

**INTEGRATED PHOSPHORUS MANAGEMENT IN
RAINFED COTTON (*GOSSYPIMUM SPP.*)**

By

MOHAMMED AIJAZ

B.Sc. (Agri.)



**MASTER OF SCIENCE
(Agriculture)
IN
AGRICULTURAL CHEMISTRY & SOIL SCIENCE**

**DEPARTMENT OF AGRICULTURAL CHEMISTRY
AND SOIL SCIENCE
MARATHWADA AGRICULTURAL UNIVERSTIY,
PARBHANI -431 402 [M.S.]
1999**

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DISSERTATION

Submitted to

*The Marathwada Agricultural University
In Partial Fulfilment of The Requirement
for The Degree Of*

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MARATHWADA AGRICULTURAL UNIVERSITY,
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1999



*Dedicated to
My Beloved
Parents*





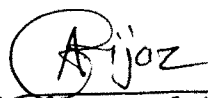
CANDIDATE'S DECLARATION

I

*Hereby declare that this dissertation
or a part thereof has not been
previously submitted by
me for a degree of any
University*

Place :- Parbhani

Date :- 28-6-99


(Mohammed Aijaz)



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“There always are in the world a few inspired men whose acquaintance is beyond the price”

Plato

Emotions cannot be expressed in words. My acknowledgement are much more than what I am expressing here to complete the formality.

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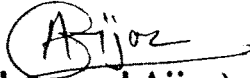
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Place : PARBHANI

Date : 28-6-99


(Mohammed Aijaz)



Dr. P.W. YENGADE

M.Sc. (Agri.) Ph.D.

Associate Professor & Incharge, AICRP

On long Term Fertilizer Experiments,

Department of Agricultural Chemistry & Soil Science

M.A.U., Parbhani (M.S.) – 431 402

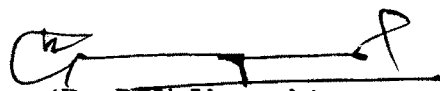
CERTIFICATE – I

Shri. MOHAMMED AIJAZ S/O. MOHAMMED HANEEF has satisfactorily prosecuted his course and research for a period of not less than two semesters and that the dissertation entitled “INTEGRATED PHOSPHORUS MANAGEMENT IN RAINFED COTTON (NHH-44),” submitted by him is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination.

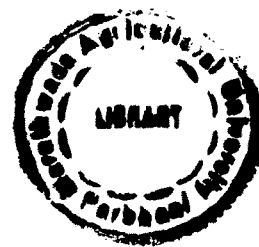
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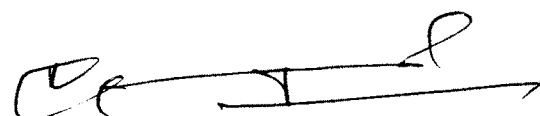
Research Guide



CERTIFICATE – II

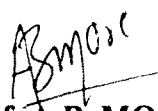
This is to certify that the dissertation entitled "INTEGRATED PHOSPHORUS MANAGEMENT IN RAINFED COTTON (NHH-44)," submitted by Shri. MOHAMMED AIJAZ S/O. MOHAMMED HANEEF to the Marathwada Agricultural University, Parbhani in partial fulfillment of the requirement for the degree of MASTER OF SCIENCE (AGRICULTURE) in the subject of AGRICULTURAL CHEMISTRY AND SOIL SCIENCE has been approved by the student's Advisory Committee after oral examination in collaboration with the examiner.


Dr. P.R. Bharambe)
EXTERNAL EXAMINER

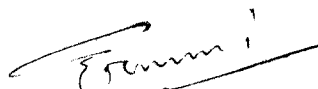

Dr. P.W. YENGADE
(Guide & Advisor)

Members of Advisory Committee

Dr. G.U. MALEWAR


Prof. A.B. MORE


Dr. B.G. KARLE


Dr. P.K. JOSHI


Associate Dean & Principal
College of Agriculture
M.A.U., Parbhani.



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Abbreviations Used

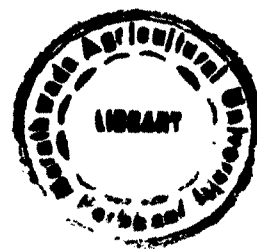
AICIP	:	All India Co-ordinated Integrated Project
AICRP	:	All India Co-ordinated Research Project.
AV.	:	Available
CD	:	Critical difference
Cv.	:	Cultiver
Dms ⁻¹	:	Desi Simen per meter
Ec	:	Electrical conductivity
Fig.	:	Figure
FYM	:	Farm Yard Manure
g.	:	Gram
ha ⁻¹	:	Per hectare
K	:	Potassium
kg	:	Kilogram
min.	:	Minimum
max.	:	Maximum
m ²	:	Square meter
mg	:	Milligram
MRP	:	Mussoorie rock phosphate



N	:	Nitrogen
No / no.	:	Number
NS	:	Non-significant
P	:	Phosphorus
PSB	:	Phosphate Solubilizing Bacteria
pp	:	Page
P.M.C.	:	Pressmud compost
Q/q	:	Quintal
R.D.	:	Recommended dose
S	:	Sulphur
SE	:	Standard Error
SSP	:	Single Super Phosphate
T	:	Treatments
t	:	Tonne
Var.	:	Variety
/ or ⁻¹	:	Per
<	:	Lesser
>	:	Higher
%	:	Per cent



INTRODUCTION



CHAPTER – I

INTRODUCTION

Cotton (*Gossypium Spp.*) is an important cash crop of India. It plays a vital role in the economy of the nation.

Cotton earns a valuable foreign exchange to the tune of rupee (Rs) 1200 crores through export of raw cotton, cotton products and other by products. Hence, it plays key role in Indian economy. Cotton has been used not only for weaving of cloths but also for other purposes like preparing industrial product from its stalks and for fuel purposes. Preparation of edible oil from its seeds and it contain vitamin A and B. Cakes as concentrated food for animals. Cotton seed oil is used for soap making and fibre in the production of paper, film, bandage, artificial fibre etc.

Cotton is grown in about 60 countries of the world, but only 9 countries are the major producer of cotton. India occupies first place in area under cotton against the world. In production, it ranks fourth after U.S.A, USSR and China. However, with regards to productivity its position is very low or rather the lowest as compared to all other cotton growing countries.

The current level of area and production in India is about 91.22 lakh hectares with annual production of 142.52 lakh bales of 170 kg each and yield per hectare is 170 kg (Crop Epitome 1996-97). In India, cotton is grown in almost all the states but Maharashtra, Gujarat, Andhra Pradesh, Madhya Pradesh and Karnataka contributes major area and production. Current level of area and production in Maharashtra is about 30.84 lakh hectare with annual production of 31.43 lakh bales of 170 kg each having average limit yield 173 kg/ha (Crop Epitome 1996-97).

Among the factors limiting for the production of this crop are dependence of large area under rainfed condition (70 per cent), cultivation of traditional varieties, untimely sowing, poor plant protection, insufficient fertilizer application and incidence of pest and diseases the major one. In addition to this, some of the physiological reasons viz. boll shedding, excess vegetative growth, leaf reddening etc. are also responsible for low yield in cotton.

Edward and Wali (1991) reported that there is ^{an} urgent need for the development of integrated nutrient management system to lower down chemical input. Integrated phosphorus supply has now assumed great significance mainly because of two reasons. Firstly the need for continued increase in agricultural production based on increase in per hectare yield by high yield potential cultivars. For achieving the optimum yield, nutrients are needed through chemical fertilizers. However, the present level of fertilizer production in India is not enough to meet the total plant requirement and the prices are also escalated. So, the common farmers cannot purchase chemical fertilizers. Secondly, the results of large number of experiment on manure's and fertilizers conducted in India reveals that neither the chemical fertilizer alone nor the organic sources exclusively can achieve the production sustainability of soil as well as crop under highly intensive cropping system (Singh and Yadhav, 1992). Even, so called the balanced use of chemical fertilizers will not be able to sustain high productivity due to emergence of deficiency of one or more of secondary and micronutrient (Nambiar and Abrol, 1989, Hegde and Sarkar, 1990).

The integrated plant nutrient management helps to restore and sustained soil fertility and crop productivity. It may also help to check the emerging deficiency of nutrient other than N, P, and K. Further, it brings an efficiency in fertilizer and

favorably effects the physical, chemical and biological environment of soils (Singh and Yadhav, 1992).

Many investigators reported that crop utilize only 15 to 20 per cent of the applied phosphorus and rest is retained in the form which is not readily available to the crop (More *et al.* 1979). The average phosphorus fixation capacity of Maharashtra soil is ^{varied from} 7 – 19 per cent (More *et al.* 1978).

Generally in Maharashtra cotton crop is grown in black heavy texture soil belongs to Vertisols. The response of crops to added P is generally less predictable on Vertisols than other soils such as Alfisols under similar agroclimatic conditions. The cause of low P response to applied P in Vertisols is not known but often attributed to some sorption of phosphate (Murthy, 1988). However recent work on the behaviour of P in Indian Vertisols indicates that the Vertisols have relatively lower phosphate sorption capacity than other soils such as Ultisols and Oxisols and the adsorbed P remained easily desorbable (Sahrawat and Warren 1989). Vertisols have a higher P sorption capacity and buffer power for phosphate sorption, implying a lower response to fertilizer P.

Use of phosphorus solubilizing bacteria may help in solubilizing insoluble phosphorus and accelerate microbial activities which in turn, may increase yield. In general, response of phosphate dissolving microorganisms was found positive only in soils with high organic matter content and low available P. The beneficial effect of artificial inoculation is now also being attributed to the production of growth promoting factors by there organisms, rather than to their role in increasing availability of P from organic compound in soils. The problems is so acute that it is beyond any single type of nutrient source to accept the challenge of appropriate nutrient supply. There is a considerable scope for supplementing of renewable sources such as biofertilizers and organic waste for improving crop productivity and

soil health. The use of FYM and compost is in practice but the use of biofertilizer and other wastes has yet to become popular as a cost effective and eco-friendly nutrient supply system.

Organic manures play a vital role in maintenance of native soil fertility and supply both macro and micro nutrients with substantial amounts of hum substance, particularly humic and fulvic acids also promote root growth, retain plant nutrients because of high CEC and acts as a slow release fertilizer thereby ensure availability of nutrient on long term basis (Gaur *et al.* 1984). To maintain this, it is well known fact that FYM, farm residues, straw, poultry manures, rural and urban compost, biogas slurry, sugar factory pressmud, are the main sources of organic manures.

Knowing the important of phosphorus for cotton production, at low cost of production, different inorganic phosphate supplements such as massoorie rock phosphate, single superphosphate and Udaipur rock phosphate could be exploited as low cost input on account of this mussoorie rock phosphate has been found suitable for direct application in acid soils (Awasthi *et al.*, 1977). However, no response has been observed in neutral and alkaline soils. (Hundal and Sekhon, 1976). Today India is the 4th largest user of inorganic fertilizer and 6th largest user of phosphorus. The costs towards the chemical fertilizer can be saved along with mark increase in the bio-availability of nutrients from inorganic fertilizer.

Practically no systematic research work is done on integrated nutrient management with respect to phosphorus on rainfed cotton in Maharashtra. ^{is very} ~~large~~ ^{effect of} ~~therefore~~ the present study was undertaken to evaluate the ~~organic and~~ ^{effect of} inorganic sources of nutrient with and without P solubilizer ~~along with~~ ^{effect of} chemical fertilizer under rainfed cotton (NHH-44) so as to make the use of organic

material to substitute fertilizer phosphorus and their beneficial effect on soil and crop yield in Vertisols.

With this feedback, an attempt was made to study integrated phosphorus management for rainfed cotton (Var. NHH – 44) with the following objectives.

- i. To assess the effect of organic manures, rock phosphate, chemical fertilizer and PSB inoculation alone or in combination on the availability of phosphorus and cotton yield.
- ii. To determine removal pattern of available NPK from soil at growth stages. **Various**
- iii. To study phosphorus use efficiency of **Various P** sources.

***REVIEW OF
LITERATURE***

CHAPTER II

REVIEW OF LITERATURE

The present study is aimed to assess the use of organic manures, mineral fertilizer with an without phosphate dissolving microbial culture for the production of cotton cv. NHH-44 (*Gossypium Spp.*). The pertinent literature on these aspects is reviewed under following heads.

- 2.1 The effect of organic manure's, rock phosphate, chemical fertilizer and PSB inoculation alone or in combination on the availability of phosphorous and cotton yield .
- 2.2 Removal pattern of available NPK from soil at growth stages.
- 2.3 Phosphorus use efficiency of sources

Phosphorus is the major plant nutrient plays a vital role in plant nutrition being a constituent of phospholipds, nucleo-proteins and enzymes. It is an development and growth, enhance flowering and seed formation. It has also as synergistic effect on other plant nutrient.

- 1) Yield of cotton
- 2) Chemical properties of soil
- 3) Available nutrient
- 4) Content and uptake of nutrient in cotton
- 5) Role of PSB inoculation in increasing P availability in soils.
- 6) Quality of cotton.

1. Yield :

Chahal *et al.* (1981) have reported significant increase in grain yield of soybean when inorganic phosphorus sources like SSP and rock phosphate were combined with FYM over the application of inorganic phosphorus alone.

Mishra *et al.* (1982) concluded that the use of rock phosphate alone is not good source of phosphate and phosphocompost as there is less biomass yield and less uptake of phosphorus in green gram and wheat crop.

Taggi and Luthru (1983) reported that, mussorie rock phosphate showed the same agronomic value as compared with water soluble source for various crops in acidic soils. They also noted that the mixture of mussoorie rock phosphate and single super phosphate (1:1) on P_2O_5 basis has been given the same performance as single superphosphate alone for maize paddy and wheat crops on neutral or alkaline soils.

Dash (1985) showed the efficiency of Pyrulliu rock phosphate along with farm yard manure (1:1) and found similar to that of diammonium phosphate in increasing rice yield, phosphorus uptake and its availability at various growth stages.

Shinde *et al.* (1985) reported that compost treating rock phosphate and inoculated with *A.Chrococcum* and *Aspergillus awamori* increase the Olsen-P and found to be better in increasing yield and P uptake by mung.

Pimpalgaonkar (1986) observed the effectiveness of Mussoorie rock phosphate was very poor, when applied alone, but in combination with single superphosphate (50 : 50) on equivalent P_2O_5 basis, it was found to be superior increasing the yield of both the crops sorghum and wheat.

Siddiqui, *et al.* (1986) observed that, the combination of mussoorie rock phosphate and farm yard manures was superior in giving more grain yield (35.97 q a⁻¹) and fodder yield (71.99 q ha⁻¹) of sorghum and wheat crops over the combination of massoorie rock phosphate plus pressmud on calcareous soil.

Mali *et al.* (1987) reported observation on field crop of cotton and reported that, the fertilizer treatment gave significant increase in the yield of seed cotton over no fertilizer. The highest yield of 23-42 of ha⁻¹ cotton was recorded in cultivar NHH-44 followed by PA-32. The P content in plant at different stages of growth from 70-150 days after sowing was significantly correlated with yield of seed cotton.

Sharma *et al.* (1988) observed that application of 15 kg P₂O₅ ha⁻¹ increased the seed cotton yield. Further increase in P levels (30 kg P₂O₅ ha⁻¹) also enhanced the seed cotton yield but the response of P application on yield of cotton decreased by increasing the P levels beyond 30 kg P₂O₅ ha⁻¹.

Chalwade *et al.* (1989) noted highest dry matter production of wheat (HD-1593) occurred by application of humus phosphate (228 mg pot⁻¹) followed by super phosphate (206 mg pot⁻¹) and also total yield per pot was maximum with humus phosphate (427 mg pot⁻¹) followed by diammonium phosphate (168 mg pot⁻¹) and SSP (109 mg pot⁻¹).

Tomar *et al.* (1989) found that in trials with cotton, applying 72 kg N + 36 kg P ha⁻¹ at sowing and 8 kg N + 4 kg P ha⁻¹ in 2 foliar sprays at the boll formation and boll development stages gave average seed cotton yields of 1.18 t ha⁻¹ compared with 1.09 t with the full N P rate at sowing and 0.74 t without NP.

Jain *et al.* (1990) studied in 2- year field trails (1985-86) with groundnut grown on a clay soil (Vertisol) containing 10 kg available P and 399 kg available K

kg ha⁻¹ in soil applying 0, 4.4, 8.8 or 13.2 kg P ha⁻¹ gave average pod yields of 0.99, 1.04, 1.22 and 1.30 t ha⁻¹ respectively. Yield increased from 1.01 to 1.98 t ha⁻¹ with 25 kg K ha⁻¹ and were not further increased with 50 kg K ha⁻¹. Increasing P rates increased P and K uptake and seed protein and oil content.

Batino and Fiksel ⁽¹⁹⁹¹⁾ concluded that application of 15-20 kg P ha⁻¹ was usually adequate for optimum yield. Matam phosphate rock (PR) from Senegal, Tilemsi PR from Mali and Tahoua PR from Niger (medium reactive) were found to be suitable for direct application. While partial acidulation (50 per cent with sulphuric acid) of the less reactive phosphate rocks resulted in products with similar agronomic effectiveness as commercial superphosphates.

✓ Gupta *et al.* (1992) observed that the use of phosphorus solubilising bacteria may help in solubilising insoluble P and accelerate rhizobial activities which in turn may increase soybean yield.

✓ Mondal *et al.* (1993) reported in field trials in the winter seasons of 1989-91 on sandy loam soils at Kalyani, West Bengal, Potatoes Cv. Kufri Badshah were given 100 or 75 per cent of the recommended NPK fertilizer 100 + 100 + 100 kg NPK with P as single superphosphate (containing 'S') or diammonium phosphate (S-free) or 75 per cent of recommended NPK with 10 ton FYM 15 days before planting. Dry matter production at 60, 80 and 100 days after planting and tuber yield were highest with 100% of the recommended NPK rates with P as single superphosphate and lowest with 75 per cent NPK with P as diammonium phosphates. Uptake of N, P, K and S was highest with 100% of the recommended NPK rates with P as single superphosphate.

✓ More and Agale (1993) studied the phosphate balance in field grown irrigated cotton on a calcareous Vertisols in Maharashtra, using 3P sources applied

at 25, 50 and 75 kg P_2O_5 ha⁻¹ single superphosphate showed significantly higher seed cotton and dry matter yields than diammonium phosphate or superphosphate (20:20:0) / plus / superphosphate. Plant uptake increased with increasing P fertilization while seed cotton and dry matter yield increased with increasing P levels upto 50 kg ha⁻¹. Fertilization at 50 and 75 kg P_2O_5 ha⁻¹ resulted in a build-up of available P in soil.

Veerabadran and Rajendran (1993) studied in a field experiment at Paiyur, Tamil Nadu with sorghum Cv. Co.19, the application of 30 kg N + 20 kg P_2O_5 /hactare as enriched FYM + seed and soil inoculation with Azospirillum in 1987-88 gave the highest grain yield (665 kg/ha⁻¹) compared with various combinations of 30 or 40 kg N + 20 kg P_2O_5 as inorganic fertilizer or enriched FYM and inoculation with Azospirillum yield in 1986-87 was not significantly different between treatment.

Agale and More (1994) observed that in cotton Cv. NHH-44 the seed cotton yield increased with increasing P rates upto 50 kg P_2O_5 ha⁻¹ with superphosphate as phosphate fertilizer.

