PHOSPHORUS NUTRITION WITH AND WITHOUT BORON IN COTTON-GROUNDNUT SYSTEM

BY

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1988

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CERTIFICATE I

Shri Penmestsa Raghu Varma has satisfactorily prosecuted his course of research for a period of not less than one academic year and that the dissertation entitled " PHOSPHORUS NUTRITION WITH AND WITHOUT BORON IN COTTON GROUNDNUT SYSTEM " submitted by him is the results of original research work and is of sufficiently high standard to warrent its presentation to the examination. I also certify that the dissertation or part thereof has not been previously submitted by him for a degree of any University.

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This is to Certify that the dissertation entitled " PHOSPHORUS NUTRITION WITH AND WITHOUT BORON IN COTTON-GROUNDNUT SYSTEM" submitted by Penmetsa Raghu Varma to the Marathwada Agricultural University, Parbhani in Partial fulfilment of the requirements for the degree of MASTER OF SCIENCE 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 External Examiner.

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ABBREVIATIONS USED

SSP	Single superphosphate
BSSP	Boronated single superphosphate
DAP	Diammonium phosphate
B+SSP	Borax + single superphosphate
DAS	Days after sowing

C O N T E N T S

Chapter 1

INTRODUCTION

Though, the essentiality of phosphorus was established in 1839 by Sprengal, it's significance in Indian agriculture is realised to the greatest extent in the recent days. Kanwar et al. (1982) reviewed the problems and prospects of phosphorus management in Indian soils and suggested intensified research for the solution of the several complexities of phosphorus. They further stated that phosphorus is often a major constraint for successful crop production in India, as about 98 per cent of the soils have inadequate supply of available phosphorus. These observations appraised that soil phosphorus and it's behaviour is a difficult problem and it encompasses an array of factors the soil, crop, fertilizer and cropping system each with a multitude of problems of it's own.

Vertisols of Central India which are characterised by high clay with smectite type of secondary clay minerals and sufficiently high calcium carbonate content posses the problem of phosphate fixation and in turn decreases availability or phosphorus. Probably, crop recovery of added phosphates seldom exceeds 20 per cent under high clay and $CaCo_3$ and this calls for ways and means to increase the efficiency of P utilization in varied soil-crop association.

Phosphorus is physiologically and bio-chemically very active nutrient. It is a constituent of nucleic acid which forms genes in the plants. Phosphorus is involved in formation of cell membrane and consequently cell formation and also as a constituent of phospholipids. Phosphorus is involved in the metabolism of carbohydrates, proteins and lipids as well as oxidation reduction like intercellular process. Phosphorus has a direct effect on root development and it's proliferation. Phosphorus occupies a central position in metabolism. The process of anabolism and catabolism of the carbohydrate can only proceed normally when the organic compounds have previously been esterized with phosphoric acid. Further, it is an essential constituent of vital compounds such as phytins, lecithins and nucleotides and it is present in majority of the enzymes.

Several workers have observed increased responses of phosphorus application to cotton in terms of seed cotton yield and improved quality parameters Dhar (1964) and gGill *et al*. (1985).

In groundnut phosphorus application promote pod formation and reduce the proportion of empty pods. It also helps in increasing nodulation, leghaemoglobin content and in turn reflected in pod yield (Kulkarni, 1982; Sankar and Reddy, 1984 and Raikhelkar, 1976).

Micronutrients, though, required in minor quantities, play an importent and specific role in the growth and development of plants. These elements have a very high effeciency value, that is very small quantities are sufficient to produce optimum effects. Boron is one of the seven recognized essential micro nutrients required for the normal growth. The beneficial effect was mentioned by Maze (1914) in France and it's essentiality was established by Warrington (1923).

Though, boron plays an important role, the bio-chemical role of boron is yet not well understood and it has not been shown to be part of an enzyme system Jackson and Chapman (1975). It is very importent for the germination of plant, root development and pollen, formation of flowers. Boron is also involved in the process of lignification and nuclic acid metabolism. It is associated with the cell division and affects the absorption of phosphorus, chloride and rubadium in a way which regulates the transport of many other substances across the plant membrane.

In groundnut, it was reported by Raju and Raju (1978) that boron deficiency leads to delayed flowering with less number of flowers, checks pegging and some times very few pegs are formed.

The little resemblance of boron and phosphorus in their chemistry and functions played by them further adds expected synergistic inter relationship of these two nutrients. Thus, it was felt necessary to plan experiments involving use of phosphorus and boron considering boron and phosphorus responsive crops in deficient soils.

