice (T_1). *Azotobacter* inoculation treatments (T_8 , T_9 and T_{10}) also showed higher oil content as compared to other no-inoculation plots. The minimum was obtained in the local practice (T_1) with 28.21 per cent and maximum in T_5 with 39.21 per cent oil.
5. The oil yield was maximum in the gypsum treatment (7.37 q/ha) which was closely followed by the treatment with *Azotobacter* inoculation and 50 per cent N topdressing (T_9) (6.72 q/ha.). The minimum of 2.81 qha⁻¹ oil was obtained in the local practice (T_1) having almost no difference from the treatment with limited irrigations in recommended practice with thinning (T_7).
6. Nitrogen content and its uptake showed an appreciable increase in gypsum treatment (T_5) over the local practice. The uptake was maximum to the tune of 124.71 kg/ha in T_5 followed by the inoculation treatment T_9 (112.53 kg/ha). The uptake was minimum in the local practice (41.96 kg/ha) closely preceded by T_7 with limited irrigation (53.42 kg/ha) and T_6 with 60 per cent N topdressed with no basal application (56.97 kg/ha).
17. Phosphorus content in seeds and stover and its uptake reached its maximum to the extent of 0.56 and 0.35 per cent and 17.04 kg/ha respectively in the gypsum treatment (T_5) closely followed by the inoculation treatments T_9 (15.01 kg/ha) and T_8 (14.01 kg/ha). *Azotobacter* inoculation did not have any significant contribution towards the P-uptake. Recommended practice with limited irrigations (T_7) had the lowest P-uptake of 4.12 kg/ha among all the treatments closely following the local practice (5.32 kg/ha).
18. Potassium uptake was found to the extent of 54.8 kg/ha in the gypsum treatment (T_5) with K-content of seeds and stover at 1.5 and 0.62 per cent respectively. The treatment with *Azotobacter* inoculation with 50 per cent N topdressing was the next best in relation to K-uptake (43.55 kg/ha) with K-content in seed and stover at 1.1 and 0.57 per cent respectively. The uptake was minimum in the

ent with limited irrigations (T_7 , 13.47 kg/ha) marginally lower than the local practice with 19.48kg

Sulphur content in seeds unlike the stover did not have any significant difference among the treatments. The maximum S-content was observed to the tune of 29.28 kg/ha in gypsum treatment followed by T_9 , i.e. inoculation with 50 per cent N topdressed and no basal with 24.73 kg S/ha. The S-content of seed and stover was also highest in the same treatment (T_5) at 0.69 and 0.38 per cent respectively. The local practice (T_1) had least uptake (11.63 kg S/ha) than all other treatments except T_7 with limited irrigations (10.14 kg S/ha).

A positive correlation was established between seed yield and other characters like plant height, primary branches per plant at harvest, number of leaves (45 DAS), leaf area and LAI (60 DAS), dry matter production at harvest, number of siliquae per plant and on main stalk, number of seeds per siliqua, 1000 grain weight both at 5 and 1 per cent levels. The seed yield and oil yield were correlated significantly at both the levels. Between the uptake of nutrients and biological yield, there also existed a significant correlation (0.05 and 0.01 levels).

The maximum net return of Rs. 17,935 /ha was obtained from the gypsum applied treatment (T_5) along with recommended practice and thinning due to higher yield and also it involved higher cost of cultivation (Rs. 9189/ha). But the net return for rupee invested was the highest (Rs.2.11) in T_9 , *Azotobacter* inoculation with 50 per cent N-topdressing so also the benefit:cost ratio (3.11). In this treatment the cost of cultivation was Rs. 8,437/ha and the net return was to the extend of Rs.17,814/ha.

treatment with limited irrigations (T_7 , 13.47 kg/ha) marginally lower than the local practice with 19.48 kg K/ha.

19. Sulphur content in seeds unlike the stover did not have any significant difference among the treatments. The maximum S-content was observed to the tune of 29.28 kg/ha in gypsum treatment followed by T_9 , i.e. inoculation with 50 per cent N topdressed and no basal with 24.73 kg S/ha. The S-content of seed and stover was also highest in the same treatment (T_5) at 0.69 and 0.38 per cent respectively. The local practice (T_1) had least uptake (11.63 kg S/ha) than all other treatments excepting T_7 with limited irrigations (10.14 kg S/ha).

20. A positive correlation was established between seed yield and other characters like plant height, primary branches per plant at harvest, number of leaves (45 DAS), leaf area and LAI (60 DAS), dry matter production at harvest, number of siliquae per plant and on main stalk, number of seeds per siliqua, 1000 grain weight both at 5 and 1 per cent levels. The seed yield and oil yield were correlated significantly at both the levels. Between the uptake of nutrients and biological yield, there also existed a significant correlation (0.05 and 0.01 levels).

21. The maximum net return of Rs. 17,935 /ha was obtained from the gypsum applied treatment (T_5) along with recommended practice and thinning due to higher yield and also it involved higher cost of cultivation (Rs. 9189/ha). But the net return for rupee invested was the highest (Rs.2.11) in T_9 , i.e. *Azotobacter* inoculation with 50 per cent N-topdressing so also the benefit:cost ratio (3.11). In this treatment the cost of cultivation was Rs. 8,437/ha and the net return was to the extend of Rs. 17,814/ha.