✓ Saravanam and Nambisan (1994) reported in a field experiment in 1991-92 at Kodaikonal, Tamil Nadu, Peas Cv. Bonneville received various combination of N and P_2O_5 each 0, 50, 100 or 500 kg ha⁻¹ with or without seed inoculation with Rhizobium or soil inoculation with phosphobacterium. Mean pod yield was highest (6.55 t ha⁻¹) with 100 kg N + 150 kg P_2O_5 + soil inoculation with phosphobacterium.

✓ Thiageswari and Perumal (1995) conducted a field trial at Coimbatore on calcareous black soil to study the effect of two sources of phosphorus, single superphosphate either with or without single superphosphate. Three levels of P, O,

✓ 20 and 40 kg P_2O_5 ha⁻¹, Vermicompost and phosphobacteria (PB) were used. The grain yield, available P, P uptake in blackgram and kapas yield, available P and uptake by cotton were recorded. The results revealed that the yield, available P and P uptake were highest for the treatment combination of 40 kg P_2O_5 ha⁻¹ as single superphosphate with Vermicompost and PSB.

Patil and Shinde (1995) conducted a field experiment during rainy season and wheat during the winter seasons *P. glaucum* received 0, 50, 75 or 100% of the recommended NPK fertilizer rate or a 50 + 50 or 75 + 25 combination of the recommended NPK rates and organic manures (*Cyamopsis tetragonoloba*, FYM/ wheat straw), respectively. Wheat received 0, 50, 75 or 100% of its fertilizer requirement through organic manure. Substituting 25% of the N fertilizer through *C.tetragonoloba* green manure gave the highest mean *P. glaucum* grain yield of 2.69 t ha⁻¹. Wheat receiving the recommended NPK rate following *P.glaucum* receiving 50% NPK fertilizer + 50% wheat straw of 2.24 ton. Total grain yield was the highest (4.30t) in the treatment producing the highest *P. glaucum* grain yield and wheat receiving 75% of its fertilizer requirement.

Pasricha *et al.* (1995) reported results on Gurdaspur loam soil (Udic Haplustalf). Pigeonpea and observed significant response to direct application of P upto 40 kg P_2O_5 ha⁻¹ in plots where previous wheat crop did not receive any fertilizer P. However, in plot where wheat was fertilizer with recommended level (60 kg P_2O_5 ha⁻¹). The following pigeonpea crop did not respond to any fresh application of P. A significantly and consistent yield and P uptake. Response of pigeonpea was observed to residual P thus, the pigeonpea. Wheat rotation direct application of recommended level of P to wheat can meet the P requirement of both the crops.

Naphade *et al.* (1995) studied response of soybean to FYM and phosphorus application by conducting field experiments with four levels of FYM 0, 2, 5 and 7.5 t ha⁻¹ and phosphorus 0, 30 60 and 90 kg P₂O₅ ha⁻¹. The application of FYM and phosphorus to soybean was beneficial in increasing its production. The highest yield was obtained with the application of 7.5 t FYM and 90 kg P₂O₅ ha⁻¹ for maximum grain yield of 10.98 q ha⁻¹. Whereas, maximum profitable combination was 4t FYM and 70 kg P₂O₅ ha⁻¹ with expected grain yield of 10.66 g ha⁻¹.

Deshmukh *et al.* (1995) were conducted a field experiments for three years (1991-93) with eleven treatment replicated 3 times in RBD with soybean on Vertisols. The soybean responded to P application through single superphosphate (SSP) or pressmud cake (PMC). There was a linear in yield with increase in the level of P (0, 30, 45 and 60 kg P₂O₅ ha⁻¹) applied through both the sources. The maximum grain yield (26.28 t ha⁻¹) was obtained at P₆₀ level through SSP followed by ½ each through SSP and PMC (24.77 q ha⁻¹). The 60 kg P₂O₅ ha⁻¹ was found beneficial for soybean in 50 : 50 proportion basis through SSP and PMC.

Trivedi *et al.* (1995) studied in a field experiment, the phosphatic fertilizer applied in conjunction with FYM and pressmud increased pod and haulm yield of groundnut. Combined applicating of P and organic amendments showed higher beneficial effects. Application of pressmud @ 5.0 t ha⁻¹ + P @ 22 kg ha⁻¹ proved superior for all the parameters. The experimental soil contains 9.96 and 5.50 kg available P ha⁻¹, the treatments application of FYM @ 10.0 and pressmud @ 2.5 and 5 t ha⁻¹ were significantly superior to control. A through application of pressmud @ 5.0 t ha⁻¹ showed higher yield (2.44 t ha⁻¹) it was at par with the treatment receiving pressmud @ 2.5 t ha⁻¹. The organic amendments generally increased the haulm yield.

Jayakumar *et al.* (1995) conducted a field trial in 1986-87 at Honnasille, Karnataka, ragi (*Eleusine corucuna*) Cv. MR-911 was grown in the *kharif* and given various rates of N, P and K with or without additional N through FYM paddy straw or gliricidia. Maize Cv. Deccan – 101 was grown in the summer with 50, 75 or 100 of the recommended NPK fertilizers. Substituting some of the N applied to ragi with organic fertilizers did not reduce ragi grain yield.

Pangaria *et al.* (1995) recorded highest dry matter and yield of seed cotton with full recommended dose of NP + 20 cartload of FYM.

Patil *et al.* (1995) concluded possibility of composting higher proportion of spent wash, spent slurry with pressmud for disposal of spent wash/spent slurry was reported. The 200, 75 and 150 kg ha⁻¹ N, P and K respectively were applied. Application of FYM and 3:1 spent + slurry compost increased maize plant height over control. However, SWL significantly decreased plant height compared with all sources and control. FYM, spend slurry 3:1 and 5:1 compost and spent wash 6:1 compost result in significantly higher dry matter of maize than control, While SWL showed a decrease. The FYM proved better than all other sources except spent slurry (3:1) and (5:1) and spent wash (6:1) compost.

Rani Perumal and Bagavathi Ammal (1996) was carried out a field experiment at TNAU farm on mixed red black soil (Typic ustocrept) with different sources of rock phosphate. The treatment consisted of four sources of rock phosphates viz. Casablanca (CRP) 30 per cent P₂O₅, Gafsa (GRP) 30 per cent P₂O₅, Tebessa (TERP) 30 per cent P₂O₅, and Mussooric (MRP) 18 per cent P₂O₅. The levels applied were 250 and 500 kg P₂O₅ ha⁻¹ as single application over 5 years. Initially FYM @ 12.5 t ha⁻¹ and phosphobacteria @ 2 kg ha⁻¹ were added to all plots. The results revealed that the application of GRP recorded the highest yield followed by MRP both in direct and residual crops of maize and cowpea.

Irrespective of the sources of P fertilizers, application of 500 kg P₂O₅ ha⁻¹ gave significantly higher percentage increase over control than 250 kg P₂O₅ ha⁻¹. The same trend was observed in the case of P use efficiency and build-up by use of rock phosphate.

Bajaj *et al.* (1996) conducted a field experiment with integrated use of fertilizers and biogas spent slurry in a maize-chickpea-sorghum (fodder) cropping system during 1992-1993 showed that the application of slurry upto 10 t ha⁻¹ increased maize yield. The residual effect of slurry on chickpea was recorded upto 15 t ha⁻¹ slurry application. Buildup of the fertilizer status of the soil was observed at the end of the system when fertilizer and slurry application was made.

Dubey *et al.* (1997) conducted a field experiment during *kharif* 1998-1992 with soybean under rainfed condition. Superphosphate @ 60 kg P₂O₅ ha⁻¹ significantly improved all the parameters yield at New Delhi. It was equally effective with rock phosphate @ 30 kg P₂O₅ ha⁻¹ + *Pseudomonas Striate* (PDB) inoculation for nodule number, nodule dry weight and yield at most of the locations where soil P was low to medium except yield at New Delhi. However, rock phosphate without PDB inoculant was found effective only at Ranchi. Maximum net return phosphorus use efficiency and relative agronomic and economic effectiveness were found significantly superior with phosphate @ 30 kg P₂O₅ ha⁻¹ + PDB inoculation.

Detroja *et al.* (1997) conducted a field experiment during summer season of 1992 and 1993. Pooled results indicated that levels of phosphorus did not exert their significant effect on growth characters, yield attributes pod and haulm yields of groundnut. Significantly higher pod weight / plant, pod and haulm yield were observed where seed, were inoculated with phosphobacteria. Large seed size was

found significantly superior to all other size for all the growth characters, yield attributes and pod and haulm yields of groundnut.

Sarkar *et al.* (1997) conducted an experiment in which application of 10 tonnes FYM ha⁻¹ gave significantly higher grain yield of pigeonpea 16.7 per cent over no FYM P @ 90 kg P₂O₅ ha⁻¹. Among the P sources single superphosphate was found superior to rock phosphates. Application of 45 and 90 kg P₂O₅ ha⁻¹, supplied through single superphosphate proved equally effective on pigeonpea in presence of FYM only in lime treated oxisol.

Gangwar *et al.* (1997) studied on farm research site Rohta of district Meerut. On an average cane yield of late planted sugarcane can be increased by 19.4 and 29 per cent over farmers practice (250 kg N, 40 kg P₂O₅ ha⁻¹) by using recommended dose of 160 kg N, 60 kg P₂O₅, and 40 kg K₂O, ha⁻¹ in conjunction with FYM @ 10 t ha⁻¹ and in situ incorporation of cowpea @ 6 t ha⁻¹ respectively. However, recommended NPK alone did not increased the cane yield beyond 14 per cent over the farmers practice. Among the different fertilizer treatments incorporation of cowpea @ 6 t ha⁻¹ contributed sugarcane yield 5.26 t ha⁻¹.

Dudhat *et al.* (1997) conducted an experiment during 1992-93 and 1993-94 on clayey soils at Junagadh to study the effect of organic manure (FYM and castorcake) and chemical fertilizers, alone and in combination with each other on wheat (*Triticum aestivum* L.) Cv. GW 496. Application of either 5 tones castorcake + 120 kg N + 60 kg P₂O₅ ha⁻¹ or 5 tones castorcake + 60 kg N + 30 kg P₂O₅ ha⁻¹, being at par with each other. Significantly improved grain yield, quality and nutrients uptake by wheat. Application of FYM alone or combination with chemical fertilizers significantly increased the residual status of available N and P in soil.

Malavia *et al.* (1997) conducted a field experiment on groundnut crop. Phosphorus applied through fertilizer did not show significant effect on pod yield, haulm yield and P uptake. Seed inoculation with *Pseudomonas striata* recorded higher pod yield, haulm yield, P uptake by pod and haulm and P content in soil after harvest in both the years and in pooled results over no inoculation. Large seed size recorded higher yield (Pod and haulm) as compared with other seed sizes.

Karad *et al.* (1998) revealed that the treatment 100 per cent MRP + Biophos gave significant higher pod yield of summer groundnut. The higher response was observed in treatment of 100% MRP + Biophos followed by 75 per cent MRP + Biophos over the control. The Biophos treatments increased the availability of phosphorus in the soil.

Prasad *et al.* (1998) conducted an experiment on soybean crop. The use of phosphorus solubilizing microorganism along with FYM was effective in dissolution of immobile form of phosphate (Gaure *et al.* 1980, Gaur, 1990). Application of FYM increased grain yield by 160 kg, 97 kg and 60 kg ha⁻¹ in soil I, soil II and soil III over their respective controls. FYM besides improving physical properties of soils also ensures availability of nutrients and food supply to microflora (Gaur *et al.* 1984). Performance of *A. awamori* with or without FYM was slightly better than *B. Polymyxa* in moderately deep soil. However in other two soils, *B. Polymyxa* did well than *A. awamori*, more particularly in soil II. The free soils classified as clayey montmorillonitic hyperthermic lithic ustochrepts (soil I), fine montmorillonitic hyperthermic (calcareous) Typic Haplusterts (soil II) and fine montmorillonitic (calcareous) Typic Halplusterts (soil III) of Waranga village of Nagpur district.

Santhy *et al.* (1998) reported the long term effect of manures and fertilizers on the yields of finger millet-maize-cowpea in a rotation and nutrient uptake by

crops were studied in Coimbatore since 1972. The data on yields show that deletion of potassium from the fertilizer schedule did not have deleterious effect on yield. Nitrogen application alone, remarkably reduced the yield of crops. Application of FYM along with NPK increased the crop yield and nutrient uptake by the crops and enhanced the nutrient status.

Biswas and Narayan (1998) studied acidulation effect on finely ground phosphate rocks from Mussoorie, Udaipur and Purulia and a sample from north Carolina (USA) were acidulated to 25, 50 and 75 per cent of full acidulation with H_2SO_4 and H_4PO_4 yield and P uptake by cowpea and wheat increased significantly with increasing levels of acidulation upto 50 per cent. At a given degree of acidulation were less efficient to the direct crop of cowpea in respect of their dry matter yield and P uptake than those prepared with H_3PO_4 . However, the residual effects of both the crops of material were comparable on wheat crop.

2. Chemical properties pH, Ec and $CaCO_3$:

Muthuvel *et al.* (1979) studied the effect of long term application of manures and fertilizers on the organic carbon and total N content of soils. Application of FYM increased the organic carbon content of the soil. The treatment in which FYM at the rate of 2240 kg ha^{-1} was applied had higher organic carbon content and this implies that in the long run only the organic manuring will improve the organic content of soils.

Singh *et al.* (1980) reported that continuous application of FYM to siernozom soil in the semiarid region of Haryana resulted in lowering of soil pH increasing in organic carbon content, CEC and exchangeable cations.

Maples (1990) reported that cotton was continuously cropped in field trial in Arkansas in 1973-89 and was given 0-150 lb N, 6 lb P_2O_5 and 90 lb K_2O / acre

annually soil organic matter increased from 0.66 – 0.69 % in 1973 to 1.2 % in 1989 with annual application of 125 or 150 lb N.

Mishra *et al.* (1996) observed the results after the 10th year study on integrated nutrient management organic carbon content decreased with increasing the depth. The soil pH and Ec was also considerably reduced with application of FYM + BGA and fertilizer.

Tompe and More (1996) observed that decreased the pH and Ec of soil due to higher dose of PMC (15 t/ha). Maximum organic carbon content of soil was observed with 15 t/ha of PMC + ¼ recommended dose of fertilizer in sugarcane.

Bellakki *et al.* (1997) conducted a field experiment at Regional Research Station, Bijapur on *Typic Chromustests* for ten years. Continuous application of organic increased the CEC and exchangeable calcium while decrease in Na and CaCO₃ was observed.

Bellakki *et al.* (1998) conducted a long term field experiment for 10 year on *Typic chromustests* indicate that exchangeable Na and CaCO₃ contents decreased but there was increase in CEC and exchangeable Ca content of the soil due to incorporation of different organic sources of nutrients.

3. Available nutrient :

Dashrath Singh and Datta, (1973) observed that the application of farm yard manure with mussoorie rock phosphate, increased the soil available phosphorus content significantly at the tillering stage in rice crop.

Singh *et al.* (1980) reported that continuous application of FYM to Siernozem soil in the semiarid region of Haryana resulted in increasing phosphorus availability.

Zende (1983) studied the behaviour of rock phosphate in different soils of Maharashtra as source of phosphorus. He observed that the addition of rock phosphate on equal calcium basis had a beneficial effect on the level of $\text{NO}_3\text{-N}$ available P_2O_5 and exchangeable Mn into soil, but the magnitude of this effect was much lower in black soil as compared to an acid soil.

Patil *et al.* (1984) were of the opinion that black soils of Maharashtra are mostly calcareous and alkaline in nature, where the availability of phosphorus is a serious problem. The soluble phosphorus when added to such soils slowly get converted into less soluble and difficulty available forms. They concluded that overall highest availability of phosphorus could be maintained with superphosphate against dicalcium phosphate.

Shinde *et al.* (1985) reported that compost treated with rock phosphate and inoculated with *A. Chroococcum* and *Aspergillus awamori* increased the olsen's P and found to be better in increasing yield and P uptake by mung.

Singh *et al.* (1988) reported that biogas plant slurry was found to be highly useful organic material for solubilization of low grade rock phosphate and continuous release of water soluble phosphorus.

Patel *et al.* (1993) reported that FYM and wheat straw were found to be most effective to increase available N and P. They opined that this may be due to liberation of organic acids, during their decomposition in soil which have solubility effects on iron and aluminum phosphates, or may have chelating effects on Fe, Al and Ca ions, thereby preventing ions to forms insoluble phosphates.

Deshmukh *et al.* (1993) observed that pressmud cake application significantly increased the phosphorus and nitrogen availability over control up to 45 days of incubation.

More and Agale (1993) studied the phosphate balance in field grown irrigated cotton on calcareous Vertisol in Maharashtra, India was studied using 3P sources applied at 25, 50 and 75 kg P₂O₅ ha⁻¹. Fertilization at 50 and 75 kg P₂O₅ ha⁻¹ resulted in a build-up of available P in soil.

Deshmukh *et al.* (1995) stated significant influence of SSP and pressmud cake on organic carbon total N and available P content in soil.

Nayak *et al.* (1995) reported that the application of farm yard manure either 5000 kg ha⁻¹ or 1000 kg ha⁻¹ enriched FYM in combination with recommended dose of fertilizer (50 kg N + 40 kg P₂O₅ + 25 K₂O ha⁻¹) was found to increase the grain and straw yields of ragi crop. Combined application of organic manures and inorganic fertilizers were better than individual application.

Thiageswari and Perumal (1995) conducted a field trial at Coimbatore on calcareous black soil to study the effect of two sources of phosphorus, single superphosphate either with or without single superphosphate. Three levels of P, 0, 20 and 40 kg P₂O₅ ha⁻¹, vermicompost and phosphobacteria (PB) were used. The grain yield, available P, P uptake in black gram and kapas yield, available P and uptake by cotton were recorded. The results revealed that the yield, available P and P uptake were highest for the treatment.

Karad *et al.* (1998) revealed that the treatment 100 per cent MRP + Biophos gave significant higher pod yield of summer groundnut. The higher response was observed in treatment of 100 per cent MRP + Biophos followed by 75 per cent MRP + Biophos over the control. The biophos treatments increased the availability of phosphorus in the soil.

Yengade and Ghonsikar (1998) studied phosphorus availability in soil on which sunflower crop was grown in *kharif*, *rabi* and summer season with the help

of P and S using PSB culture. They reported the availability of P and S was significantly at higher doses of P_2O_5 and SO_4 with PSB inoculation over no PSB treatment.

4. Content and uptake of nutrient :

Mishra *et al.* (1982) reported that use of rock phosphate alone is not good source of phosphate as compared to single superphosphate and phosphocompost as there is less biomass yield and less uptake of phosphorus in green gram and wheat crop.

Shinde *et al.* (1985) reported that compost treated with rock phosphate and inoculated with *A. Chroococcum* and *Aspergillus awamiri* increased the Olsen's P and found to be better in increasing yield and P uptake by Mung.

Dash (1985) showed that the efficiency of Pyrullia rock phosphate along with farm yard manure (1:1) and found similar to that of diammonium phosphate in increasing rice yield, phosphorus uptake and its availability at various growth stages.

Mathur *et al.* (1986) reported that paddy straw compost by enriching with rock phosphate and inoculated with P solubilising organisms was found to be superior in yield and P uptake in wheat over rock phosphate alone.