Recent research has brought to focus the need to determine fertilizer doses for a entire crop rotation rather than on individual crop basis. Moreover, the difect and residual effects of boron and phosphorus were also likely to be encouraging in a suitable cropping system. This warrants systematic study on the relative benefits of direct and residual effects on component crops in different sequences in a wall defined soil-climate complex.

Phosphorus is widespread deficient in Marathwada soils with sporadic dificient patches of boron and crop responses to added boron and phosphorus are also found to be encouraging (Anonymous, 1987 and Malewar, 1987) though, the data are inadequate to draw generalised conclusions. Thus, it was felt necessary to assess the efficiency of phosphate sources with and without boron keeping inview the following objectives;

1) To study the agronomic effectiveness of various phosphorus sources with and without boron in Kharif cotton and Summer groundnut cropping system.

2) To study the availability of phosphorus and boron in cotton - groundnut cropping sequence.

3) To evaluate the direct and residual effect of various sources and levels of phosphorus on subsequent groundnut crop.

Chapter 2

REVIEW OF LITERATURE

2.1 Cotton

2.1.1 Effect of phosphorus alone and incombination with nitrogen on yield and quality attributes of cotton

Saxena (1962) found that application of 40 kg P_2O_5/acre increased total seed cotton yield and induced early maturity, but did not affect the vegetative growth.

Dhar (1964) and Singh et al. (1971) reported increase in yield of seed cotton at higher doses of phosphorus. In both reports phosphorus application gave higher seed cotton yield over control.

Increase in number of bolls/plant due to increasing levels of P_2O_5 was recorded by Datsur (1968).

Sinha and Pandey (1969) conducted a field experiment for four years continously with different levels of phosphorus and reported significant increase in yield, fibre length and ginning percentage with increasing levels of P in all years.

Phosphorus was reported to increase the root development favourably in cotton (1970).

Bairama (1977) reported increase in seed oil content by 1.7 to 2 per cent due to 100 kg application of P_2O_5/ha. The combination of N with P gave still further increase in oil content in cotton seeds.

Effect of levels of phosphorus and nitrogen on different cultivars were studied by Wankhede and Sadaphal (1977) and Khan and Hanif (1978). They reported significant increase in seed cotton yield irrespective of the cultivars with increase in doses of P alone and in combination with N and P.

Thakle (1979) confirmed the increase in seed cotton yield (g/pot) due to increasing levels of P_2O_5/ha.

Jambunath et al. (1981) studied the effect of nitrogeneous and phosphatic fertilizer on yield and quality of H_4 cotton at four levels of nitrogen and 3 levels of phosphorus. They concluded that P_2O_5 along is non-significant in attributing to pod yield, seed index and lint index. Only fibre maturity coefficient showed significance with P_2O_5.

Dhanpati and Kumarswami (1983) reported that DAP as 1.07 foliar spray alongwith some pesticides showed increase in yield of seed cotton.

Reddy in the same year conducted an experiment with four levels and sources of phosphorus i.e. 30, 60 and 90 kg/ha through, SSP, rock phosphate, fused magnecium phosphate and di calcium phosphate. He recorded increase in no. of bolls/plant, weight of boll and seed cotton yields with different phosphorus levels and sources.

Gill *et al.* (1985) and Ramakrishna Reddy (1985) observed increase in seed cotton yield due to the increasing levels of phosphorus. Further, they have also shown an increase in no. of bolls/plant and lint percentage by the application of P_2O_5.

Syed Ismail (1987) reported increase in seed cotton yield, lint index and fibre length due to increasing levels of phosphorus applications.

2.1.2 Effect of boron through soil and foliar spray on yield and quality attributes of cotton

Brand (1969) studied the symptoms of boron in cotton in Central Australian Republic and estimated that 15 ppm of B is critical concentrations for leaves during peak concentration.

Dertle and Roth (1969) depicted that suitable level of plant growth was highest for sugarbeat, lowest for soyabean and intermediate in cotton.

Chaudhary and Hisiani (1970) showed an increase in yield with increasing levels of boron as borax and recommended 2.5 ppm as optimum concentration as soil application.

Faulner *et al.* (1970) reported that boron increased the seedling emergence, leaf boron content and yarn strength when applied in boron defecient soils. Agav (1973) noted increase in seed cotton yield with application of boron 2 kg/ha.

Murphy and Landeaster (1971) studied the report of cotton to boron using different rates and methods of boron. They found broadcost was as effective as drilling. Boron concentration of plant increased with increasing application.

Mathews (1972) conducted experiment at 58 farmer's field's and recommended concentrated boronated compounds for applications with other nutrients in areas where only small amount is required.