CONCLUSION

From the results summarised above, it may be concluded that gypsum application at the rate of 250 kg/ha with the recommended practice and thinning is essential to increase the seed and oil yield of Indian mustard profitably. This practice recorded 18.76 and 7.37 qha⁻¹ of seed and oil yields respectively. The cost of cultivation was highest (Rs.9,189/ha) and also the net return (Rs.17,935/ha) in this treatment. But considering the seed and oil yields and economics as a whole, the *Azotobacter* inoculation with 50 per cent N-topdressing along with the recommended practice and thinning was the most efficient one giving highest benefit:cost ratio (3.11) and net return /rupee invested (Rs.2.11). It also attained a sizeable yield of seed and oil 18.16 and 6.11 qha⁻¹ respectively with the variety Pusa Bahar under the agro-climatic condition of Bhubaneswar. However, for confirmation of results the experiment needs repetition for at least one or two more seasons.

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APPENDICES

APPENDIX I (a)

COST OF CULTIVATION (Rs./ha) FOR LOCAL PRACTICE

Sl. No.	ITEM	QUANTITY	COST (Rs.)
1.	Cost of seed	7.5 kg @ Rs. 15.00/kg	112.50
2.	FYM including transportation	5 tonnes @ Rs 250.00/t	1,250.00
3.	Chemical fertilizers (30:15:15 N:P ₂ O ₅ :K ₂ O kg/ha)		
	Urea	52.17 kg @ Rs.3.38/kg	176.33
	DAP	32.6 kg @ Rs.8.50/kg	277.10
	MOP	93.75 kg @ Rs.4.08/kg	382.50
4.	Irrigation	2 numbers @ Rs.60.00 per irrigation	120.00
5.	Plant protection		500.00
6.	Bullock labour	18 pairs @ Rs. 60.00 per pair	1,080.00
7.	Human labour	80 mandays @ Rs. 30.00 per manday	2,400.00
8.	Interest on working capital	12% for half of the growing period	150.00
9.	Land revenue		10.00
	TOTAL		7,294.43

APPENDIX I (b)

COST OF CULTIVATION (Rs./ha) FOR RECOMMENDED PRACTICE

Sl. No.	ITEM	QUANTITY	COST (Rs.)
1.	Cost of seed	7.5 kg @ Rs. 15.00/kg	112.50
2.	FYM including transportation	5 tonnes @ Rs 250.00/t	1,250.00
3.	Chemical fertilizers (60:30:30 N:P ₂ O ₅ :K ₂ O kg/ha)		
	Urea	104.34 kg @ Rs.3.38/kg	352.67
	DAP	65.2 kg @ Rs.8.50/kg	554.20
	MOP	187.5 kg @ Rs.4.08/kg	765.00
4.	Irrigation	6 numbers @ Rs.60.00 per irrigation	360.00
5.	Plant protection		
	i) BHC 10% dust	25 kg @ Rs. 10.00/kg	250.00
	ii) Endosulphan	1 liter @ Rs.33.00/100 ml	330.00
	iii) Quinalphos	1 liter @ Rs.40.00/100 ml	400.00
	iv) Bavistin	150 g @ Rs. 62.00/100 g	93.00
	v) Indofil M-45	2.5kg @ Rs. 183.00/ kg	457.50
6.	Bullock labour	18 pairs @ Rs. 60.00 per pair	1,080.00
7.	Human labour	80 mandays @ Rs. 30.00 per manday	2,400.00
8.	Interest on working capital	12% for half of the growing period	150.00
9.	Land revenue		10.00
TOTAL			8,564.87

Gypsum 250 kg/ha @ Rs. 2.50/ kg (T₅)
Azotobacter 10 kg/ha @ Rs. 25.00/ kg (T₈, T₉ and T₁₀)

APPENDIX II

ANALYSIS OF VARIANCE (MEAN SUM OF SQUARES) FOR IMPORTANT GROWTH PARAMETERS, YIELD AND YIELD ATTRIBUTES.

SL. NO.	CHARACTERS	MEAN SUM OF SQUARES		
		REPLICATION	TREATMENT	ERROR
1.	Number of primary branches/ plant			
	45 DAS	0.047	0.273	0.205
	60 DAS	0.115	1.996 **	0.300
	75 DAS	0.025	1.666 **	0.246
	At harvest	0.115	1.693 **	0.477
2.	Dry matter production/plant			
	30 DAS	1.715	0.196	0.485
	45 DAS	6.021	8.520 **	0.520
	60 DAS	0.443	15.550 **	4.380
	75 DAS	0.999	26.250 **	4.460
	At harvest	10.440	141.650 **	5.370
3.	Number of siliquae/plant	432.990	21657.590 **	383.091
4.	Number of seeds/siliqua	0.511	15.650 **	0.471
5.	Number of siliquae/main stalk	5.043	98.666 **	20.750
6.	Test weight	0.094	0.679 **	0.047
7.	Seed yield	0.075	36.540 **	0.088
8.	Stover yield	20.223	65.443 **	6.220
9.	Oil content	2.302	27.868 **	0.986
10.	Oil yield	0.049	7.263 **	0.163

** Significant at 1 per cent level.