Mali *et al.* (1987) reported that in field grown crop of cotton, the fertilizer treatment gave significant increase in the yield of seed cotton over no fertilizer. The highest yield of 23-42 qha⁻¹ cotton was recorded in cultivar NHH-44 followed by PA-32. The P-content in plant at different stages of growth from 70-150 days after sowing was significantly correlated with yield and seed cotton.

Ahmed (1989) studied that urea ammonium nitrate was applied to cotton through a drip irrigation for maximum yield. The lower N rates were sufficient for the yields obtained, although plant N uptake and dry matter production were increased. The levels of petiole nitrate-N for N sufficiency and deficiency which are accepted for furrow irrigated cotton were shown to apply to drip irrigated cotton.

Jain *et al.* (1990) studied in 2 years field trials (1985-86) with groundnut grown on a clay soil. Increasing P rates increased P and K uptake and seed protein and oil content. P and K uptake and protein content were highest with 25 kg kha⁻¹ and oil content with 50 kg k ha⁻¹.

Kapoor *et al.* (1990) observed that inoculation of phosphate solubilizing fungus. *Aspergillus acoamori* during composting was found to be better over ordinary compost in yield and P uptake in field trails conducted with wheat as a test crop.

Prasad and Rokima (1991) studied the transformation of N applied as manures and blue green algae to a calcareous soil was investigated. All fraction of N except. NO₃ and hexose amine – N increased with increasing doses of NPK with or without manures. Exchangeable, hydrolysable and available were significantly correlated with yields and N content and uptake by rice and wheat.

Mondal *et al.* (1993) reported the field trial in the winter season of 1989-91 on sandy loam soils at Kalyani, West Bengal, Potatoes cv. Kafri Badshah were given 100 or 75 per cent of the recommended NPK fertilizer rates 100 + 100 + 100 kg NPK with P as single superphosphate (containing S) or diammonium phosphate (S free). Uptake of NPK and was highest with 100 per cent of the recommended NPK rates with P as single superphosphates.

Pasricha *et al.* (1995) reported that on Gurdaspur loam soil. Pigeonpea showed significant response to direct application of P upto 40 kg P₂O₅ ha⁻¹ in plots where previous wheat crop did not receive any fertilizer P however, in plots where wheat was fertilized with recommended level (60 kg P₂O₅ ha⁻¹). The following pigeonpea crop did not respond to any fresh application of P. A significant and consistent field and P uptake.

Dubey and Gupta (1996) revealed that the reduction in NPK fertilizer consumption due to decontrol of chemical fertilizer widened the NPK ratio. The use of FYM and compost is in practice but the use of biofertilizer and other waste has yet to become popular as a cost effective and eco-friendly supply system.

Dubey (1996) studied with soybean under rainfed condition (1991-96) vertisols. Seed total dry matter yield and P content increased with use of *Pseudomonas Striata* with superphosphate.

Tilk and Singh (1996) reported that phosphorus solubilizing microorganism are broad spectrum biofertilizer effective for cereals, legumes and vegetables. This bioinoculant solubilises inert phosphorus sources increase yield of crops by 10 to 30 % and supplement phosphatic fertilizer by about 30 kg P₂O₅ ha⁻¹).

Dubey (1997) conducted a field experiment (1991 and 1992) co-inoculation of *Bradyrhizobium Japonicum* and phosphate solubilizing bacteria *Pseudomonas striates* along with superphosphate increased the nodulation, shoot weight, N content at 60 days N₂ fixation, total P contents seed yield and phosphorus use efficiency of soybean.

Malavia *et al.* (1997) conducted a field experiment on groundnut crop. Phosphorus through fertilizer did not exert their significant effect on pod yield, haulm yield and P uptake. Seed inoculation with *Pseudomonas striata* recorded

higher pod yield, haulm yield, P uptake by pod and haulm and P content in soil after harvest in both the years and in pooled results over no inoculation.

Santhy *et al.* (1998) reported the long term effect of manures and finger millet maize cowpea in a rotation and nutrient uptake by crops are being studied in Coimbatore since 1972. Application of FYM along with NPK increased the crop yield and nutrient uptake by the crops and enhanced the nutrients status.

Biswas *et al.* (1998) studied acidulation effect on finely ground phosphate rock from Mussorie, Udaipur and Purulia and a sample from Carolina (USA) were acidulated to 25, 50 and 75 per cent of full acidulation with H_2SO_4 and H_3PO_4 yield and P uptake by cowpea and wheat increased significantly with increasing level a given degree of acidulation were less efficient to the direct crop of cowpea in respect of their dry matter yield and 'P' uptake than those prepared with H_3PO_4 .

Sharma *et al.* (1988) studied the effect of phosphorus on yield and uptake of nutrient in different parts of cotton plant at different stages of growth. Phosphorus application @Q 15 kg P_2O_5 ha⁻¹ resulted significant increase in seed cotton yield during the consecutive stage. Total P uptake was observed directly proportional with the increasing levels at all the three stages of growth of the total uptake of P 9.94 to 15.42 per cent took place at squaring stage dominated by leaf and 25.42 to 43.42 per cent at flowering stage dominated by leaf.

5. Role of PSB inoculation in increasing P availability in soils :

Mathur *et al.* (1986) reported that paddy straw compost by enriching with rock phosphate and inoculated with P solubilising organisms was found to be superior in yield and P uptake in wheat over rock phosphate alone.

// Gaur, (1998) reported that combine use of an efficient P solubilising microorganism and low grade rock phosphate can add about 30 to 35 P_2O_5 ha⁻¹.

Tiwari *et al.* (1988) reported that phosphocompost prepared by composting rice straw with MRP and P solubilizer increases both citrate and water soluble P and this enriched compost found to be better source of P for green gram as compared to SSP.

Kapoor *et al.* (1990) observed that inoculation of phosphate solubilizing fungus, *Aspergillus awamori* during composting was found to be better over ordinary compost in yield and P uptake in field trials conducted with wheat as a test crop.

//Gupta *et al.* (1992) concluded that use of phosphorus solubilising bacteria may help in solubilizing insoluble P and accelerate rhizobial activities which in turn may increase soybean yield.

Saravanan and Nambisan (1994) reported in a field experiment in 1991-92 at Kodaikanal Tamil Nadu, peas Cv. Bonneville received various combination of N and P_2O_5 each 0, 50, 100 or 150 kg ha⁻¹ with or without seed inoculation with Rhizobium or soil inoculation with phosphobacterium. Mean pod yield was highest (6.55 t ha⁻¹) with 100 kg N + 150 kg P_2O_5 + soil inoculation with phosphobacterium.

// Thiageswari and Perumal (1995) conducted a field trial at Coimbatore on calcareous black soil to study the effect of two sources of phosphorus. Single superphos (GP) either with or without GP. Three levels of P O, 20 and 40 kg P_2O_5 ha⁻¹, Vermicompost and phosphobacteria (PB) were used. The grain yield, available P, P uptake in blackgram and kapas yield, available P and uptake by cotton were recorded. The result revealed that the yield available P and P uptake

were highest for the treatment combination of 40 kg P_2O_5 ha⁻¹ as GP with Vermicompost and PSB.

Detroja *et al.* (1997) conducted a field experiment during summer season of 1992 and 1993. Pooled results indicated that levels of phosphorus did not exert their significant effect on growth characters, yield attributes and pod and haulm yields of groundnut. Significantly higher pod weight/plant, pod and haulm yield were observed where seeds were inoculated with phosphobacteria. Large seed size was found significantly superior to all other size for all the growth characters, yield attributes and pod and haulm yields of groundnut.

Mali *et al.* (1998) conducted a field study on soybean crop on Vertisols at University research farm ARS, Kota. The results revealed that bacteriazation of Vertisols with Rhizobia and phosphorus solubilising bacteria (PSB) in conjunction with N and P fertilizer is beneficial for enhancing soybean productivity. An economy of about 25 per cent of N and P chemical fertilizers could be made by use of Rhizobia and PSB cultures respectively.

Sreenivasan *et al.* (1998) carried out an experiment on greengram with the main treatments were two phosphorus sources i.e. rock phosphate (R) and superphosphate were three levels i.e. 0, 25 and 50 kg P_2O_5 ha⁻¹ (R_0 , R_1 , R_2 , S_0 , S_1 , S_2). The sub-treatments were with and without PSM (phosphorus solubilising microorganism) inoculation (V_1 & V_0). The results reported that inoculation of greengram with PSM offers a viable method for better utilization of added and native phosphorus in soil. Also it has shown that the rock phosphate can be used as a source of phosphorus for green gram and its efficiency can be increased with PSM inoculation.

Karad *et al.* (1998) revealed that the treatment 100 per cent MRP + Biophos gave significant higher pod yield of summer groundnut. The higher response was observed in treatment of 100% MRP + Biophos followed by 75 per cent MRP + Biophos over the control. The Biophos treatments increased the availability of phosphorus in the soil.

Yengade and Ghonsikar (1998) studied phosphorus availability in soil on which sunflower crop was grown in *kharif*, *rabi* and summer season with the help of P and S using PSB culture. They reported that the availability of P and S was significantly at higher doses of P_2O_5 and SO_4 with PSB inoculation over no PSB treatment.

6. Quality :

Gururaja (1983) reported higher oil content in sunflower inoculated with *Glomus fasciculatum*, *penecillum glaucum* and *azotobactor croococcum*.

Kim *et al.* (1987) found that application of 100 kg N + 40 kg P_2O_5 + 50 kg K_2O ha⁻¹ was positively correlated with number of fruiting branches, yield, boll weight and lint percentage. The number of fruiting branches were positively correlated with number of bolls/plant yield of boll weight.

Sawan *et al.* (1988) observed that protein content increased with increased N and P fertilizer but had no significant effect on seed oil properties.

Rajinder Singh *et al.* (1988) reported that direct application of phosphorus to cotton did not have any effect on seed cotton yield. Phosphorus application did not have any effect on no. of bolls/ plants, boll weight, however plant weight was found to be increased with increasing phosphorus levels.

Jain *et al.* (1990) studied in 2 year field trails (1984-85) with groundnuts grown on clay soil (Vertisol) containing 10 kg available P and 399 kg available K/kg soil, applying 0, 4.4, 8.8 or 13.2 kg P ha⁻¹ gave average pod yields of 0.99, 1.04, 1.22 and 1.30 t ha⁻¹ respectively. Yield increased from 1.01 to 1.18 t ha⁻¹ with 25 kg k ha⁻¹ and were not further increased with 50 kg k ha⁻¹. Increasing P rates increased P and K uptake and seed protein and oil contents. P and K uptake and protein content were highest with 25 kg k ha⁻¹ and oil content with 50 kg k ha⁻¹.

Pandurangi *et al.* (1992) found that with application of N and P in combined form increased oil yield in cotton.

Nirmalnath and Sreenivasa (1993) studied sunflower plant in pot inoculated with *Glomus fasciculatum* and *Pseudomonas striata* at different P levels and sources of P and found that combined inoculation significantly increased plant height, dry biomass, seed yield, oil content and shoot P concentration through all these parameters increased with increase in level of P in both.

Brar *et al.* (1993) found that nitrogen fertilizer increased plant height number of bolls/ plant and boll weight of cotton.

Virendra *et al.* (1994) reported that the twelve rates of organic manures and N as main plots, with 4 levels of P as subplots, were tested in a split plot field trail with *B. Campestris var, toria* and *B. napas* intercropped during the winter of 1988-89 on a loamy sand soil with a low N and P status. Organic manures and N rates of up to 150 kg applied in equal splits increased the seed protein content of the crops. P application increased oil and protein contents.

Yengade and Ghonsikar (1997) conducted a field experiment during *kharif*, *rabi* and summer (1994-95). The levels of phosphorus (0, 30, 60 and 90 kg P₂O₅ ha⁻¹) through DAP with and without PSB (biophos) culture inoculation to seed as main

plot treatment and three levels of sulphur (0, 20 and 40 kg ha⁻¹) through elemental sulphur at Agricultural Research Station, Badnapur. Oil content in sunflower seed was influenced significantly due to varied levels of P in all the seasons. Maximum oil content (34.59 per cent) obtained was in summer which slightly decreased in *rabi* and lowest (31.0 per cent) in *kharif*. PSB inoculation did not influence oil quantity parameters.

Detroja *et al.* (1997) conducted a field experiment during summer season of 1992 and 1993. Pooled results indicated that levels of phosphorus did not exert their significant effect on growth characters, yield attributes and pod and haulm yield of groundnut. Significantly higher pod weight/ plants pod and haulm yield were observed where seeds were inoculated with phosphobacteria.

***MATERIALS
AND
METHODS***

CHAPTER – III

MATERIALS AND METHODS

The details of materials used and methods adopted for the conduct of experiment are described in this chapter at appropriate heads.

3.1 Details of the experiment :

3.1.1 Experimental site :

The field experiments were conducted at soil science and Agricultural Chemistry Departmental farm, Marathwada Agricultural University, Parbhani during kharif season of 1998-99. Topography of the experimental plot was fairly leveled. The soil was medium deep, well drained and calcareous, developed over weathered basalt. About 20 surface soil samples (0-20 cm) were taken from various randomly selected spots all over the experimental area before the conduct of experiment. A composite soil samples was prepared and it was analyzed for various physio-chemical properties. The relevant data are presented in Table-1.

3.1.2 Climate :

Geographically Parbhani is situated in 409 m altitude, 19°, 16' North latitude and 76 °, 47' East latitude. It has tropical climate, the area comes under semiarid tropics. The average precipitation was 1123 mm in 1998-99. The average temperature maximum and minimum 31.73 °C and 20.99 °C respectively. The humidity recorded was maximum and minimum 78.8 per cent and 49.58 per cent respectively. The rainfall during the year (1998-99) of experimentation was more than average by one and half.

3.1.3 Geology :

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On the basis of morphology, soil depth and texture the experimental soil was identical to that of Parbhani series (Typic Chromustert) as classified by Malewar (1976). The black soils of Parbhani are formed from weathering of trap rock rich in Fe and Mn. Black soils are formed as weathered products of basalts and also metamorphic rock transported down by stream as alluvium deccan basalt's uncomfortable overlies all the pretrapian formation, ranging age from Archeans to Iomets and during the multicule erosion disruption land steps of the order formation of Sathpuda, Ajanta and Myhi, rocky hills and terren. According to Vidya and Joshi (1972), soils of Parbhani are brown to black in colour with adequate content of calcium carbonate.

3.1.4 Previous cropping history :

The previous cropping of experimental plot was jowar in *kharif* and wheat in *rabi* during the year 1997-98.

3.1.5 Experimental layout :

The experiment was laid out in randomized block design with 12 treatments and three replications.

Treatment

- | | | |
|----------------|---|---|
| T ₁ | - | Control (No. manures and fertilizers) |
| T ₂ | - | 100% recommended P through chemical fertilizer |
| T ₃ | - | 100% recommended P through PMC. |
| T ₄ | - | 75% recommended P through fertilizer + PSB |
| T ₅ | - | 75% recommended P through fertilizer + 25% FYM + PSB. |
| T ₆ | - | 75% recommended P through MRP + 25% FYM + PSB. |
| T ₇ | - | 75% recommended P through PMC + 25% FYM + PSB. |

- T₈ - 50% recommended P through fertilizer + 50% MRP + PSB.
 T₉ - 50% recommended P through fertilizer + 50% PMC + PSB.
 T₁₀ - 50% recommended P through MRP + 50% PMC + PSB.
 T₁₁ - 50% recommended P through MRP + 50% FYM + PSB.
 T₁₂ - 50% recommended P through PMC + 50% FYM + PSB.

Plan of layout

- Design : Randomised Block Design
 Treatments : Twelve
 Replications : Three
 No. of plots : Thirty six
 Plot size :
 Gross : 4.5 x 3.6 m.
 Net : 3.6 x 2.7 m

3.1.6 Other details of the experiment :

1. Crop : Cotton
2. Variety : NHH-44
3. Spacing :
 - i) Row to Row : 90 cm
 - ii) Plant to plant : 60 cm
4. Year of conduct : Kharif 1998-99

3.1.7 Seed and sowing :

The certified seed of cotton (NHH-44) was sown in *kharif* on 15th July, 1998 by dibbling at the seed rate 18.45 g/ha⁻¹. The crop was sown late due to non receipt of sufficient rains.

3.1.8 Date of harvesting :

Seed cotton was picked at different dates as the bolls found fully opened.

3.1.9 Fertilizer and manuring material :

Urea (46 per cent N), single superphosphate (16 per cent P_2O_5) Muriate of potash (60 per cent K_2O) Rock phosphate (18-20 per cent P_2O_5), Pressmud compost (3 per cent P_2O_5), Pressmud cake (2.4 per cent P_2O_5) FYM (0.2 per cent P_2O_5) and phosphorus solubilizing bacterial seed inoculation was done by adopting standard procedure. Quantity of P.M. cake, P.M. compost, MRP and FYM were added on P equivalent basis. Recommended dose of nutrients (80 : 40 : 40 NPK kg ha⁻¹) were applied to cotton crop in *kharif*. Half dose of nitrogen and full dose of phosphorus and potassium were applied at the time of sowing and remaining half dose of nitrogen as top dressing after 30 days of sowing. Phosphorus was applied through different organic sources 15 days before sowing and were thoroughly mixed in soil manually.

3.1.10 Cultural operations :

The cultural operations such as gap filling, thinning, weeding, spraying of insecticides / pesticides as per the recommendations. The seed cotton was picked after the attainment of maturity as and when bolls observed fully opened.

3.2 Methods of soil analysis :

3.2.1 Collection and preparation of soil samples :

Surface soil samples (0-20 cm depth) were collected at square formation, 50% flowering stage as well as at harvest from each plot. The soil samples were thoroughly mixed, air dried, ground with wooden pestle and mortar and passed through 2 mm, sieve. The sieved soil samples were stored in cloth bags with proper label for further analysis.

3.2.2 Soil reaction (pH) :

Soil pH was determined using 1:2.5 (soil : water) suspension by using pH meter with glass electrode as described by Piper (1966).

3.2.3 Electrical conductivity (Ec) :

Electrical conductivity in 1:2.5 (soil : water) suspension was measured with the help of conductivity meter is given by Jackson (1967).

3.2.4 Calcium carbonate (CaCO₃) :

It was estimated by Puri's (1949) method using Bromothymol blue and Bromocresol green as an indicator.

3.2.5 Organic carbon :

Modified method of Walkley and Black as described by Jackson (1967) was used for estimation of organic carbon.

3.2.6 Available nitrogen :

It was determined by distilling soil with alkaline potassium permanganate solution as described by Subbaih and Asija (1956).

3.2.7 Available phosphorus :

The soil was extracted with 0.5 N sodium bicarbonate solution and phosphorus was estimated as per method suggested by Olsen *et al.* (1954).

3.2.8 Available potassium :

The soil was extracted with neutral normal ammonium acetate as an extractant and K in the extract was determined by using flame photometer (Piper, 1966).

3.3 Methods of plant and grain analysis :

Collection of plant and grain samples. The plant samples from each plot were randomly selected at growth stages like square formation, 50 per cent flowering and maturity and removed without any damage to the plant. The plant roots were cleaned by tap water. After cleaning the plants were air dried under shade and oven dried at 80°C for 12 hours. Simultaneously cottonseed from each plot after harvest were collected and stored seeds were separated from lint. The plant and seed cotton were ground separately in an electrically operated grinder with stainless steel blades upto maximum fineness. The ground samples were stored in polythene bags with proper labeling for further analysis.