Oosterhuis and Venter (1974-75) reported that boron has no influence on cotton grown on a site with no boron defeciency but he has reported less shedding of flowers.

Honish (1975) reported that B increased the seed cotton in yield in 5 out of 8 trials and found maximum yield with 2.4 kg B/ha at 20-30 ppm leaf content.

Zodorohnil (1976) reported that the germination and plant stand increased alongwith the yield of seed cotton when 0.01% boric acid solution was sprayed preceded by a seed treatment.

Modzhidor (1977) and Oosterhuis (1977) recommended boron application for increasing seed cotton yield.

Increased oil content due to the application of K and B were suggested by Gridley and Smithson (1977) while N decreased it.

Anter *et al.* (1978) studied the effect of foliar sprays of 25, 50 or 100 ppm, Cu, Mo or Zn or 10, 20 or 40 ppm B applied at different growth stages. They found that all treatments increased the fibre strength. Molybdinum and B increased fibre maturity but fibre length was decreased with boron application.

Cotton showed good response at 0.25 and 0.50 per cent boric acid spray in Punjab. But the increase was high at significantly higher levels of nitrogen (Brar *et al.*, 1983).

2.1.3 Effect of P and B on yield and quality attributes of cotton

Phosphorus application increased the seed cotton yield, weight of kapas/boll, no. of seeds/boll and tended to bring early maturity. This was reported by Datsur and Dabir (1962) from field experiments conducted at Amarvati.

Miley *et al.* (1969) concluded that boron enhanced the uptake and influence effeciency of applied nitrogen. They noticed that the yield of seed cotton increased only when N was applied with boron.

Mathews (1972) evaluated the effect of nitrogen and phosphorus at different levels in combination with 0.68 kg B/ha in 8 field trials. Six out of eight sites showed good response when nitrogen was applied. Where as P and B gave significant increase in yield of seed cotton in one site only. He recommended a concentrated boronated compound fertilizer for the application.

Agave (1973) the efficiency of boron in various combination and reported an increase in boll formation and maturation. He found that the dose of 2 kg/borax/ha with the main dose of 120:120:90 kg NPK/ha was most economical and beneficial to cotton crop.

An experiment was conducted at the main cotton research station Surat in 1972-73 and 1973-74. With graded doses of fertilizers. At higher doses increase in seed cotton was recorded (Bapna <u>et</u> <u>al</u>., 1975).

Highest dry matter weight and seed cotton yield was recorded at 200 kg N; 60 kg P_2O_5; 60 kg K_2O by Hasan <u>et</u> <u>al</u>. (1975) in a glass house experiment. The experimental doses were 100 or 200 kg N/hact and 0, 60 or 100 kg P_2O_5 kg/ha.

Smithson and Heathlcote (1976) evaluated efficacy of boronated super phosphate particularly on B deficient soils. He reported low yields of seed cotton at very high doses of nitrogen like 250 kg N/ha. But when it was supplemented with boron, significantly higher yields were recorded.

Varshney (1977) concluded that there was no significant effect on seed cotton yield due to phosphorus or when applied with nitrogen and potassium. But Khan and Hanif (1978) showed significant effect on seed cotton yield with N + P on cotton. The above report was endorsed by Jambhunathan et al. (1981) alongwith good ginning percentage, fibre length and staple length with nitrogen and phosphorus.

Reddy et al. (1985) confirmed the dose of 69.7 kg N/ha with 43.9 kg/P_2O_5 on the basis of pooled analysis of two years.

Zanzan (1986) evaluated the various sources and levels of phosphorus with and without boron on yield and quality parameter of cotton. He has reported significant increase in yield and improvement in quality of the yield due to phosphorus levels when applied with boron.

Several workers have made efforts to study the efficiency of phosphatic fertilizers in different crops. The research results published in the past on the various aspects relevent to phosphorus and boron nutrition in groundnut are compiled and presented in the following paragraphs.

2.2 Groundnut

2.2.1 Effect of phosphorus and boron on root growth and nodulation in groundnut.

Gopalkrishnan and Nagarajan (1958) observed practically no root formation when a nutrient solution without phosphorus was applied to groundnut, however, Thronton (1964) recorded that phosphorus addition to groundnut increased the number and density of nodules, nodule growth and in turn, rate of nitrogen fixation in groundnut.

Pillai and Sen (1970) studied the effect of trace elements on growth of rhizobium in groundnut and concluded that boron was not essential for Rhizobium but it enhanced the growth of organisms. On the contrary, Kulkarni (1982) noticed significant increase in nodulation due to boron application to groundnut.

Pawar and Khuspe (1976) reported positive effect of phosphorus in increasing the volume of nodules and this was evident in the ciritical stages of nodulation. Increasing levels of 'P' increased significantly the number of nodules/plant in groundnut. This was confirmed by Patil et al. (1981).

KoteswarRao (1979) concluded that phosphorus application alone or in combination with rhizobium increased nodule number as well as nodule weight in groundnut.

Sankar and Reddy (1984) showed increase in the number and weight of nodules, and leghaemoglobin content in groundnut with increasing levels of P_2O_5 application.

Zanzan (1987) recorded an increase in root mass, number of nodules, nodule weight with increasing levels of P_2O_5.

2.2.2 Effect of P and B on dry matter and other plant components in groundnut.

Gorgiev (1974) found that dry matter accumulation was more intense for the whole plant and pod with the application of phosphorus. Similar findings were also endrosed by Rathee and Owawal (1977).

Dongale (1974) in a pot culture experiment observed that the dry matter yield of groundnut at maturity stage was favourably influenced by the application of boron.

Cohen and Lepper (1977) concluded that boron is essential for the maintaince of meristematic activity of growing noot and stem tips, elongation of internodes, increasing root length and density of root hairs. Thus, boron plays an important role in growth and development of plant.

Enyi (1977) found that stem and pod dry weight was positively correlated with increased phosphate application (0, 224 and 443 kg/ha) in Tanzania. The soil used for experiment was clay loam.

Shradual (1980) observed that the dry matter yield of groundnut was not influenced by phosphorus application at any stage of plant growth except at the pegging.

Kadlong (1982) reported that application of B as borax 5 kg/ha was beneficial for dry matter production of groundnut at majority of the locations. The average dry matter varied from 0.45 to 2.44 g/plant at seedling stage.

Reddy and Krishnamurthy (1984) reported that P application significantly increased dry matter production of groundnut. Several experiments conducted under the jurisdiction of MPKV, Rahuri on boron nutrition in groundnut indicated that 5 kg borax/ha once in two or three years was useful in increasing the creaper yield of groundnut (Anonymous, 1985, 1986, 1987 and Malewar, 1986 and 1987).

2.2.3 Effect of P and B on nutrient concentration and their uptake by groundnut.

Increased root mass, root density and length of root provide greater root contact with the soil which in turn enhance higher nutrient uptake. Boron enhanced nodulation which helps in increasing N_2 fixation, phosphorus has also a role in root development and N_2 fixation. The following literature gives an insight into the research findings on the influence of P and B on nutrient concentration uptake by groundnut.

Pantakumar and Bathkal (1967) in a field trial, carriedout for the kharif season with N(0,20, lb's/acre), P(0,20 and 40 lb's/acre) and K(0 and 30 lb's/avre) reported that phosphate application increased N, P and K concentration and their uptake by pod and way of groundnut.

Gopal (1975) studied the effect of 10 ppm 'B' on the P, K and Ca status of plant in groundnut grown in sand culture over a period of 12 days and found that 'P' content of roots, middle and apical leaves increased slowly and was highest at 6th day. Boron application had increased K uptake and reduced Ca, middle leaves showed chlorosis at 8th day. In boron treated plants the ratio of P:Fe content increased in roots, middle and apical leaves.

Asokan and Raj (1976) estimated boron availability in groundnut in pot experiment using boric acid and borax as sources of boron. They found that availability of B increased with increasing rate of B and inturn increased the concentration and uptake by groundnut. Among them, borax was more available than boric acid.

Dongale and Zende (1976) in their experiment with groundnut in medium black calcareous soil, reported that application of 11.3 kg borax/ha increased uptake of N and K while 'P' uptake remained unaffected.

Applied phosphorus increased the concentration of P in kernel and foliage over control, irrespective of the fertilizer sources (Aulakh et al., 1980).

Patil et al. (1981) evaluated growth and nutrient uptake by groundnut as influence by 'P' levels. Higher leavels of 'P' significantly increased the concentration and uptake of N by roots. Similar results were reported by Karle (1982).

Kulkarni (1982) found that boron application showed increased uptake and concentration of N, P and B in groundnut plants.

In a green house experiment conducted Chahal *et al.* (1983) observed the shoot N, P and K contents were highest at early and midflowering stages. About 63 and 66 per cent of total N and P were absorbed before mid-flowering respectively. Phosphorus application significantly increased uptake of N and P.

Zalwadia and Patil (1983) reported that 'P' application at various levels (0,25,50 and 75 kg P_2O_5/ha) significantly increased uptake and concentration of N at various growth stages of groundnut. Similar results were also recorded by Mehta (1985) in groundnut.