3.2.3 Preparation of acid extract :

One gram fine powder of dry matter or grain samples was taken in conical flask and digested with tri-acid mixture (HNO_3 , H_2SO_4 and HClO_4 in 10:1:4 ratio). After complete digestion the content was cooled and filtered in volumetric flask by washing with hot distilled water until filtrate become free of acid and 100ml volume was made. The extract was used for determination of phosphorus and potassium. The nitrogen content from plant and seed cotton was determined by taking 0.5 gm sample added 10 ml of H_2SO_4 , catalyst mixture were used for digestion and volume made to 100 ml. The extract was used for nitrogen analysis on Microkjeldahl set.

3.3.3 Nitrogen content :

The nitrogen content in dry matter and seed cotton was determined by Kjeldahl method (Piper, 1966).

3.3.4 Phosphorus content :

The phosphorus content in dry matter and seed cotton was estimated colorimetrically by Vanadomolybdate phosphoric acid yellow colour method (Jackson, 1967).

3.3.5 Potassium content :

The potassium content in dry matter and seed cotton was determined on flame photometer as suggested by Jackson (1967).

3.4 Uptake of nutrients :

The uptake of N, P and K (kg ha^{-1}) were computed by multiplying the respective nutrient content in seed cotton and dry matter with per hectare yield.

3.4.1 Efficiency :

Efficiency of treatments was theoretically calculated from total dry matter, seed protein and uptake of nutrient at squaring, 50% flowering and maturity stage of cotton crop by using the formula given below.

$$\text{Phosphorus use efficiency} = \frac{\text{Uptake in treatment} - \text{Uptake in control}}{\text{Quantity of P added in soil}} \times 100$$

3.5 Balance sheet of nutrients in soil :

The balance sheet of nutrients (net gain or loss) were worked out by subtracting final nutrient status (after harvest) from the initial nutrients status (before sowing) in soil.

3.6 Post harvest studies :

After maturity, the experimental crop was harvested and seed cotton yield per plot was recorded. The seed cotton was stored in paper bags.

After harvesting, the plants were harvested from each plot and sun dried for one week and dry weights of the stalk were recorded per plot.

3.7 Oil content :

Seed cotton was separated for seed and lint. The cotton seeds were subjected for oil content on NMR (Instrument).

3.8 Statistical analysis :

Results obtained were statistically analysed using the methods given in “Statistical method for Agricultural workers” by Panse and Sukhatme (1961). Appropriate standard error (SE) were worked out and critical differences (CD) at 5 per cent level were recorded whenever necessary.

Table 1a : Physio chemical properties of the experimental soil

	Character	Values
P	A. Mechanical composition	
1.	Course sand (%)	6.46
2.	Fine sand (%)	16.12
3.	Silt (%)	24.05
4.	Clay (%)	53.36
	Textural class	Clay
	B. Fertility constituents	
1.	Organic carbon (%)	0.51
2.	pH (%)	8.2
3.	Ec (1:2) dsm ⁻¹	0.38
4.	CEC Cmol (P+) kg ⁻¹	48.62
5.	Free CaCO ₃ (%)	4.43
6.	Total nitrogen (%)	0.049
7.	Total phosphorus (%)	0.039
8.	Total potassium (%)	0.048
9.	Available nitrogen (Kg ha ⁻¹)	274.72
10.	Available phosphorus (Kg ha ⁻¹)	17.68
11.	Available potassium (Kg ha ⁻¹)	305.00

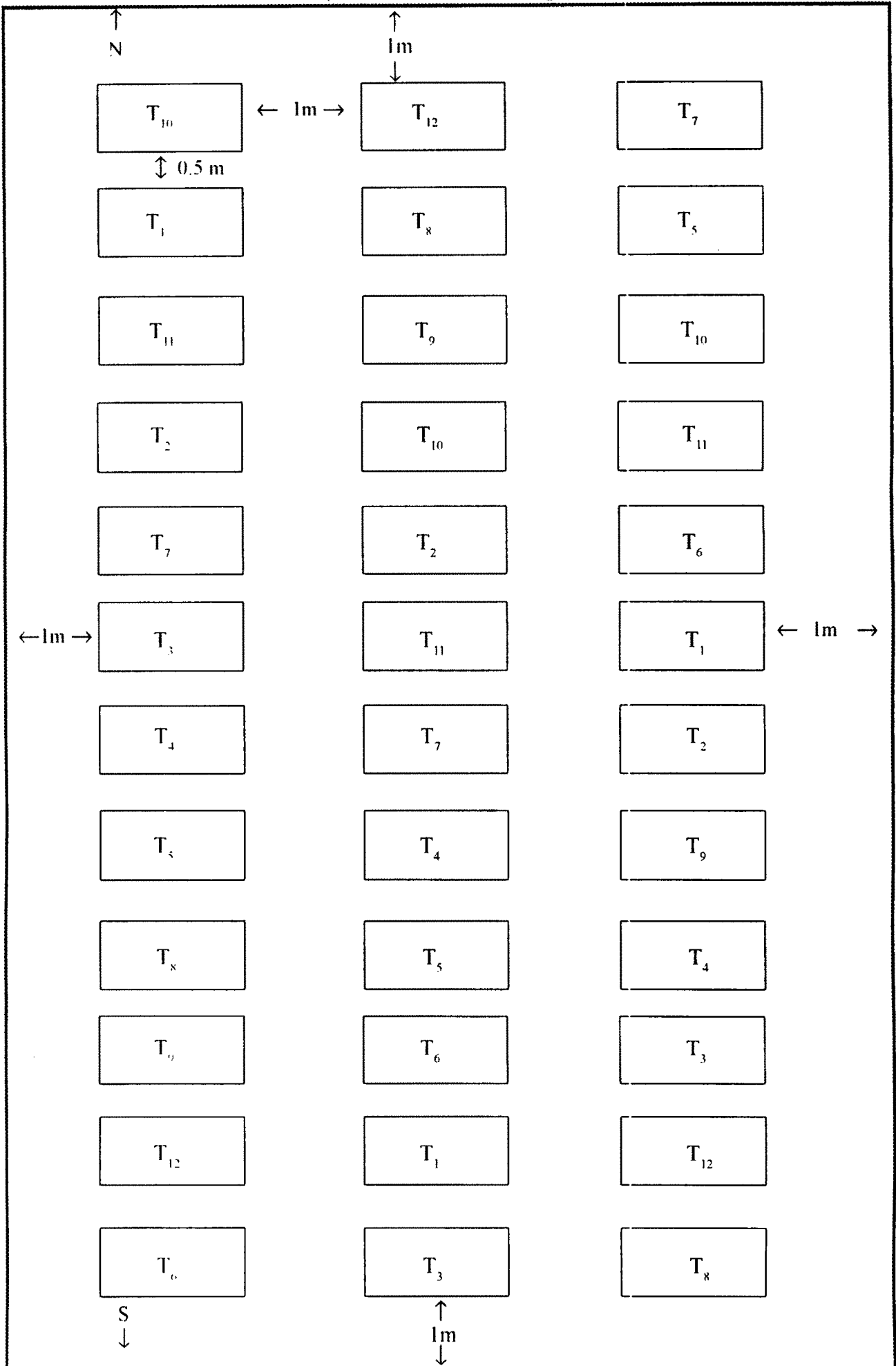
Table 2a : Meteorological weekwise data recorded during experimental period (kharif 1998)

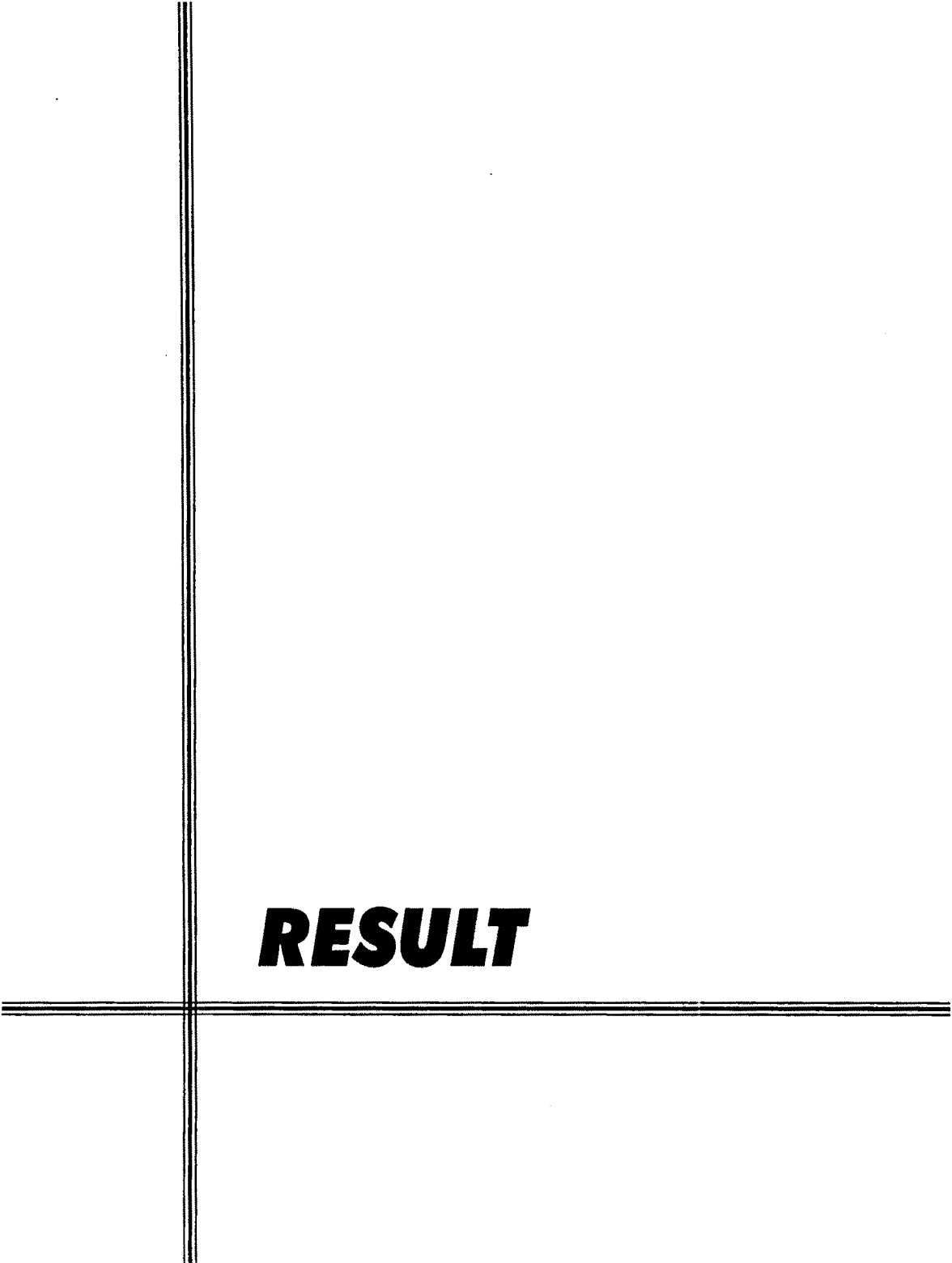
Date & months	Meteo- rological week no.	Rainfall (mm)	Temp (^o C)		Humidity (%)	
			Max	Min	A.M.	P.M.
June 1998	24	93.3	32.8	23.8	84	51
	25	32.0	33.9	23.7	85	54
	26	37.2	33.9	23.7	85	54
	27	10.0	31.0	23.8	84	64
	28	6.4	33.1	23.2	82	56
July	29	1.0	33.3	23.3	82	51
	30	253.8	32.7	23.7	86	62
	31	173.8	28.8	22.3	92	78
August	32	116.6	29.5	23.4	92	78
	33	18.0	30.3	23.3	84	68
	34	133.9	31.2	22.9	91	73
	35	28.4	30.6	22.8	86	69
	36	124.7	31.0	23.0	89	68
September	37	24.5	30.0	23.0	88	76
	38	123.0	30.0	22.0	89	67
	39	27.0	31.8	22.6	90	70
	40	32.6	30.8	22.1	85	63
	41	86.0	29.8	22.6	89	73
October	42	107.0	28.9	19.9	91	68
	43	1.0	30.0	19.2	85	65
	44	4.6	30.8	19.5	76	58
	45	22.0	29.6	20.0	78	58
November	46	0.0	29.6	16.6	74	44
	47	0.0	29.6	13.7	80	39
	48	0.0	28.9	9.9	78	29
	49	0.0	29.7	9.7	74	28
December	50	0.0	28.4	8.4	77	27
	51	0.0	27.8	8.4	77	29
	52	0.0	27.4	6.9	77	27
January	1	0.0	28.0	7.8	80	30
	2	0.0	26.2	6.9	71	30
	3	0.0	28.7	9.0	78	29
	4	0.0	30.6	11.0	74	28
	5	0.0	30.5	11.7	74	27
February	6	0.0	31.5	12.6	76	29
	7	0.0	32.0	14.7	77	36
	8	0.0	34.5	14.7	66	31
	9	0.0	35.5	15.8	69	29
Mean	-	-	-	-	-	-

Note : C.R. = Cumulative Rainfall (mm)

EXPERIMENTAL LAYOUT

(Randomised Block Design)





RESULT

CHAPTER – IV

RESULTS

The present experiment was conducted ^{on Cotton crop (var. NH4-44)} in *Kharif* 1998-99 at Agricultural College Farm of Parbhani to evaluate the influence of organic manures and mineral fertilizer singly or in combination with and without phosphate solubilising bacterial culture and inorganic fertilizers and soil fertility status. Cotton crop responded well to phosphorus application in central India. However added P gets ~~fixed~~ in swelling clay soils due to alkaline in nature. Majority of soil are unable to furnish sufficient quantities of P for high yield on a sustained basis. The result obtained during experimentation are presented in this chapter under appropriate heads as under :

- 4.1 Available N, P_2O_5 and K_2O at different growth stages.
- 4.2 Chemical properties of soil at different growth stages.
- 4.3 Yield and yield attributes
- 4.4 Quality of cotton seed.
- 4.5 N, P and K concentration at different growth stages.
- 4.6 Uptake of N, P and K by plant at different growth stages.
- 4.7 Phosphorus use efficiency at different growth stages.
- 4.8 Phosphate balance sheet in soil at maturity.

Table 1 : Available N (kg ha⁻¹) at different growth stages of rainfed cotton as influenced by the treatments

Treatment	Stages		
	Square	50% flowering	Maturity
T ₁	265.05	260.01	250.01
T ₂	327.07	333.32	303.32
T ₃	316.97	325.24	315.03
T ₄	323.20	329.28	318.07
T ₅	335.12	353.86	327.86
T ₆	330.05	339.12	324.12
T ₇	333.25	347.78	319.00
T ₈	316.08	315.98	310.07
T ₉	319.08	315.63	310.01
T ₁₀	308.06	318.18	303.08
T ₁₁	317.38	309.20	295.44
T ₁₂	310.06	313.52	287.30
SE $\pm$	5.381	4.711	6.641
CD (at 5%)	15.75	13.79	19.45
Mean	316.78	322.20	305.61

4.1 Available nutrients at growth stages :

4.1.1 Available N :

Available N at different growth stages of rainfed cotton was estimated and results are given in Table1. It was seen that the status of available N was increased at 50% flowering and it was decreased at maturity stage in all the treatments. There was maximum ($335.12 \text{ kg ha}^{-1}$) available N was determined with the application of 75 per cent recommended P_2O_5 through inorganic fertilizer and 25 per cent FYM with PSB inoculation (T_5) followed by T_7 ($333.25 \text{ kg ha}^{-1}$) and lowest was at T_1 (control) at square formation. The treatment T_2 , T_3 , T_4 , T_5 , T_6 , T_7 were at par. However, these were significantly superior over control.

The available N at 50% flowering of cotton (Table 1) indicated that there was highest ($353.86 \text{ kg ha}^{-1}$) amount of available N with the application of 75 per cent recommended P_2O_5 through inorganic fertilizer and 25 per cent FYM with PSB inoculation (T_5) followed by T_6 ($339.12 \text{ kg ha}^{-1}$). There were significant differences in available N in all the treatment over control. However the T_8 , T_9 , T_{10} , T_{11} and T_{12} were at par and significantly inferior over remaining treatments.

The data on available N (Table1) at maturity showed that maximum N $327.86 \text{ kg ha}^{-1}$ was recorded ($318.07 \text{ kg ha}^{-1}$) T_5 followed by T_6 ($324.12 \text{ kg ha}^{-1}$). The treatments viz. T_3 , T_4 , T_5 , T_6 , T_7 , T_8 and T_9 were at par. While all these were significantly superior over T_1 , T_2 , T_3 and T_{10} . The available N in all the treatments were significantly superior over control. It was found that treatment T_5 was highly significantly over all the treatments at all the growth stages of the crop.

Table 2 : Available P_2O_5 (kg ha⁻¹) at different growth stages of rainfed cotton as influenced by the treatments

Treatment	Stages		
	Square	50% flowering	Maturity
T ₁	15.05	12.05	9.96
T ₂	25.07	26.18	23.07
T ₃	20.70	24.65	19.60
T ₄	22.34	24.54	20.43
T ₅	30.43	33.44	29.03
T ₆	26.67	27.68	24.07
T ₇	28.19	30.20	27.90
T ₈	19.07	21.99	18.09
T ₉	19.90	22.17	20.28
T ₁₀	24.70	28.17	22.13
T ₁₁	22.90	25.30	17.50
T ₁₂	21.07	23.72	19.25
SE $\pm$	0.786	1.356	0.850
CD (at 5%)	2.301	3.973	2.489
Mean	23.008	25.012	20.943

4.1.2 Available P_2O_5 :

Results on available P_2O_5 at different growth stages of cotton was significantly influenced due to the application of P_2O_5 through different sources over control in all the growth stages (Table 2). It was observed that there was increase of available P_2O_5 at 50% flowering of the crop and it was declined at maturity stage in all the treatments.

Available P_2O_5 was recorded maximum (30.43 kg ha^{-1}) T_5 (75 per cent recommended P_2O_5 through inorganic fertilizer and 25 per cent FYM with PSB inoculation) followed by T_7 (28.19 kg ha^{-1}) and lowest at control (T_1). There were significant differences on available P_2O_5 with the application of P_2O_5 through 100 per cent recommended P_2O_5 through pressmud compost (T_3) and T_4 (75 per cent recommended P_2O_5 through fertilizer and PSB) over T_8 , T_9 while T_3 , T_4 were at par and T_8 , T_9 were also at par with each other.

The data on available P_2O_5 (Table 2) indicated that there was maximum (33.44 kg ha^{-1}) was estimated with the application of 75 per cent P_2O_5 through fertilizer + 25 per cent FYM with PSB inoculation (T_5). Among the application of manures in combination with FYM showed highest availability of P_2O_5 over all other treatments receiving organic manures (T_5) followed T_7 . The treatments T_2 , T_3 , T_4 and T_9 were at par. The treatment receiving 50 per cent MRP + 50 per cent PMC + PSB recorded available P_2O_5 superior over 100 per cent P_2O_5 significantly applied through PMC (T_3).