Patil (1984) tested the efficiency of 'P' sources. He noticed that 'P' sources blended with boron showed significant increase in concentration of N, P, K and Ca and boron is groundnut over control.

The results of pot culture experiment revealed that application of 2 ppm boron significantly increased the uptake of N, P, K, Fe Cu and B but decreased that Ca, Mn and Zn (Patel *et al.*, 1986).

2.2.4 Effect of P alone and incombination with other nutrients on yield and quality attributes of groundnut.

Wahab *et al.* (1958) studied the effect of N and P fertilization on groundnut and observed that

'P' application of 37.5 lb's P_2O_5/acre resulted in an average increase in yield of 257 founds of nuts/acre. The increase in yield was observed till 520 pounds/acre. The increase in yield due to phosphorus application was confirmed by Rao and Govindarajan (1960) Pense and Khanna (1964).

Ajaykumar and Venkatachari (1972) indicated better shelling percentage at higher dose of P_2O_5. Oil content of kernels improved appreciably with higher phosphate levels.

Saini and Tripathi (1973) and Dhatonde and Rahate (1974) recorded better kernel weight and test weight with increasing levels of P_2O_5 over control.

Raikhelkar _et al_. (1976) studied the effects of different levels of P on pod yield of groundnut at Bandnapur from 1972-75 and concluded that P did not show any significant difference in dry pod yield.

Aulakh _et al_. (1980) compared effectiveness of three phosphatic fertilizers for groundnut and summarised that groundnut yield increased with applied phosphorus, but significant increase was obtained with SSP in first year and SSP and DAP in second year.

Ali and Rawat (1983) conducted an experiment to study the response of four groundnut cultivars to phosphate application under dryland condition and depicted more or less equal response to phosphorus.

Karle (1982) and Chavan and Karle (1983) reported significant increase in dry pod yield with higher shelling percentage and oil content at higher doses of phosphorus application.

Singh and Ahuja (1985) evaluated the effect of fertilizers and plant density on groundnut. They concluded that phosphorus application found to increase both growth and pod yield of groundnut.

Zanzan (1987) also showed an increase in pod yield, shelling percentage, oil content and 100-kernel weight of groundnut with increasing levels of phosphorus. Super phosphate with boron proved more effective than SSP alone.

2.2.5 Effect of boron on yield and quality attributes of groundnut.

Pilland (1944) reported that soil application of 10-20 lb/borax/acre gave significantly higher pod yield in groundnut, but slightly reduced shelling percentage. Similar reports of increase in pod yield were reported by Sanjeeviah (1969) and Yadahallia (1970).

Muthaswamy and Sandarrajan (1973) observed that boron has contributed to the increase in no. of pods/plant, weight of pod/plant and kernel wt. This was confirmed by Ashokan and Raj (1974) in a pot culture.

Dongale and Zende (1976) studied the response of groundnut to application of Mn, B and S through soil and foliar applications. They confirmed that soil application of borax (1.97 kg/ha) and foliar spray (0.5%) at 35 and 50 days crop age was beneficial to increase the yield attributes of groundnut.

Saxena and Mehrotra (1976) concluded that application of 11.2 kg borax/ha gave maximum yield at Kanpur, where as lower dose of 5 to 6 kg borax/ha was found to be optimum at Manipuri.

Sankaran <u>et al</u>.(1977) recorded an increase in oil content with increase in levels of 'B' from 0 to 30 kg borax/ha. Similar reports were received from Patil <u>et al</u>. (1981) with and without FYM. Kulkarni (1982) also endrosed similar findings on the use of boron for groundnut.

Patil and Narkhede (1978) noted that application of boron through soil or spray increased pod yield of groundnut on sandy loam soils rather than on clayey soils.

Bulbule (1983) studied the effect of boron and sulphur on yield and quality of groundnut and showed increase in pod yield, shelling percentage, 100-kernel weight and oil content significantly with application of boron.

Data reported by Patil (1984) revealed that application of 5 kg borax/ha + 50 kg P_2O_5 as single superphosphate and Boronated single super phosphate (50 kg/ha) significantly increased pod yield of groundnut from 13.8 to 21.36 q/ha.

Soil research review report presented at Joint Agresco of Maharashtra Agricultural Universities clearly depicted that 5 kg borax/ha significantly increased pod yield of groundnut and recommended application of 5 kg borax/ha once in two or three years on boron deficient soils. Beneficial residual effect of boron was also found in suceeding wheat crop (Malewar, 1986, 1987).

Mehta (1985) conducted a field experiment to study the effect of boronated superphosphate in comparison with SSP in Gujarat. He inferred that BSSP is a best source, which significantly increased maximum yield of dry pod, dry matter and oil yield. Maximum oil yield was obtained with application of BSSP (100 kg P_2O_5/ha).

Shinde and Kale (1985) indicated significant increase in pod yield due to the application of boron as foliar spray or soil application in calcareous soils from 20 trials on cultivators field from Maharashtra.

Kongale (1986) and Zanzan (1987) studied the effect of different sources of phosphorous in combination with boron. They found superiority of BSSP followed by Borax + single super phosphate in improving the yield potential and quality parameters.

Chapter 3

MATERIALS AND METHODS

The details of the materials used for conduct of experiment and methods employed for various estimations in soils and plants are presented in this chapter.

3.1 Details of experiment :

The experiment was conducted during *Kharif* 1987, on cotton (*Gossypium hirsutum*; Linn) and on groundnut (*Arachis hypogea*) in summer 1988, respectively at departmental farm, College of Agriculture, Maratawada Agricultural University, Parbhani.

3.2 Climate and geography of Parbhani

The sites of the field trials are geographically situated at 19°16' N latitude and 76°47' longitude at an altitude of 409 meter (MSL). The region falls in assured rainfall zone. The annual average rainfall in this region is 830 mm. Most of the rainfall is received during June to September from south-west monsoon.

Table 1. Metereological data of 1987 (June to January) and 1988 (January to June)

Month	Rainfall	Temperature °C		Humidity	
		Max.	Min.	AM	PM
June	127.8	37.8	25.2	69	36
July	111.6	33.1	24.3	81	55
August	345.6	31.1	23.2	87	67
Sept.	4.7	35.2	22.9	79	41
Octo.	122.4	32.8	18.2	84	42
Nov.	49.2	30.6	16.6	83	44
Dec.	38.0	28.8	9.9	85	33
Jan.	0.0	31.3	12.1	73	26
Feb.	0.0	34.5	15.4	53	18
Mar.	0.0	37.2	16.9	35	12
April	9.5	40.3	22.9	42	16
May	0.0	43.3	26.8	35	15
June	238.5	36.2	24.4	87	66

3.3 Experimental soil

The experimental field was properly levelled and a composite soil sample from 0-25 cm deapth was collected from all over the experimental field before giving the treatments. The composite soil sample was analysed for it's various physico-chemical properties. The results obtained are tabulated below.

Table 2. Physico-chemical composition of the experimental soil used for cotton groundnut cropping system

Soil property		Content
A) Mechanical composition		
1.	Coarse sand	8.46 per cent
2.	Fine sand	13.13 per cent
3.	Silt	24.20 per cent
4.	Clay	54.22 per cent
B) Chemical composition		
1.	pH (1:2 soil water suspention)	8.3
2.	EC (m mhos/cm)	0.31 m mhos/cm
3.	Total nitrogen(%)	0.056 per cent
4.	Available nitrogen	0.003 per cent
5.	Total phosphorus(%)	0.052 per cent
6.	Available phosphorus	9.70 kg/ha
7.	Boron (hot water soluble)	0.31 ppm
8.	$CaCo_3$	2.50 per cent
9.	Organic carbon	0.51 per cent

3.4 Experimental Treatments

The experiment on cotton was conducted in Kharif 1987 and groundnut in Summer, 1988 using four levels of phosphorus with four sources. The levels were (P_0-control, P_1-recommended dose of P_2O_5, P_2- recommended dose + 25% more and P_3-recommended dose + 50% more P_2O_5). The sources were; single superphosphate (SSP), Boronated single superphosphate (BSSP), Di-ammonium phosphate (DAP) and Borax + single superphosphate (B + SSP). There were sixteen treatment combinations. The experiment was laid out in a factorial randomized block design (FRBD) with three replications and the net plot size was 3.6 x 3.6 m^2 using cotton as a test crop (NHH.44).

This was followed by another experiment on groundnut (variety-SB XI) during Summer, 1988 on the same layout to list the residual effect of different applied phosphatic carriers. Direct effect of there treatment combinations on Summer groundnut was also studied simultaneously in a seperate experiment on the adjacent experimental plot.

The details of the treatment combinations are given in table 3 and layout plan of both the experiments are depicted in figure 1 and 2.

Table 3. Details of the fertilizer materials and levels.

	Abbre-vation	Total phosphate content (per cent)	Boron concent (per cent)
A) Fertilizer materials			
Single superphosphate	SSP	16	-
Boronated superphosphate	BSP	16	0.18
Diammonium phosphate	DAP	46	-
Borax	B	-	11
B) Phosphate levels			
Control	P_0		
Recommended dose	P_1		
Recommended dose + 25 per cent more	P_2		
Recommended dose + 50 per cent more	P_3		

Note In the phosphate source, Borax + single superphosphate mixture, borax is mixed with single superphosphate in increasing amounts with increase in phosphorus levels so as to maintain the amount of boron equal to that in boronated superphosphate.