It is revealed from the data given in Table 2 indicated that the available P_2O_5 was estimated highest (29.03 kg ha^{-1}) followed by T_7 (27.90 kg ha^{-1}) with the application of 75 per cent recommended P_2O_5 through fertilizer + 50 per cent P_2O_5 through PMC + PSB were at par and significantly superior over control. It was seen

Table 3 : Available K₂O (kg ha⁻¹) at different growth stages of rainfed cotton as influenced by the treatments

Treatment	Stages		
	Square	50% flowering	Maturity
T ₁	293.00	287.00	280.00
T ₂	372.00	379.03	370.00
T ₃	364.00	370.01	362.03
T ₄	370.00	373.40	365.00
T ₅	401.82	455.30	399.10
T ₆	378.08	382.10	374.09
T ₇	396.70	399.50	391.03
T ₈	355.09	360.07	351.07
T ₉	363.07	367.90	361.06
T ₁₀	343.03	348.01	339.00
T ₁₁	348.04	360.10	344.07
T ₁₂	351.90	363.06	347.30
SE $\pm$	6.693	5.950	4.958
CD (at 5%)	19.60	17.42	14.52
Mean	353.06	379.46	356.98

that there was increase in available P_2O_5 at advance growth of the crop (50% flowering) and lowered at maturity in all the treatments. There was maximum and same influence of treatment receiving 75 per cent P_2O_5 through fertilizer + 25 per cent FYM + PSB (T_5) and same trend was recorded by T_7 at all the growth stages of the crop.

4.1.3 Available potassium :

Scrutiny of the mean data on available K_2O at different stages of cotton presented in Table 3 indicates the varying range from 293.00 (T_1) to 401.82 $kg\ ha^{-1}$ (T_5) of available potassium at squaring stage. There was highest availability of potassium 401.82 $kg\ ha^{-1}$ at the treatment receiving 75 per cent recommended P_2O_5 through fertilizer + 25 per cent FYM + PSB (T_5) and it was at par with T_7 . There were significant differences in between T_5 over T_{12} and remaining treatments were at par.

The data on available K_2O at 50% flowering (Table 3) revealed that the maximum amount of K_2O was estimated maximum (455.30 $kg\ h^{-1}$) at T_5 followed by T_7 and lowest (287.00 $kg\ ha^{-1}$) in control (T_1). The treatments T_2 , T_3 , T_4 , T_6 , T_8 , T_{10} , T_{11} and T_{12} were at par.

The amount on available K_2O (Table 3) in soil at maturity stage of cotton reveals that it was recorded highest at T_5 (399.10 $kg\ ha^{-1}$) followed T_7 (391.03 $kg\ ha^{-1}$) and least at T_1 (280.00 $kg\ ha^{-1}$). The available K_2O ranges from 280 (T_1) – 399.10 $kg\ ha^{-1}$ (T_5). The available K_2O recorded was significantly higher over control and the treatment T_2 , T_3 , T_4 , T_9 were at par.

It was observed that there was increase in available K_2O at 50% flowering and decline at maturity in all the treatments. It is surprise to note that there was

Table 4 : Soil pH at different growth stages of rainfed cotton as influenced by the treatments

Treatment	Stages		
	Square	50% flowering	Maturity
T ₁	8.19	8.19	8.09
T ₂	8.02	7.99	7.85
T ₃	7.92	8.02	7.88
T ₄	7.96	7.97	7.62
T ₅	7.76	7.74	7.78
T ₆	7.93	7.95	7.79
T ₇	7.80	7.89	7.79
T ₈	8.06	8.06	7.90
T ₉	7.96	8.03	7.90
T ₁₀	7.46	8.16	8.35
T ₁₁	8.13	8.17	8.05
T ₁₂	8.06	8.10	7.94
SE $\pm$	0.1278	0.0266	0.1346
CD (at 5%)	0.3744	0.0779	0.3943
Mean	7.94	8.02	7.91

decreasing magnitude of available K_2O as $T_5 > T_7 > T_6 > T_2 > T_5 > T_3 > T_9$ in all the growth stages of crop.

4.2 Chemical properties of soil at different growth stages :

4.2.1 pH :

It would be seen from the data (Table 4) on pH at different growth stages of cotton observed that there was decreasing trend from square to 50% flowering and maturity stage except T_{10} (50 per cent recommended P_2O_5 through MRP + 50 per cent PMC + PSB). However, mean value of soil pH was increase from 7.94 to 8.02 at square and 50% flowering respectively.

There was maximum reduction in soil pH (7.46) at T_{10} followed by T_5 (7.76). The pH was significantly reduced in treatments T_5 , T_7 and T_{10} over all other treatment at square stage (Table 4).

It was seen that at 50% flowering there was maximum reduction in soil pH at T_5 followed by T_7 . While T_5 and T_7 were significantly influenced in the reduction of soil pH over all other treatments. T_3 , T_8 , T_9 were at par and significantly reduced soil pH over control (T_1).

pH of the soil determined at maturity stage of cotton was found to decrease at T_{12} (50% recommended P_2O_5 through PMC + 50% recommended P_2O_5 through FYM + PSB). The treatments T_1 , T_2 , T_3 were at par and significantly lower than all other treatments. In general, it was observed that application of organic manures in combination with inorganic fertilizer showed decrease in soil pH over control (T_1).

Table 5 : Soil EC (dSm⁻¹) at different growth stages of rainfed cotton as influenced by the treatments

Treatment	Stages		
	Square	50% flowering	Maturity
T ₁	0.403	0.407	0.410
T ₂	0.301	0.320	0.306
T ₃	0.360	0.370	0.360
T ₄	0.315	0.360	0.350
T ₅	0.260	0.210	0.273
T ₆	0.290	0.290	0.293
T ₇	0.270	0.280	0.286
T ₈	0.390	0.400	0.380
T ₉	0.370	0.380	0.370
T ₁₀	0.400	0.405	0.406
T ₁₁	0.390	0.400	0.400
T ₁₂	0.380	0.390	0.390
SE ±	0.0168	0.0299	0.0284
CD (at 5%)	0.0494	0.0876	0.0832
Mean	0.344	0.351	0.352

Table 6 : Soil CaCO₃ (%) at different growth stages of rainfed cotton as influenced by the treatments

Treatment	Stages		
	Square	50% flowering	Maturity
T ₁	3.96	3.970	3.89
T ₂	3.26	3.260	3.20
T ₃	3.46	3.460	3.32
T ₄	3.44	3.450	3.31
T ₅	3.16	3.030	3.01
T ₆	3.23	3.230	3.11
T ₇	3.11	3.110	3.01
T ₈	3.51	3.510	3.40
T ₉	3.54	3.500	3.36
T ₁₀	3.96	3.970	3.87
T ₁₁	3.96	3.960	3.83
T ₁₂	3.96	3.560	3.46
SE ±	0.171	0.152	0.0117
CD (at 5%)	0.501	0.446	0.0342
Mean	3.54	3.50	3.39

4.2.2 E_c:

The results on E_c was recorded highest at T₁ (control) followed by T₁₀ at squares stage of cotton (Table 5). While T₁, T₈, T₁₁ were at par and significantly higher over T₇ (75% recommended P₂O₅ through PMC + 25% FYM + PSB).

Electrical conductivity recorded at 50% flowering at cotton was significantly influenced by the treatments (Table 5). The maximum (0.407 dsm⁻¹) E_c was at T₁ followed by T₁₀. The T₈ and T₁₁ were at par while these were significantly higher over all other treatments except T₁ and T₁₀.

The observation of E_c at maturity stage of crop was significantly influenced due to the treatments. The E_c was recorded significantly highest at T₁ followed with the application of 50 per cent recommended P₂O₅ through MRP + 50 per cent recommended P₂O₅ through PMC + PSB and minimum value (0.273 dsm⁻¹) at T₅. In general, E_c was maximum at T₁ at all the growth stages of cotton crop (Table 5).

4.2.3 CaCO₃ :

From the data given in (Table 6) indicates that CaCO₃ content in soil at different growth stages showed decrease at 50% flowering over square stage of cotton. It was seen that there was similar magnitude of decrease as T₁ > T₁₀ > T₁₁ > T₁₂ > T₉ > T₈ > T₃ > T₄ > T₂ > T₆ at square and 50% flowering stage it was also similar decreasing trend as that of square and 50% flowering as T₁ > T₁₀ > T₁₁ > T₁₂.

CaCO₃ content in soil was significantly influenced at all the stages of crop due to the treatments. CaCO₃ content was recorded minimum at T₇ (3.11%) and T₅ (3.03%) T₇ (3.01%) at square, 50% flowering and maturity respectively.

Table 7 : Soil organic carbon (%) at different growth stages of rainfed cotton as influenced by the treatments

Treatment	Stages		
	Square	50% flowering	Maturity
T ₁	0.440	0.443	0.520
T ₂	0.551	0.554	0.568
T ₃	0.564	0.568	0.582
T ₄	0.554	0.532	0.569
T ₅	0.630	0.585	0.532
T ₆	0.570	0.574	0.568
T ₇	0.690	0.573	0.565
T ₈	0.540	0.555	0.542
T ₉	0.599	0.551	0.562
T ₁₀	0.643	0.475	0.523
T ₁₁	0.516	0.463	0.528
T ₁₂	0.689	0.561	0.548
SE $\pm$	0.0315	0.0296	0.0077
CD (at 5%)	0.0924	0.867	0.0227
Mean	0.582	0.536	0.550

4.2.4 Organic carbon :

The study on ^{reveals that} organic carbon content in soil at different growth stages of cotton (Table 7). It was significantly influenced by the treatments at all the stages of cotton. Mean values of organic carbon was reduced at 50% flowering as compared to square stage and it was again increased from 0.536 – 0.550% at maturity stage.

Organic carbon at square stage of cotton ranged from 0.44 – 0.69%. While maximum organic carbon obtained at T₇ followed by T₁₂ and significantly superior over all other treatment.

All the treatments led to the significantly different with each other in respect of organic carbon content at 50% flowering except T₈ and T₉. The mean value of organic carbon were recorded 0.443 (T₁) – 0.585% (T₅). The highest (0.585%) organic carbon was at T₅.

The observations on organic carbon in soil at maturity stage of cotton was maximum with the application of 100 per cent recommended P₂O₅ through PMC (T₃) followed by 75 per cent recommended P₂O₅ through fertilizer + PSB (T₄). The significant increase of organic carbon (0.582%) was higher at T₃ and 0.56 9% at T₄ over T₂ (100% recommended P₂O₅ through chemical fertilizer). The range of organic carbon was recorded 0.520 (T₁) – 0.582% at T₃ (100 per cent recommended P₂O₅ through PMC).

Table 8 : Bolls per plant, dry matter and seed cotton yield of rainfed cotton as influenced by the treatments

Treatment	Stages		
	Square per plant	Dry matter q ha ⁻¹	Seed cotton yield q ha ⁻¹
T ₁	14	26.74	2.31
T ₂	17	36.69	3.61
T ₃	16	34.97	2.79
T ₄	18	36.00	3.16
T ₅	20	40.11	4.07
T ₆	18	39.08	3.61
T ₇	19	39.09	3.70
T ₈	17	32.20	2.48
T ₉	18	33.90	2.56
T ₁₀	15	28.10	2.37
T ₁₁	17	28.39	2.47
T ₁₂	16	30.11	2.47
SE ±	0.5050	1.651	0.261
CD (at 5%)	1.479	4.835	0.766
Mean	17.08	33.78	2.96

4.3 Yield and yield attributes :

4.3.1 Bolls per plant :

The Table 8 depicts the data regarding the effect of different treatments on the number of mature bolls counted per plant of cotton was observed that there were significant effect of different treatments. The highest number of bolls (20) were counted with the application of 75 per cent recommended P_2O_5 through fertilizer + 25 per cent FYM + PSB followed by T_7 . The average bolls were varying from 14 (T_1) – T_3 (20). Number of bolls per plant were at par with the treatment T_2 , T_3 , T_8 , T_{11} and T_{12} . Number of bolls / plant were significantly influenced at T_5 , T_6 , T_7 and T_9 over T_2 (100% recommended P_2O_5 through chemical fertilizer).

4.3.2 Dry matter :

It is seen from the Table 8 that the total dry matter was obtained (40.11 qha^{-1}) with the application of 75 per cent recommended P_2O_5 through fertilizer + 25 per cent FYM + PSB followed by T_7 (39.09 qha^{-1}). Mean dry matter yield ranged from $26.74 - 40.11 \text{ qha}^{-1}$. The treatments T_2 , T_3 , T_4 and T_8 were at par. There were non-significant difference in between the treatment T_{10} , T_{11} and T_5 .

4.3.3 Seed cotton yield :

From the data given in Table 8 indicated that there was significant influence on the seed cotton yield due to the treatments. The highest (4.07 q ha^{-1}) weight of seed cotton was obtained with the application of 75 per cent recommended P_2O_5 through fertilizer + 25 per cent FYM + PSB (T_5) followed by T_7 (3.70 q ha^{-1}). The range of seed cotton yield recorded $2.31 - 4.07 \text{ qha}^{-1}$. The treatment T_2 , T_6

Table 9 : Oil content and protein (%) content of rainfed cotton as influenced by the treatments

Treatment	Oil content (%)	Protein content (%)
T ₁	16.18	19.06
T ₂	16.23	21.70
T ₃	16.65	21.20
T ₄	16.75	21.50
T ₅	17.70	20.90
T ₆	17.00	19.91
T ₇	17.05	20.10
T ₈	16.49	21.20
T ₉	16.58	22.75
T ₁₀	16.27	19.30
T ₁₁	16.33	21.75
T ₁₂	16.40	20.90
SE $\pm$	0.259	0.67 0
CD (at 5%)	0.760	1.962
Mean	16.63	20.95

recorded similar seed cotton yield (3.61 q ha^{-1}). However they were significantly superior over T_3 , T_8 , T_9 , T_{10} , T_{11} and T_{12} .

4.4 Quality of cotton seed :

4.4.1 Oil content :

From the results on oil content of cotton seed given in Table 9, It is seen that there was significant differences due to the treatments. The highest (17.70%) oil was obtained at T_5 (75 per cent recommended P_2O_5 through fertilizer + 25 per cent FYM + PSB) followed by T_7 . Mean values on oil content ranges from 16.18 – 17.70 per cent. There were significant differences on oil content with the application of 100 per cent recommended P_2O_5 through PMC (T_3) and 75 per cent recommended P_2O_5 through fertilizer + PSB (T_4). The treatment T_6 , T_7 , T_8 , T_{11} and T_{12} were at par.

4.4.2 Protein content :

It is clear from the data in Table 9 indicates that protein content in cotton seed was significantly influenced by the different treatments. The protein content was significantly highest (22.75%) with the application of 50 per cent recommended P_2O_5 through fertilizer + 50 per cent PMC + PSB (T_9) and lowest at T_{12} (20.90%). The protein content at the treatment T_2 , T_3 , T_4 , T_{11} and T_{12} were at par.

Table 10 : N concentration (%) at different growth stages of rainfed cotton as influenced by the treatments

Treatment	Stages		
	Square	50% flowering	Maturity
T ₁	2.430	3.00	1.880
T ₂	2.663	3.210	1.980
T ₃	2.600	3.197	1.960
T ₄	2.630	3.200	1.975
T ₅	2.730	3.250	2.006
T ₆	2.693	3.216	1.986
T ₇	2.700	3.235	1.997
T ₈	2.550	3.165	1.939
T ₉	2.580	3.177	1.951
T ₁₀	2.472	3.108	1.897
T ₁₁	2.492	3.125	1.910
T ₁₂	2.520	3.145	1.930
SE $\pm$	0.0493	0.0228	0.00333
CD (at 5%)	0.1446	0.0670	0.0976
Mean	2.588	3.169	1.950

4.5 N, P and K concentration at different growth stages :

4.5.1 N Concentration :

As apparent from the Table 10 showed the concentration of total nitrogen from cotton plant at different growth stages. It was seen that there was increase N concentration from square to 50% flowering and decrease at maturity in all the growth stages.

N content at square stage (Table 10) showed that significantly highest (2.730%) at T_5 followed T_7 and least (2.43%) at T_1 . There were significant difference in all the treatment except T_{10} .

It is clear from the data in Table 10 reveals that maximum (3.25%) N content was recorded at T_5 followed by T_7 (75% recommended P_2O_5 through PMC + 25 % FYM + PSB). The mean values ranges from 3.00–3.25 per cent. There were significant differences observed in all the treatment.

Table 10 indicates that the N content at maturity stage of cotton crop was ranged from 1.88 – 2.00 per cent. There were significant influence on N content at maturity in all the treatments.

Generally it was seen that there was decreasing magnitude of N concentration as $T_5 > T_7 > T_6 > T_2 > T_4 > T_3$ at all the growth stages of cotton.

4.5.2 P Concentration :

The Table 11 depicts the data regarding the P concentration as influenced by different treatments indicated that there was increase P content in all the treatments at 50% flowering of cotton except T_{10} .

Table 11 : P concentration (%) at different growth stages of rainfed cotton as influenced by the treatments

Treatment	Stages		
	Square	50% flowering	Maturity
T ₁	0.782	0.848	1.882
T ₂	1.129	1.264	1.965
T ₃	0.946	1.200	1.943
T ₄	1.110	1.230	1.955
T ₅	1.321	1.398	1.996
T ₆	1.157	1.287	1.973
T ₇	1.239	1.298	1.984
T ₈	0.901	1.176	1.925
T ₉	0.920	1.197	1.932
T ₁₀	0.979	0.890	1.897
T ₁₁	0.886	0.996	1.905
T ₁₂	0.897	1.150	1.910
SE $\pm$	0.0224	0.0554	0.1819
CD (at 5%)	0.0658	0.1624	0.5328
Mean	1.007	1.161	1.938

Table 12 : K concentration (%) at different growth stages of rainfed cotton as influenced by the treatments

Treatment	Stages		
	Square	50% flowering	Maturity
T ₁	2.178	2.540	2.220
T ₂	2.378	3.197	2.347
T ₃	2.297	2.997	2.310
T ₄	2.337	3.097	2.317
T ₅	2.440	3.278	2.390
T ₆	2.397	3.230	2.363
T ₇	2.412	3.259	2.379
T ₈	2.252	2.797	2.279
T ₉	2.273	2.897	2.299
T ₁₀	2.196	2.641	2.242
T ₁₁	2.208	2.674	2.260
T ₁₂	2.232	2.786	2.267
SE $\pm$	0.4811	0.2329	0.3788
CD (at 5%)	1.408	0.6823	11.095
Mean	2.300	2.949	2.306

**Table 13 : Uptake of N (kg ha⁻¹) by plant at different growth stages
of rainfed cotton as influenced by the treatments**

Treatment	Stages		
	Square	50% flowering	Maturity
T ₁	26.74	80.22	50.44
T ₂	98.61	118.86	73.31
T ₃	90.92	111.68	68.37
T ₄	94.68	115.20	71.10
T ₅	112.83	130.35	80.46
T ₆	105.24	125.68	77.61
T ₇	105.54	126.45	78.06
T ₈	82.11	101.91	62.43
T ₉	87.46	107.70	66.13
T ₁₀	69.46	87.33	53.30
T ₁₁	72.41	90.81	55.50
T ₁₂	75.87	94.69	58.11
SE ±	3.223	4.209	4.717
CD (at 5%)	9.439	12.32	13.81
Mean	85.15	10.75	66.23

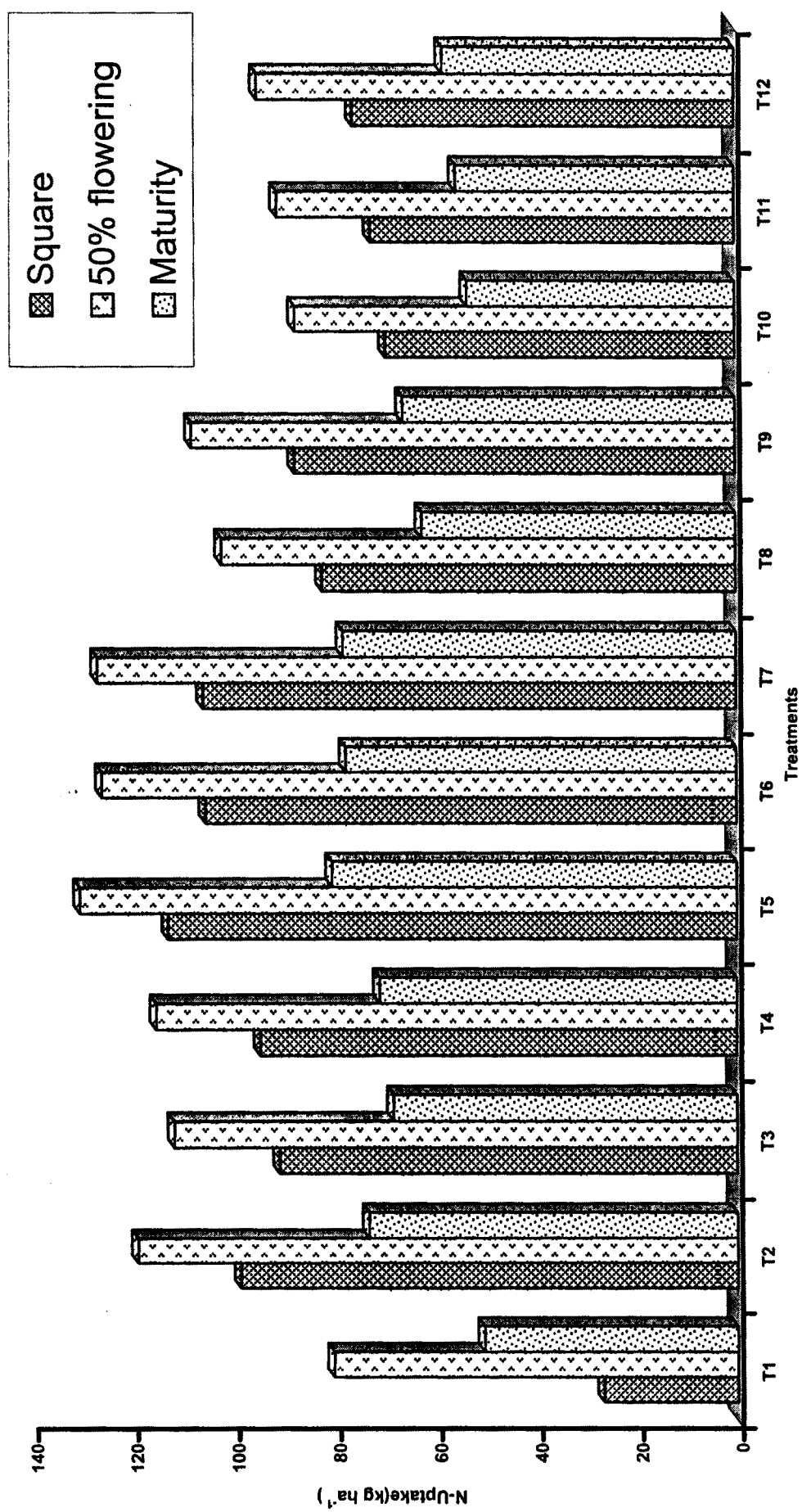


Fig 1 : Uptake of N (kg ha⁻¹) by plant at different growth stages of rainfed cotton as influenced by the treatments

Further it was also recorded increasing trend at maturity in all the treatments over 50% flowering. On the other hand maximum P content at T₅ 1.321, 1.398 and 1.996 at square, 50% flowering and maturity respectively. There was similar decreasing magnitude from T₅ > T₇ > T₆ > T₂ > T₄ > T₃ > T₉ > T₈ > T₁₂ > T₁₁ > T₁₀ > T₁ at all the growth stages, of the cotton.

The P content was significant influenced by the treatment at square stage 50% flowering and maturity stage.

4.5.3 K concentration :

From the data given in Table 12 indicates K concentration in cotton plant at different growth stages significantly influenced due to the treatments. It was seen there was increase K concentration from square to 50% flowering and further it was decrease at maturity in all the treatments.

The decreasing magnitude was similar as that of P concentration in plant (As stated earlier in Table 11).

4.6 Uptake of N, P and K by plant at different growth stages :

4.6.1 Uptake of N :

From the data given in Table 13 indicates that N uptake by cotton plant at different growth stages was significantly affected due to treatments. Uptake of N recorded was increasing trend from square to 50% flowering stage and decreased at maturity in all the treatments (Fig.1).

**Table 14 : Uptake of P (kg ha⁻¹) by plant at different growth stages
of rainfed cotton as influenced by the treatments**

Treatment	Stages		
	Square	50% flowering	Maturity
T ₁	20.91	22.67	50.32
T ₂	41.80	46.80	72.76
T ₃	33.08	41.96	67.94
T ₄	39.96	44.28	70.38
T ₅	52.98	56.07	80.05
T ₆	45.21	50.29	77.10
T ₇	48.43	50.73	77.55
T ₈	29.01	37.86	61.98
T ₉	31.18	40.57	65.49
T ₁₀	22.34	25.00	53.30
T ₁₁	25.74	28.64	55.35
T ₁₂	25.00	34.62	57.51
SE $\pm$	1.813	3.893	3.107
CD (at 5%)	5.3109	11.402	8.835
Mean	34.63	39.95	65.81

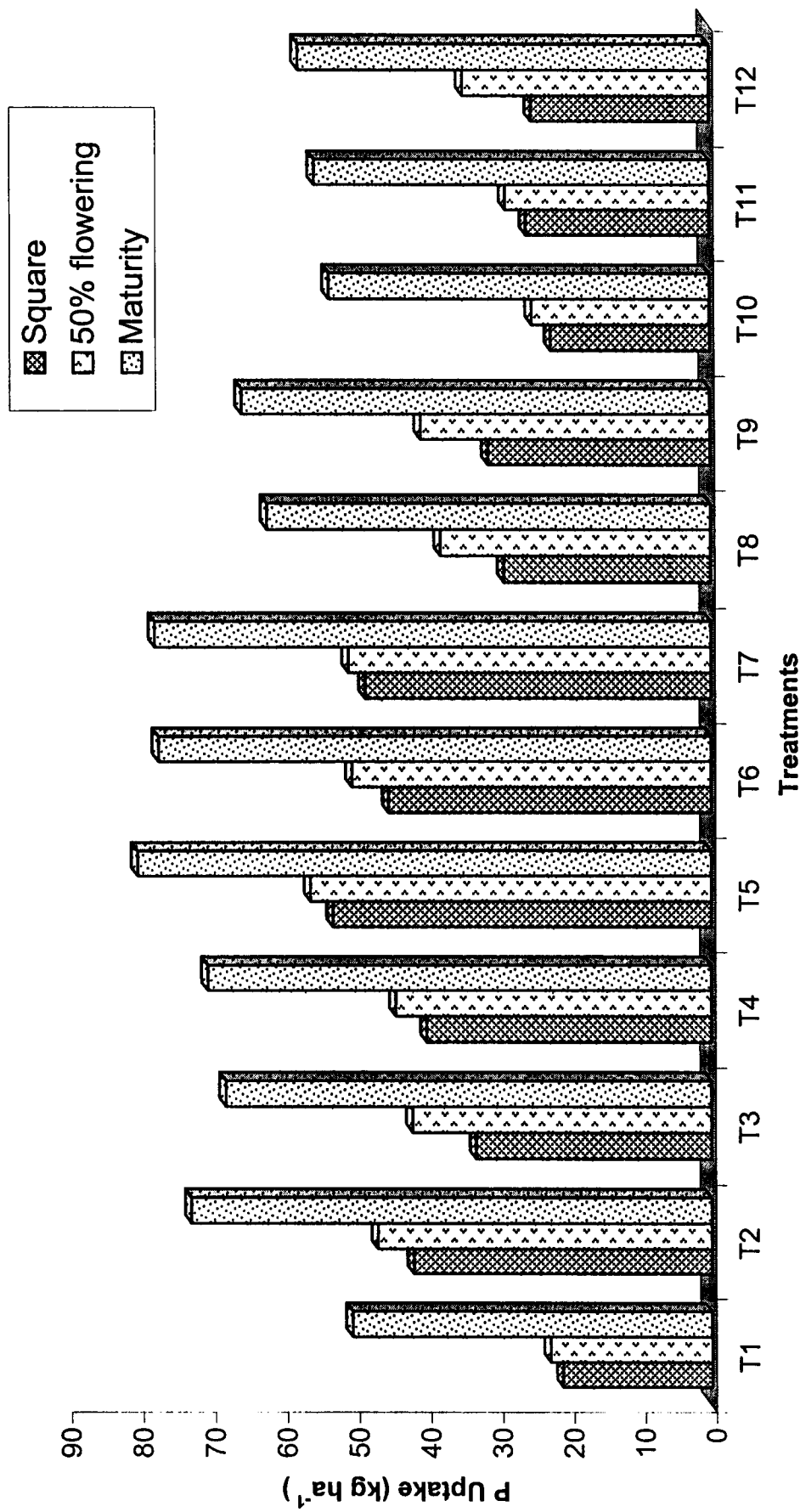


Fig 2 : Uptake of P (kg ha⁻¹) by plant at different growth stages of rainfed cotton as influenced by the treatments.

**Table 15 : Uptake of K (kg ha⁻¹) by plant at different growth stages of
rainfed cotton as influenced by the treatments**

Treatment	Stages		
	Square	50% flowering	Maturity
T ₁	61.56	67.91	59.36
T ₂	88.05	118.38	86.90
T ₃	80.32	104.80	80.78
T ₄	84.13	111.49	83.41
T ₅	97.86	131.48	95.86
T ₆	93.67	126.22	92.34
T ₇	94.28	127.39	92.99
T ₈	73.17	90.06	73.38
T ₉	77.05	98.20	77.93
T ₁₀	61.70	74.21	63.00
T ₁₁	64.22	77.76	65.67
T ₁₂	67.20	85.54	68.25
SE $\pm$	2.269	4.524	3.358
CD (at 5%)	6.644	13.25	9.8361
Mean	78.60	101.12	78.32

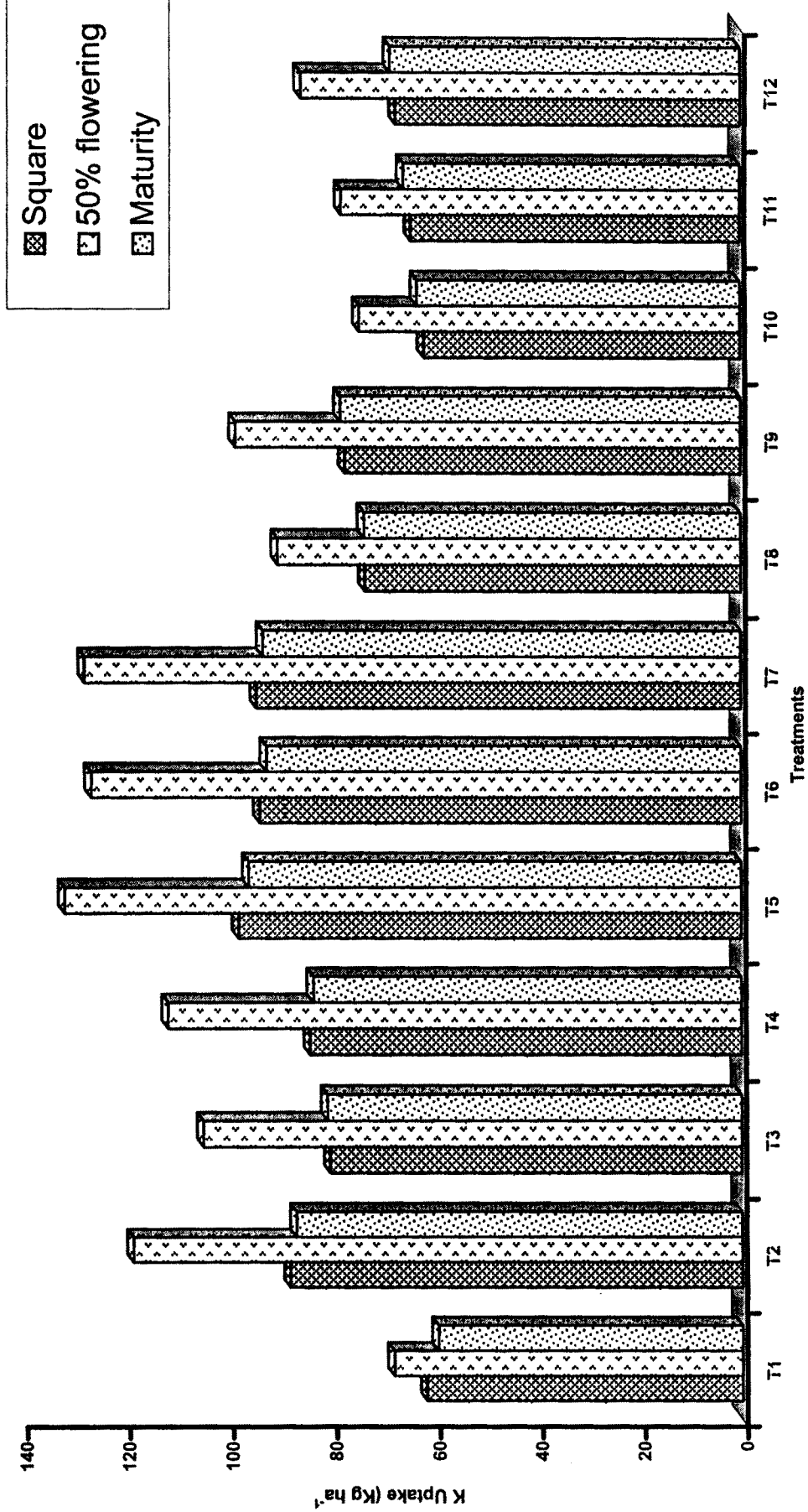


Fig 3 : Uptake of K (kg ha⁻¹) by plant at different growth stages of rainfed cotton as influenced by the treatments

Mean value ranged from 26.74 – 112.83, 80.22 – 130.35, 50.44 – 80.49 kg ha⁻¹ at square, 50% flowering and maturity stage of cotton respectively. It was observed that N uptake at T₂, T₃ and T₁₀, T₁₁, T₁₂ were at par at square stage. While N uptake was also at par at T₂, T₃, T₄, T₆, T₇ and T₁₀, T₁₁, T₁₂.

Similar results were recorded at maturity as that of 50% flowering stages.

4.6.2 Uptake of P

Scrutiny of the data presented in Table 14 indicated that the uptake of phosphorus by cotton plant at different growth stages. The mean values ranges from 20.91 – 52.98, 22.67 – 56.07, 50.32 – 80.05kg ha⁻¹ at square, 50% flowering and maturity stage of cotton respectively (Fig. 2).

Uptake of P was significantly affected by treatments at all the growth stages. P uptake recorded was increased from square to 50% flowering and decreased at maturity in all the treatments. There was decreasing magnitude viz. T₅ > T₇ > T₆ > T₂ > T₄ > T₃ > T₉ > T₈ > T₁₂ > T₁₁ > T₁₀ > T₁ at all the growth stages (Fig. 2)

4.6.3 Uptake of K :

Scrutiny of the data presented in Table 15 indicated that the uptake of potassium by cotton plant at different growth stages. The mean values ranges from 61.56 – 97.86, 67.91 – 131.48, 59.36 – 95.86 kg ha⁻¹ at square, 50% flowering and maturity stage of cotton respectively (Fig. 3).

Uptake of K was significantly affected by the treatments at all the growth stages. K uptake recorded was increase from square to flowering and decrease at maturity in all the treatments. There was decreasing magnitude viz. T₅ > T₇ > T₆ > T₂ > T₄ > T₃ > T₉ > T₈ > T₁₂ > T₁₁ > T₁₀ > T₁ at all the growth stage (Fig. 3).

Table 16 : Phosphorus use efficiency at different growth stages of rainfed cotton as influenced by the treatments

Treatment	Stages		
	Square	50% flowering	Maturity
T ₁	20.91	22.67	50.35
T ₂	52.22	60.32	56.10
T ₃	30.42	48.22	44.05
T ₄	47.55	54.02	50.15
T ₅	80.17	83.50	74.32
T ₆	60.75	69.05	66.95
T ₇	68.80	70.15	68.07
T ₈	20.25	36.97	28.48
T ₉	22.33	44.75	38.17
T ₁₀	03.70	58.30	07.45
T ₁₁	12.07	15.67	12.57
T ₁₂	15.22	28.92	17.97
SE $\pm$	2.715	3.197	2.352
CD (at 5%)	7.951	9.364	6.888
Mean	36.20	49.38	42.88

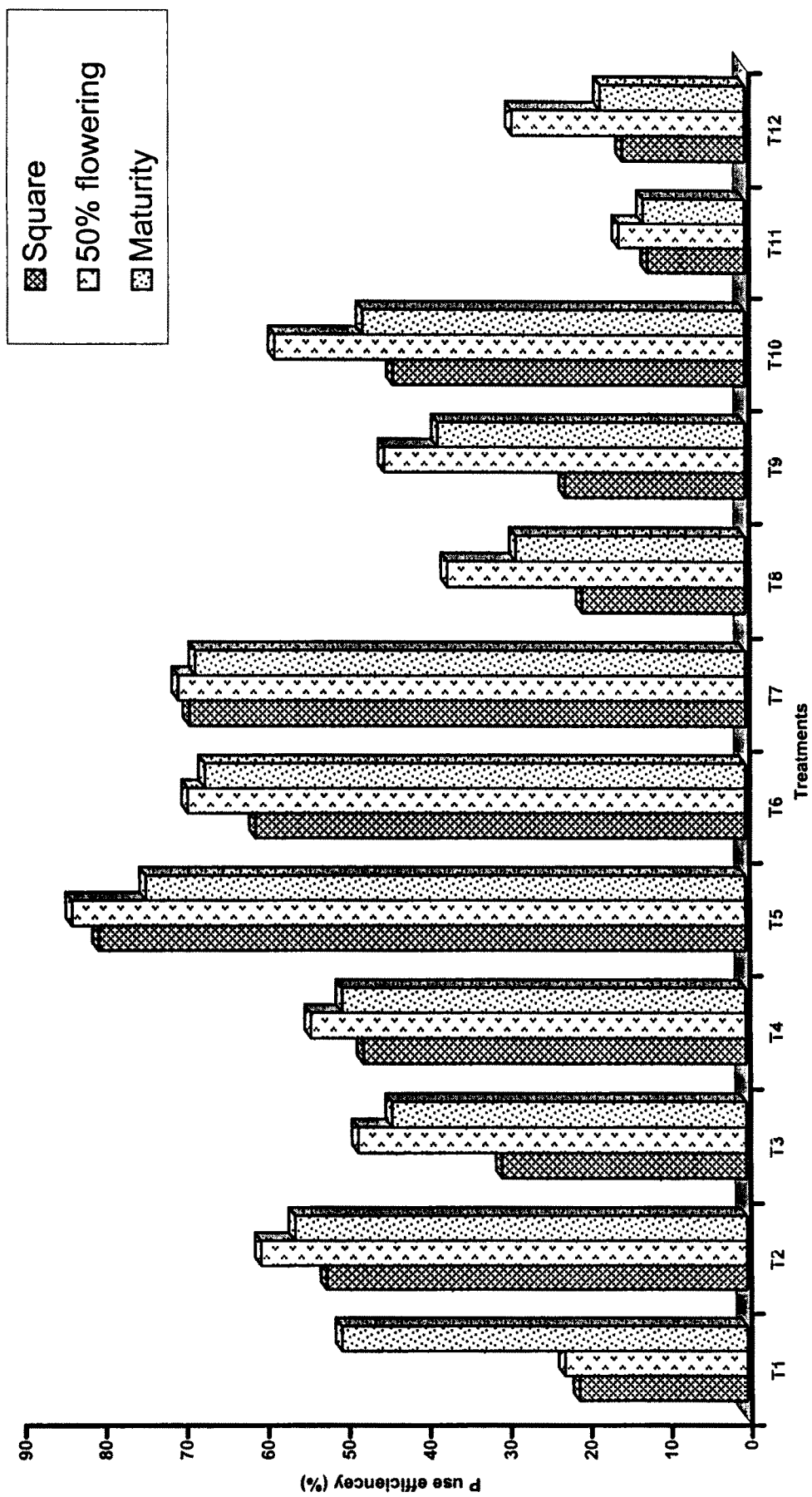


Fig 4 : Phosphorus use efficiency at different growth stages of rainfed cotton as influenced by the treatments.