Characteristics of different phosphate carriers used for experiment.

3.4.1 Single super phosphate (SSP)

It is completely water soluble phosphatic fertilizer containing 16 per cent P_2O_5 manufactured by the action of ground rock phosphate with sulphuric acid. The product is cured, dried and marketed in powder and granular form.

3.4.2 Boronated single super phosphate (BSSP)

Single superphosphate is blended with boron at the time of manufacture in 50 kg P_2O_5, 5 kg borox is added and mixed thoroughly to give final product of 16 per cent P_2O_5 and 0.18 per cent boron. The single superphosphate blended with boron was supplied by Dharamsi Morarji Chemicals Ltd., Bombay for experimental porpose.

3.4.3 Di-ammonium phosphate (DAP)

Di-ammonium phosphate is a graneular mixed fertilizer having ratio of N:P 18:46 proportion. It contained phosphorus in water soluble form while all it's nitrogen is in an ammonical form. It is produced by reacting ammonia with phosphoric acid in the pH range of 5.8 to 6.0.

3.4.4 Borax + single super phosphate (B + SSP)

Single superphosphate is hand mixed with borax (Sodium borate, $Na_2B_4O_7.10H_2O$) containing 11.0 per cent boron. The requisite quantity of borax is mixed with single superphosphate as per level of P_2O_5 to maintain 0.18 per cent boron identical to that of BSSP.

3.5 Fertilizer application

The recommended doses of fertilizers for irrigated cotton (*G. hirsutum*) and 100:50:50 kg and summer groundnut 25:50:0 kg NPK/ha, respectively.

Nitrogen and potassium were applied through urea (46% nitrogen) and murate of potash (60% K_2O) respectively. Calculated quantity of phosphorus was applied treatment wise to the respective crops.

Nitrogen was given in two split doses in cotton. Fifty per cent nitrogen was applied at the time of sowing and remaining 50 per cent was applied one month after sowing. Entire dose of phosphorus and potassium was applied at the time of sowing.

In order to test the direct effect of P levels and sources on Summer groundnut, an experiment with 16 treatment combinations was laid out.

The summer groundnut was also taken after cotton simultaneously without application of different levels and sources of P except 25 Kg N/ha at the time of sowing.

3.6 Seeds and sowing

The cotton seeds(NHH 44) were dibbled. Two seeds per hill were placed at the space of 90x60 cm as per package of practice. In groundnut (SB XI) seeds were also dibbled at a spacing of 30x15 cm as recommended for Summer groundnut.

Table 4. Schedule of cultural operations carried out on experimental plot during kharif and summer season

Cotton (Kharif) 1987

Sr. No.	Particulars	Frequency	Date of operation
A)	Presowing operations		
1.	Ploughing	1	4/7/1987
2.	Harrowing with bladed harrow	2	5/7/1987 and 9/7/1987
3.	Cleaning of field	1	10/7/1987
4.	Experimental layout	1	11/7/1987
B)	Sowing		
1.	Dibbling	1	13/7/87
C)	Fertilizer application		
1.	Basal application	1	13/7/1987
2.	Top dressing	1	14/8/1987
D)	Post sowing operations		
1.	Gap filling	1	28/7/1987
2.	Thinning	1	8/8/1987
3.	Hoeing	2	9/8/1987 and 10/8/1987
4.	Hand weeding	3	16/7/1987
E)	Irrigation	3	16/7/1987
F)	Plant protection measures		
1.	Sucking pest complex	3	3/8/1987 21/8/1987 4/9/1987
2.	Demacron and Rogar altermately		
3)	For boll worms	3	
4.	For fusarium wilt	1	
5.	Pickings	3	24/11/987 27/12/1987 20/1/1987

Table 5. Schedule of cultural operation carried out on experimental plot during summer season

Groundnut (Direct effect of fertilizers)

Sr. No.	Particulars	Frequency	Date of operation
A)	Presowing operations		
1.	Ploughing	1	21/1/88
2.	Harrowing	2	23/1/88 30/1/88
3.	Cleaning the field	1	27/1/88
4.	Experimental layout	1	3/1/88
B)	Sowing		
1.	Dibbling	1	5/2/88
C)	Fertilizer application	1	5/2/88
D)	Post sowing operation		
1.	Gap filling	1	20/2/88
2.	Thinning	1	27/2/88
3.	Hoeing	1	29/2/88
4.	Hand weedings	2	5/3/88 20/3/88
E)	Irrigations		7/2/88 and subsequent irrigations at 10 days interval
F)	Harvesting	1	2/6/88 3/6/88