Table 17 : Balance sheet of nutrients in soil at harvest of rainfed cotton as influenced by the treatments

Treat ment	At harvest (kg ha ⁻¹)			Before sowing (kg ha ⁻¹)			Net gain (+) or Loss (-) (kg ha ⁻¹)		
	N	P	K	N	P	K	N	P	K
T ₁	50.44	9.96	59.36	112.86	9.85	468.40	62.42	0.11	409.04
T ₂	73.31	23.07	86.90	112.86	9.85	468.40	39.55	13.22	381.50
T ₃	68.37	19.06	80.78	112.86	9.85	468.40	44.49	9.21	387.62
T ₄	71.10	20.43	83.41	112.86	9.85	468.40	41.76	10.58	384.99
T ₅	80.46	26.03	95.86	112.86	9.85	468.40	32.40	16.18	372.54
T ₆	77.60	22.09	92.34	112.86	9.85	468.40	35.20	14.22	376.06
T ₇	78.06	24.07	92.99	112.86	9.85	468.40	34.80	14.22	375.41
T ₈	62.43	18.09	73.38	112.86	9.85	468.40	50.43	8.24	395.02
T ₉	66.13	20.28	77.93	112.86	9.85	468.40	46.73	10.43	390.47
T ₁₀	53.30	18.00	63.00	112.86	9.85	468.40	59.56	8.15	405.40
T ₁₁	55.89	17.40	65.67	112.86	9.85	468.40	57.36	7.55	402.73
T ₁₂	58.11	19.25	68.25	112.86	9.85	468.40	54.75	9.40	400.15

4.7 Phosphorus use efficiency at different growth stages :

The perusal of the data in Table 16 reveals as under on phosphorus use efficiency at different growth stages. The P use efficiency was significantly increased by the treatments from square to flowering stage and decreased at maturity except T₁ (control).

There was similar decreasing magnitude of P use efficiency viz. T₅ > T₇ > T₆ > T₂ > T₄ at all the growth stages (Fig. 3).

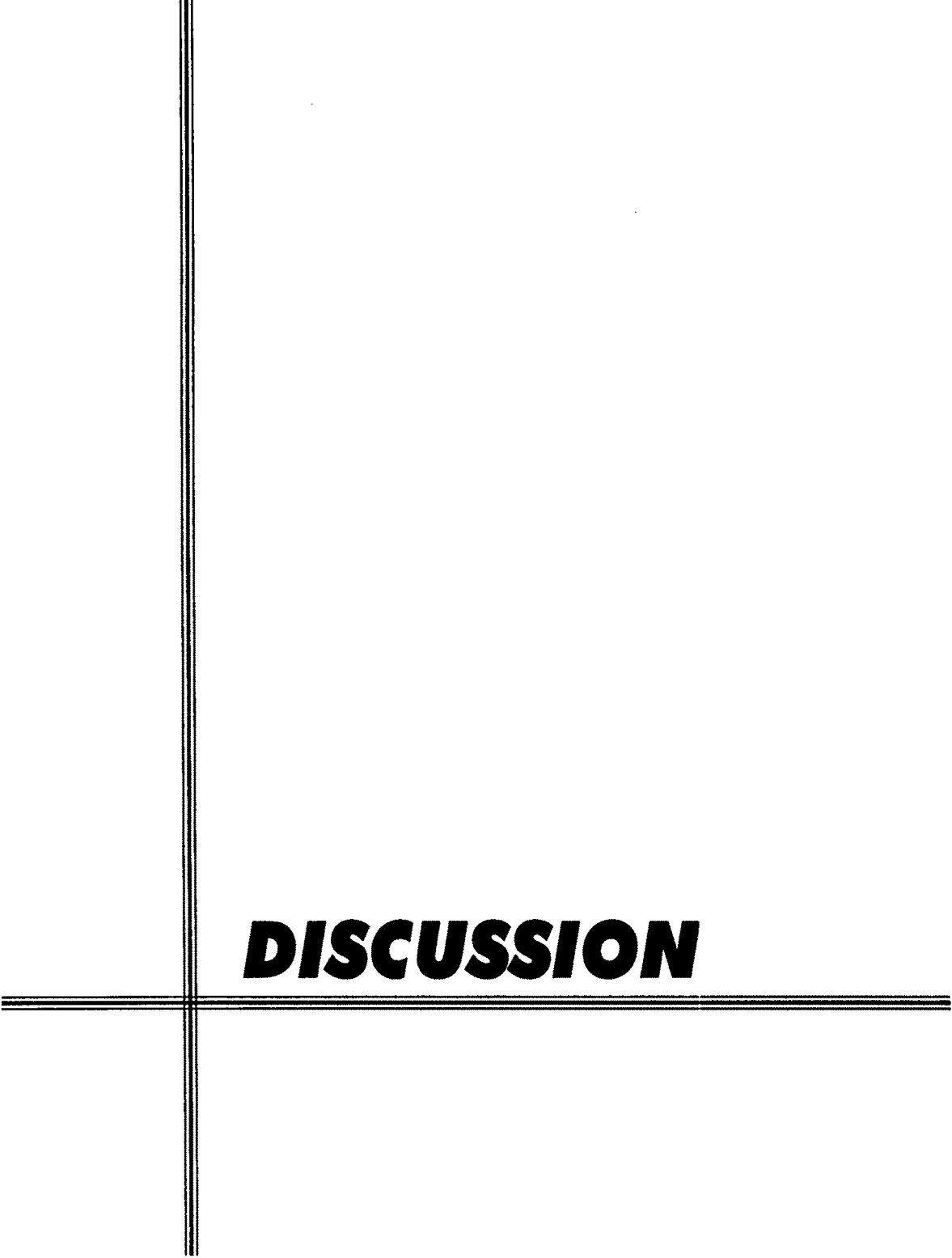
Mean values of P use efficiency ranged from 20.91 – 80.17, 15.67 – 83.50, 47.45 – 74.32 at square, 50% flowering and maturity respectively. It is seen that T₈, T₉ and T₁₀, T₁₁, T₁₂ were at par. The maximum P use efficiency was recorded at T₅ at all the growth stages followed by T₇.

4.8 Phosphate balance sheet in soil at harvest :

The study of Table 17 reveals balance sheet of N, P, K at harvest stage as affected by different treatments. The mathematical calculation showed positive N balance at all the treatments. The maximum 215.00 kg ha⁻¹ N was recorded as balance at T₅ of cotton followed by T₆ (210.26 kg ha⁻¹) and minimum at T₁₂ (12.44 kg ha⁻¹).

Similarly there was gain of phosphorus in all the treatments. The maximum gain (16.18 kg ha⁻¹) was recorded with application of 75 per cent recommended P₂O₅ through fertilizer + 25 per cent FYM + PSB (T₅) followed by T₇ (14.22 kg ha⁻¹) and minimum at T₁₂ (9.4 kg ha⁻¹).

There was gain of potassium at the treatment T₂, T₅, T₆, T₇, T₈ (Table 17). There was highest gain of 30.70 kg ha⁻¹ by T₅ followed by T₇ and remaining treatments showed loss of K at maturity stage of the crop.



DISCUSSION

CHAPTER – V

DISCUSSION

The experimental finding presented in preceeding chapter provides a detail account of the performance of rainfed cotton (Var. NHH-44) in terms of seed cotton yield, dry matter yield available nutrients in soil at different growth stages (square, 50% flowering and maturity), quality of cotton seed, uptake of nutrients, nutrient balance, P-use efficiency. An attempt has made in this chapter to examine and evaluate the important observations recorded in the course of presentation in terms of cause and effect relationship as far as possible to derive valid conclusion with regards to objectives on the project. INTEGRATED PHOSPHORUS MANAGEMENT IN RAINFED COTTON (Var. NHH-44)

5.1 Soil weather and crop growth :

It is evident from the Table 1 of soil analysis textural class of soil was clay, medium in available nitrogen and phosphorus and fairly rich in available potash with slightly alkaline reaction. Previous crop of the experiment site was experimental. Weather condition played a important role during the season (Table 2). The crop was sown on 15th July 1998, when optimum rains were received and sufficient moisture in the soil. The normal sowing of the crop is 15th to 25th June. The crop was sown late because of non-receipt of sufficient rain during the month of June and first fortnight of July 1998. There was 90% germination of the crop. Rainfall during the growing was erratic. There were continuous and heavy rains for prolonged period. This condition favour heavy weed growth and affected inter culture operations untimely. In addition to this, soil condition was also unfavorable for better stand of the crop, untimely crop growth was stunted which adversely affected yield attributes of the crop, hence seed cotton yield recorded were less than

average yield due to poor crop stand. Secondly, due to humid climate there were infestation of insect and pest oftenly. At the time of boll maturity at late stage of crop there was moisture stress in soil due to which that there was reddening of leaves. The condition causes non viable and small bolls sized and less numbers per plant.

5.2 Available N, P_2O_5 and K_2O at different growth stages :

5.2.1. Available N :

The results on available N (Table 1) at different growth stages was increased at 50% flowering and was decreased at maturity in all the treatments. The maximum available N ($335.12 \text{ kg ha}^{-1}$) was recorded with the application of 75 per cent recommended P_2O_5 through inorganic fertilizer and 25 per cent FYM with PSB inoculation and it was lowest at control (T_1). Similarly maximum ($353.86 \text{ kg ha}^{-1}$) and ($327.86 \text{ kg ha}^{-1}$) available N was determine at 50% flowering and maturity stage respectively of cotton.

It is clear that there was great influence of available N in the soil with treatment receiving 75 per cent recommended P_2O_5 through inorganic fertilizer + 25 per cent organic (FYM) with the PSB inoculation (T_5). This is in confirmative with the findings of Nayak *et al.* (1995). That the analysis of soil sample after the harvest of the finger millet reveal that the maximum available N was noticed with the combine application of ordinary FYM and recommended dose of fertilizer and the lowest was observed without FYM and recommended dose of fertilizer. Also reported by Mali and Gupta (1998) revealed that the bacterization of vertisols with Rhizobia and phosphorus solubilising bacteria (PSB) in conjunction with N and P fertilizer is beneficial for enhancing soybean productivity. An economy of about 25 per cent of N and P chemical fertilizer could be made by use of Rhizobia and PSB

cultures respectively. Similar quantum of available nitrogen at growth stages as reported by Sharma *et al.* (1998). Secondly the application of P_2O_5 through MRP + 25 per cent FYM + PSB and 75 per cent recommended P_2O_5 through PMC + 25 per cent FYM + PSB also stood second position on the availability of nutrients. Similar observation in cotton were reported by Dubey *et al.* (1997) in rainfed soybean. It was equally effective with rock phosphate @ 30 kg P_2O_5 ha⁻¹ + *Pseudomonas striata* inoculation.

5.2.3. Available P_2O_5 :

Available P_2O_5 (Table 2) was significantly influenced at growth stages of cotton with the application of P sources over control. It was observed that available P was estimated maximum 30.43 kg ha⁻¹ with the application of 75 per cent recommended P_2O_5 through inorganic fertilizer and 25 per cent FYM with PSB inoculation (T_5) at squaring stage. Similar performance of the treatments (T_5) has been shown at flowering and maturity stage of the crop followed by T_7 (75% recommended P_2O_5 through PMC + 25% FYM + PSB) at all the growth stages of crop. The result obtained in present studies are in agreement with those of Dubey *et al.* (1997) as they have reported superphosphate @ 60 kg P_2O_5 significantly improved all the parameter of soybean crop. It was equally effective with rock phosphate @ 30 kg P_2O_5 ha⁻¹ + *Pseudomonas striata* inoculation for nodule number, nodule dry weight and yield where soil P was low to medium. Another worker like Detroja *et al.* (1997) and Prasad (1998) stated that PSB increase the availability of P content in soil at growth stages in groundnut and soybean crop. This may be the fact that PSB inoculation phosphorus solution convert insoluble organic compound in to available form. Beside the fixation of inorganic phosphate in soil can be minimize due to PSB inoculation. These findings are in conformity

with Gururaja (1983), Nirmalnath and Sreenivasa (1993) and Thaigerhwari and Perumal (1995), Dash (1985).

5.2.4 Available K₂O :

Available potassium in soil (Table 3) indicated that maximum K₂O was estimated with the application 75 per cent P₂O₅ through fertilizer + 25 per cent FYM + PSB inoculation (T₅) at all the growth stages of the crop. The application of inorganic, minerals and organic fertilizer in presence of PSB inoculation collectively influence the mineralization of phosphorus process at advance stage of decomposition / mineralization. It may be due to fact that multiplication of P solubilizing microorganism and organic matter decomposers. This findings are in line with those of Nayak *et al.* (1960) when K is applied with N and P the efficiency of K is increased (Gaur *et al.* 1980). Among the treatments T₂, T₃, T₄, T₆, T₈, T₁₀, T₁₁, T₁₂, were at par these may be because initial status of the soil was rich (Table 1) due to which there would not be treatment effect on the K availability in soil throughout the growing period of the crop.

5.5 Chemical properties of soil at difference growth stage :

5.5.1 pH :

In general it was observed that the application of organic manures in combination with inorganic fertilizer showed decrease in soil pH over control (Table 4). At advance stage of crop where manures and fertilizers were applied in soil at the time of sowing showed significant decrease in soil pH at it was lowest at T₁₀, T₅, and T₁₂ at square, 50% flowering and maturity. This may be due to decomposition of organic and mineral fertilizer in presence of PSB. It support the finding reported by Singh *et al.* (1980). Continuous application of FYM to chirnozems soil in semiarid Haryana resulting in lowering of soil pH with

increasing in organic carbon content. Organic manure is associated with the production of organic acids released during the decomposition and minimizing the salt concentration. Tompe and More (1996). This also supported by Mishra *et al.* (1996) that the soil pH was considerably reduced with the application FYM + BGA and fertilizer.

5.5.2 Ec :

The observation on the electrical conductivity were invariably significantly different significantly in the treatment receiving organic manures in general over control, There was reduction in the treatments where organic manure were applied (T₃, T₅, T₇, T₈, T₉, T₁₁, T₁₂). It was also noticed that P applied through chemical fertilizer reduced Ec (T₂), except T₆, T₅, T₇ at all the growth stages Table 5). The reduction in Ec may be due to production of acid during the decomposition of organic manure and chemical fertilizer, Tompe and More (1996) have been reported decrease the pH and Ec of the soil due to higher dose of PMC. Mishra *et al.* (1996) also observed that the result after 10th year study on nutrient management. The soil pH and Ec was considerably reduced with application of FYM + BGA and fertilizer.

5.5.3 CaCO₃ :

Application of 75 per cent recommended P₂O₅ through PMC in combination with 25 per cent FYM with PSB inoculation (T₇) showed lowest free CaCO₃ at square and maturity stage of the crop (Table 6) and 3.11 % at T₇ followed by T₅. On the other hand this reduction was at T₅ (3.16%) square and maturity (3.01%) finding of Bellakki *et al.* (1997) also revealed that continuous application of organics increased CEC and exchangeable Ca. While, decrease in Na and CaCO₃. Further Bellakki *et al.* (1998) indicated that exchangeable Na and Ca content

decrease but there was increase in CEC and exchangeable Ca content of soil due to incorporation of organic sources of nutrients.

5.5.4 Organic carbon :

Organic carbon content in soil at all the growth stages invariably influenced due to the treatments (Table 7). It was noticed that the early stage of the crop (square) there was maximum organic carbon content due to the application of 75 per cent recommended P_2O_5 through PMC + 25 per cent FYM + PSB (T_7). While at 50 per cent flowering stage there was maximum organic carbon determined with the application of 75 per cent P_2O_5 through fertilizer + 25 per cent FYM + PSB (T_5). Further at maturity stage of the crop O.C. was maximum with the addition of 100 per cent recommended P_2O_5 through PMC (T_3) recorded highest O.C. (0.568%). There was increasing trend from square to maturity at T_3 , T_5 , at 50 per cent flowering and decreasing trends at T_7 from square to maturity 0.690, 0.573 and 0.565 at squaring, 50 per cent flowering and maturity respectively. The higher carbon content is attributed due to the high amount of addition of PMC at T_3 , FYM application at T_5 and 75 per cent P_2O_5 through PMC + 25 per cent FYM + PSB. This organic manure influenced the organic matter content at higher level with and without chemical fertilizer and PSB inoculation. This corroborate the finding of Dubey and Gupta (1996) reported that response at phosphate dissolving micro organism was positively in soil with high organic matter content and low available P. This supports the finding reported several worker (Muthuvel *et al.* 1979, Maples, 1990, Rasal, *et al.* 1996).

5.6 Yield and yield attributes :

5.7 5.6.1 Bolls per plant :

Number of bolls per plant of cotton (Table 8) were counted and it was observed that there were significant differences due to the treatments over control. Highest number of bolls (20) were counted with the application of 75 per cent recommended P_2O_5 through fertilizer + 25 per cent FYM + PSB (T_5) followed by T_7 (75% recommended P through PMC + 25% FYM + PSB). Number of bolls per plant were non-significant at T_3 , T_8 , T_{11} and T_{12} over T_2 (100% P_2O_5 through fertilizer). Application of PMC at different proportions + fertilizer at the treatments T_3 , T_8 , T_{11} and T_{12} were equally effective for the boll formation. Result confirm the findings of Trivedi *et al.* (1995) studied the effect of phosphatic fertilizer in conjugation with FYM and pressmud increased pod haulm yield of groundnut due to combined application of P and organic manures showed higher beneficial effect. Similar type of distribution pattern was reported for the soils of Coimbatore on calcareous black soils by Thiaswari and Rani Perumal 1995. There was significant influenced of inorganic fertilizer in combination with vermicompost and phosphobacteria. similar findings reported by several workers (Mali *et al.* 1987, More and Agale 1993, Sharma *et al.* 1988, Tomar *et al.* 1989, Rani Perumal and Bhagavati 1996, Detroja *et al.* 1996).

5.6.2 Dry matter :

Dry matter of cotton was significantly influenced due to the treatments (Table 8) Dry matter yield was maximum (40.11 q ha^{-1}) with the application of 75 per cent P_2O_5 through fertilizer + 25 per cent FYM + PSB (T_5), followed by T_7 . The dry matter yield at T_3 , T_4 and T_8 were non-significant with T_2 (100% P_2O_5 through fertilizer) there were non-significant differences in between T_{10} , T_{11} and T_5 .

It is clear that influence of T₁₀, T₁₁ and T₅ were non significant. It is indicated that performance of T₅, T₁₀, T₁₁ and T₄ was equal Pangaria *et al.* (1995) reported that highest dry matter and yield of cotton with the full recommended dose of NP + 10 cartload of FYM. Jaikumar *et al.* (1995) and Trevide *et al.* (1995) observed the substitution of chemical fertilizer by organic manures and the organic amendments increase the halum yield of groundnut with the application of inorganic fertilizer with organic manures. Similar findings were also reported by Deshmukh *et al.* (1995) Naphade *et al.* (1995), Sarkar *et al.* (1997) Dubey *et al.* (1997), Prasad *et al.* (1998), Karad *et al.* (1998) Srinivasa *et al.* (1998).

5.6.3 Seed cotton yield :

Application of inorganic and organic fertilizer increase significantly the seed cotton yield of cotton (Table 8) there was significantly highest (4.07 q ha⁻¹) seed cotton yield with the application of 75 per cent P₂O₅ through fertilizer + 25 per cent FYM + PSB (T₅) followed by T₇ (3.07 q ha⁻¹) it was observe that there was similar seed cotton yield (3.61 q ha⁻¹). It is clear that 100% P₂O₅ applied through chemical and 70 per cent recommended P₂O₅ through MRP + 25 per cent FYM + PSB performed equally. Moreover it was also significantly superior over T₃, T₈, T₉, T₁₀, T₁₁, T₁₂. The yield observation were invariably statistically non-significant with the application of inorganic, organic, mineral fertilizer with PSB inoculation (T₃, T₈, T₉, T₁₀, T₁₁ and T₁₂). Similar finding were also observed by many workers (Male *et al.* 1987, More and Agale 1993, Agale and More 1994, Sharma *et al.* 1988, Tomar *et al.* 1989, Pangaria *et al.* 1995, Trivedi *et al.* 1995, Thiageshwari and Perumal 1995, Sharma *et al.* 1988, Pimpalgaonkar 1986, Chahal *et al.* 1981, Siddique *et al.* 1986).

5.8 Quality of cotton seed :

5.9 5.7.1 Oil content :

Oil extracted from cotton seed was significantly influenced due to the treatments (Table 9). The maximum (17.70%) oil was obtained due to the application of 75 per cent recommended P_2O_5 through fertilizer + 25 per cent FYM + PSB (T_5) followed by T_7 . The treatment T_3 receiving 100 per cent P_2O_5 through PMC was significantly obtained oil cotton seed over control (T_1) and T_9 while T_4 , T_6 , T_7 , T_8 , T_{11} and T_{12} were at par. It is clear that there were slight differences with the treatments with the application of organic manure, mineral fertilizer with PSB inoculation. Yengade and Ghonsikar (1997) supported this finding that the oil content in sunflower seed was influenced significantly due to varied level of P in all the seasons. They also stated that there was no significant influence of PSB inoculation on oil content in sunflower seed. However Nirmalnath and Sreenivasa (1993) stated that *Pseudomonas striata* at different levels and sources of P found significant increase in yield dry biomass and oil content with increase in level of P. This results are supported by the findings of Gururaja (1983). The increase in oil content due to phosphorus application may be explain as phosphorus plays an important role in carbohydrate metabolism and helps in the conversion of carbohydrates into oil. In plant synthesis of fatty acids occurs through conversion of Acetyl COA to malonyl COA. This reaction required ATP and inorganic phosphate (Bonner and Narner, 1965).

5.7.2 Protein content :

Protein content in seed cotton was significantly maximum with the application of 50 per cent recommended P_2O_5 through fertilizer + 50 per cent PMC + PSB (T_9) and lowest at T_{12} (Table 9). There were slight difference in between the

treatments receiving organic manures in combination with mineral and inorganic fertilizer. The treatments rated high per cent of protein (T₉) where the combination of 50 per cent PMC with 50 per cent fertilizer + PSB. The quantity of PMC added was high for the compensation of 50 per cent P. This condition may be favoured for available nitrogen (Table 1) which resulted in high protein in seed. In addition to this the PSB inoculation with phosphorus fertilization increased the availability of phosphorus in soil (Table 2) resulted in high uptake of phosphorus (Table 14) and ultimately there may be complementary effect of phosphorus on nitrogen and potash uptake. The similar finding were observed with those given by Jain *et al.* (1990). Who reported that with increasing P rates increased P and K uptake and seed protein and oil content. Similar finding reported by earlier worker Sawan *et al.* (1988), Virender *et al.* (1994).

5.8 N, P and K concentration at different growth stages :

5.8.1 N concentration :

Estimation data on nitrogen content in cotton plant (Table 10) showed the increased from square to 50% flowering and further decrease at maturity in all the growth stages. Also N content was significantly maximum (T₅) 2.73, 3.25, 2.00 per cent at square 50% flowering and maturity followed by T₇ at all the stages respectively. The finding in the line those of Prasad and Rokima (1991) reported that blue green algae applied to calcareous soil increased N content and uptake rice and wheat. Similar results with soybean reported by Dubey (1997). Soybean seed inoculated with *Pseudomonas Striata* along with superphosphate increased N content at 60 days. There was increase of phosphorus concentration from square to maturity. This may be due to grand growth stage of crop and ultimately high amount of nitrogen absorption and it decrease at late stage of crop (maturity). Similar results were reported by Muthuvel (1979) N content due to application of

either inorganic sources or in combination with inorganic sources increased the N content due to inorganic sources.

5.8.2 P concentration :

P content in cotton plant at different growth stages (Table 11) indicated increasing trend at maturity in all the treatments over 50 per cent flowering. The maximum P content was estimated at T₅ 1.321, 1.398 and 1.996 at square, 50% flowering and maturity respectively. The treatment T₅ (75% recommended P₂O₅ through fertilizer + 25 % FYM + PSB) was significantly influenced at all the growth stages with increasing trends from square to maturity. It was seen that there was continuous absorption of phosphorus available in the soil throughout the growing period of the crop.

The results are almost in confirmative with those obtained by Dubey and Gupta (1996) reported that response of phosphorus dissolving microorganism was positive in soil with high organic matter content and low available P thus the response could be attributed to solubilization of P directly by bacteria and favouring N fixation indirectly. Similar findings reported by Dubey (1996), Mali *et al.* (1987), Malavia (1997), Dubey (1997).

5.8.3 K concentration :

K concentration in cotton plant at different growth stages (Table 12) observed that there was increase from square to 50% flowering and further it was decrease at maturity (Table 12). Maximum 2.44, 3.27 and 2.39 was at T₅ to the stages square flowering and maturity respectively followed by T₇. The maximum K concentration may be attributed due to the fact that at grand growth of the crop K absorbed at high amount and decline at advance stage (maturity). This findings are inconfirmative with Jain *et al.* (1990) grown groundnut crop in vertisol applying P

and K. They observed that with increasing period of crop increased K uptake and seed protein and oil content. Tilak and Singh (1996) reported that phosphorus solubilizing microorganism noticed effective for the solubilization insoluble phosphorus in soil. This condition may be favour as P content in cotton plant at high proportion as complementary effect on potassium concentration. Similar observation were recorded by Gaur (1988).

5.9 Uptake of N, P and K by plant at different growth stage :

5.9.1. Uptake of N :

It is evident the observation give in (Table 13) indicates the total uptake of N by cotton plant was significantly influenced due to the treatments. It was seen that there was increasing trends from square to 58 per cent flowering stage and decreased at maturity at all the treatments. While significantly highest uptake of N was recorded with the application of 75 per cent recommended P_2O_5 through fertilizer to 25 per cent FYM + PSB (Fig.1). The results obtained in present study are in agreement with those of Dubey (1997), Prasad and Rokima (1991), Ahmed (1989), Mondal *et al.* (1993).

5.9.2 Uptake of P :

P uptake by cotton plant at different growth stages (Table 14) was increased from square to 50 per cent flowering and decreased at maturity in all the treatments. There was maximum uptake at T_5 followed by T_7 (Fig.2) and minimum with control (T_1). This may be due to the fact that at grand growth stage of crop (50% flowering) observed high amount of phosphorus and further it decrease at maturity because of less moisture content in soil which may be resulted in less absorption of phosphorus. Secondly maximum uptake at T_5 favoured addition of inorganic fertilizer in conjugation with 25% FYM + PSB.

Reports on P availability with organic and inorganic fertilizer and microbial culture (PSB) made P available to the crop. This finding confirms Dubey *et al.* (1997) maximum net return, phosphorus use efficiency relative agronomic effectiveness were found with rock phosphate + PDB inoculation. Similar observations were reported by Mishra *et al.* (1986), Shinde *et al.* (1985), Dash (1985), Mathur *et al.* (1986), Jain (1990), Kapoor *et al.* (1990) Mondal *et al.* (1993), Pasricha *et al.* (1995), Malavia *et al.* (1997), Biswas, (1998), Sharma *et al.* (1988), Dash (1985).

5.9.3 Uptake of K :

The uptake of potassium (Table 15) by cotton plant was significantly highest (T_5) 97.86, 131.48 and 95.86 kg ha⁻¹ at square 50% flowering maturity respectively. (Fig.3). The high uptake at flowering may be resulted due to higher N and P uptake as stated earlier (5.9.1, 5.9.2). Similar findings described by Jain *et al.* (1990), Mondal *et al.* (1993), Santhy *et al.* (1998).

5.9 Phosphorus use efficiency at different growth stage :

Phosphorus use efficiency at (Table 16) different growth stage significantly increased from square to flowering and decrease at maturity. There was maximum 80.17, 83.50, 74.32 at square, 50 per cent flowering and maturity respectively (T_5) followed by T_7 (Fig. 4). There was decreasing magnitude $T_5 > T_7 > T_6$ at all the stages. The computation of observation for P use efficiency dependent on uptake yield and quantity of nutrient added. This parameters were affected at high response for P with the treatment T_5 . The results obtained in present studies are in agreement with those of Nayak *et al.* (1960), Batino and Mokwunjye (1991), Taggi and Luthral (1983), Sarkar *et al.* (1997), Dubey *et al.* (1997).

5.10 Phosphate balance sheet in soil at harvest :

The balance sheet of nutrients (NPK) at harvest stage showed maximum N balance at T₅ (215.00 kg ha⁻¹) followed by T₆ (210.26 kg ha⁻¹) and least at T₁₂ (12.44 kg ha⁻¹).

There was also maximum (16.18 kg ha⁻¹) gain of phosphorus at T₅ followed by T₇. N and P gain at all the treatments may be due to continuous mineralization / decomposition of mineral fertilizer / organic manure and inorganic fertilizer in the soil with the inoculation of PSB. There may be release of these nutrients and their persistence in soil as residual balance of nutrients. This findings confirms by may worker Sharma (1997), Gururaja (1995), Nirmalnath and sreenivasa (1993), Thiageshwari and Perumal (1995), Dubey and Gupta (1996), Nayak *et al.* (1995), Mali *et al.* (1998), Dubey (1997), Gaur (1980).

There was loss of potassium with the treatments T₃, T₄, T₉, T₁₀, T₁₁ and T₁₂. This may be due to absorption of nutrient by the crop and microbial immobilization of K due to proliferation of microorganism in the soil with the application of organic manures at high rates i.e. equivalent to P basis, similar findings were reported by Tandon (1987).

***SUMMARY
AND
CONCLUSION***

CHAPTER VI

SUMMARY AND CONCLUSION

SUMMARY

Major observations of the present investigation were assess the comparative efficiency of different organic manures, mineral phosphate source and biofertilizer singly or incombination to determine the response of rainfed cotton (var. NHH-44) in respect of yield chemical properties of soil at growth stage, nutrient concentration and uptake, quality, phosphorus use efficiency and phosphate balance sheet in soil. A field experiment was conducted for studying above objectives. Twelve treatments were taken and replicated three times in Randomized Block Design. The crop was grown during *kharif* 1998-99. Experimental soil was medium black clay medium in available nitrogen and phosphorus and fairly rich in available potash with slightly alkaline reaction. Recommended dose of phosphorus (40 kg ha^{-1}) was integrated with the application of organic manures (FYM, pressmud compost) mineral sources phosphate (RP). The sources were applied in the soil of P equivalent basis, 15 days before sowing. Cotton seeds were inoculated with PSB as P solubilizer at the time of sowing. Plant and soil sampling was done at squaring, 50% flowering and maturity. The study has given some understanding regarding the effect of treatments on crop which are summarised on different aspects as under.

There was increase in available N from squaring to 50 per cent flowering and decrease at maturity in all the treatments. The maximum available N was recorded with the application 75 per cent recommended P_2O_5 through inorganic fertilizer and 25 per cent + FYM, with PSB inoculation (T_5) and lowest at control (T_1) to all the growth stages.

Phosphorus availability in soil during the growth stages of cotton observed maximum with the application 75 per cent recommended P_2O_5 through fertilizer +

25 per cent FYM + PSB inoculation (T_5) followed by 50% recommended P_2O_5 through fertilizer + 50 % MRP + PSB (T_7) at all the growth stages of the crop.

Available potassium in soil during the growth stages of cotton noticed highest at 75 per cent recommended P_2O_5 through fertilizer + 25 per cent FYM + PSB inoculation (T_5) followed by 50 per cent recommended P_2O_5 through fertilizer + 50 per cent MRP + PSB (T_7) and all the growth stages of the crop.

Soil reaction (pH) significantly lowest with the application of 50 per cent recommended P_2O_5 through MRP + 50 per cent PMC + PSB (T_{10}), 75 per cent recommended P_2O_5 through fertilizer + 25 percent FYM + PSB inoculation (T_3) and 50 per cent recommended P_2O_5 through PMC + 50 per cent FYM + PSB (T_{12}) at squaring, 50 per cent flowering and maturity respectively.

Electrical conductivity (Ec) was reduced the treatment receiving organic manures singly or in combination (T_3 , T_5 , T_7 , T_8 , T_9 , T_{11} and T_{12}). The reduction of Ec was also observed due to the application of P through chemical fertilizer.

Calcium carbonate ($CaCO_3$) reduced with the application of 75 per cent recommended P_2O_5 through PMC + 25 Per cent FYM + PSB (T_7) at square and maturity stage while it was least with T_7 at flowering.

Organic carbon content in soil was significantly highest with the application of 75 per cent recommended P_2O_5 through PMC + 25 per cent FYM + PSB(T_7), 75 per cent P_2O_5 through fertilizer + 25 per cent FYM + PSB (T_5) and 100 per cent P_2O_5 through PMC (T_3) at square, flowering and maturity respectively.

Number of bolls per plant dry matter and seed cotton yield of cotton were maximum with the application of 75 per cent recommended P_2O_5 through fertilizer

+ 25 per cent FYM + PSB (T₅) followed by 75 per cent recommended P₂O₅ through PMC + 25 per cent FYM + PSB (T₇).

The maximum cotton seed oil extracted with the application of 75 per cent recommended P₂O₅ through fertilizer + 25 per cent FYM + PSB followed by 75 per cent recommended P₂O₅ through PMC + 25 per cent FYM + PSB (T₇).

Protein contain in seed cotton was significantly maximum with the application of 50 per cent recommended P₂O₅ through fertilizer + 50 per cent, P₂O₅ through PMC + PSB (T₉) and least with the application of 50 per cent recommended P₂O₅ through PMC + 50 per cent FYM + PSB (T₁₂).

N, P and K content in cotton plant was increased from square to 50 per cent flowering and decreased at maturity at all growth stages. The maximum N content recorded was with the application of 75 per cent recommended P₂O₅ through fertilizer + 25 per cent FYM + PSB (T₅) followed by 75 per cent recommended P₂O₅ through PMC + 25 per cent FYM + PSB (T₇).

Nitrogen (N) phosphorus (P) and Potassium (K) uptake by cotton plants was increased from square to flowering stage and decreased at maturity. The highest N uptake was determined with application of 75 per cent recommended P₂O₅ through fertilizer + 25 per cent FYM + PSB (T₅) followed by 75 per cent recommended P₂O₅ through PMC + 25 per cent FYM + PSB (T₇).

The maximum balance of nitrogen at maturity stage of cotton computed maximum at 75 per cent recommended P₂O₅ through chemical fertilizer + 25 per cent FYM + PSB (T₅) followed by 75 per cent recommended P₂O₅ through PMC + 25 per cent FYM + PSB (T₇).

Phosphorus balance at maturity stage was noticed highest with the application of 75 per cent recommended P_2O_5 through chemical fertilizer + 25 per cent FYM + PSB (T_5) followed by 75 per cent recommended P_2O_5 through MRP + 25 per cent FYM + PSB (T_6).

CONCLUSION

Based on the present investigation following conclusion can be draw.

Available N, P and K was recorded maximum with the application of 75 per cent recommended P_2O_5 through chemical fertilizer + 25 per cent through FYM + PSB followed by 75 per cent recommended P_2O_5 through PMC + 25 per cent through FYM + PSB.

There was reduction in soil pH with the application of 50 per cent recommended P_2O_5 through MRP + 50 per cent PMC + PSB at squaring 75 per cent recommended P_2O_5 through fertilizer 25 per cent through FYM + PSB at flowering and 50 per cent recommended P_2O_5 through PMC + 50 per cent FYM + PSB at maturity. While electrical conductivity reduced with the application of organic manures in conjugation with chemical fertilizer and alone inorganic fertilizer. Calcium carbonate reduction was happen due to application of 75 per cent P_2O_5 through PMC + 25 per cent through FYM + PSB at squaring and maturity. Organic carbon content in soil was recorded maximum with the application of 75 per cent recommended P_2O_5 through fertilizer + 25 per cent FYM + PSB at all the growth stages.

Number of bolls per plant, dry matter yield, seed cotton yield and oil content was recorded maximum with the application of 75 per cent recommended P_2O_5 through chemical fertilizer + 25 per cent through FYM + PSB.

While protein content was highest with 50 per cent recommended P_2O_5 through fertilizer + 50 per cent PMC + PSB followed by 50 per cent recommended P_2O_5 through MRP + 50 per cent through FYM + PSB.

N, P, K and P use efficiency was maximum with the application of 75 per cent recommended P_2O_5 through chemical fertilizer + 25 per cent FYM + PSB followed by 75 per cent recommended P_2O_5 through PMC + 25 per cent FYM + PSB.

Observation on balance sheet of nitrogen and phosphorus was maximum with 75 per cent recommended P_2O_5 through fertilizer + 25 per cent through FYM + PSB followed by 75 per cent P_2O_5 through MRP + 25 per cent through FYM + PSB. While phosphorus also recorded maximum as that of nitrogen followed by 75 per cent recommended P_2O_5 PMC + 25 per cent through FYM + PSB. K balance was positive at all the treatments.

***LITERATURE
CITED***

LITERATURE CITED

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* Originals are not seen.

APPENDIX – I

Nutrient content and quantity of the sources used

for phosphorus integration for cotton crop.

Source	Nutrient content (%)			Quantity (Tonn ha-1)
	N	P	K	
FYM	0.52	0.23	0.54	30
Press mud compost	1.80	3.0	2.32	2.0
Mussoorie rock phosphate	---	20	---	3.0