Table 6 Schedule of cultural operations

Groundnut (Residual effect) Summer, 1987

Sr. No.	Particulars	Frequency	Date of operation
A)	Presowing operations		
1.	Digging the plot with pick area	1	22/1/88
2.	Clod crushing and levelling	1	23/1/88 and 24/1/88
3.	Re layout on same markings	1	4/2/88
B)	Fertilizer applications	1	6/2/88
C)	Sowing		
1.	Dibbling	1	6/2/88
D)	Post sowing operations		
1.	Gap filling	1	22/2/88
2.	Thinning	1	29/2/88
3.	Hoeing	1	30/2/88
4.	Hand weeding	2	7/2/88 23/2/88
E)	Irrigations		7/2/88 and subsequent irrigations every after 10 days
F)	Harvesting	1	3/6/88 and 4/6/88

3.7 Growth observations

Cotton (Kharif) 1987

3.7.1 Sampling technique

Five plants were randomly selected from each plot, marked with tags and all biometric observations were recorded on them.

3.7.2 Stamen count

Stamens are having direct influence on length of pollen tube and number of pollens. For this purpose five flowers were collected from each plot from selected for biometric observations in the morning hours after 60 days of sowing. The stamens were seperated with the help of forecep and counted.

3.7.3 Biometric observations

Biometric observations on number of branches/ plant and no.of bolls/plant were recorded as 85 and 115 days after sowing.

3.7.4 Yield of seed cotton

Seed cotton yield was recorded from each net plot and gross plot and then converted to hectare basis.

3.7.5 Dry matter studies

The cotton plants were sun dried for 15 days, weighed and then converted into hectare basis.

3.8 Post harvest studies

3.8.1 Ginning percentage

Ginning percentage was calculated treatment wise by ginning 200 g of seed cotton gfrom each treatment and weight of lint obtained was recorded. The formula used for ginning percentage is as follows:

$$\text{Ginning percentage} = \frac{\text{Lint weight}}{\text{Seed cotton lot}} \times 100$$

3.8.2 Mean halo length (Staple length)

The lint per cent on seed was combed keeping it on seed as it is and halo length was read at point on three radical lines marked on standard halo disc in mm and mean halo length was estimated.

3.8.3 Lint index

Lint index was calculated using formula

$$\text{Lint index} = \frac{\text{Cot of 100 seed x Ginning \%}}{\text{100- ginning \%}}$$

3.8.4 Seed index

It is weight of 100 seed which was calculated seperately for each treatment as a quality parameters.

3.9 Dry matter production

After final picking plants were up rooted from each net plot, dried (sun dried) for 10 days and weight was recorded treatment wise.

3.9.1 Groundnut observations

Groundnut (Direct and residual effect of phosphorus):

3.9.1.1 Nodule count per plant

Number of nodules/plant were counted periodically at pre flowering and mid bloom stage (30 and 50 days after sowing) of crop growth. Five plants were up rooted from each plot carefully avoiding border rows and brought to laboratory. The plant roots were washed carefully to remove soil sticking to them and number of nodules were recorded by seperating nodules with blade.

3.9.2.2 Weight of nodules

Immediately after nodule count, free nodules were weighed on monopan electrical balance and weights were recorded in mg

3.9.1.3 Root volume

These root characteristics were recorded from plants uprooted for nodule count. For this purpose three plants were uprooted by digging carefully from inner border rows of plots without damaging roots. Root portion was cut off and volume was measured with the help of measuring cylinder containing water by simple displacement method.

3.9.1.4 Root and shoot weight

Plants uprooted were oven dried and over dry weight of root and shoot was recorded on monopan electrical balance.

3.10 Post harvest studies

3.10.1 Pod yield

Experimental plot of each treatment in three replication were harvested pods from net plot were sun dried, weighed and recorded. The pod yield per plot was further converted into hectare basis.

3.10.2 Test weight

The hundred kernel weight was recorded from each treatment in three replications and considered as test weight.

3.10.3 Dry matter production

Uprooted plants at the time of harvest from all treatment plots were sun dried for 10 days and dry weight was recorded.

3.11 Soil analysis

3.11.1 Soil reaction

The pH was determined by using 1:2 soil water suspension on pH meter (Piper, 1950).

3.11.2 Electrical conductivity (EC mmhos/an)

The electrical conductivity of supernatant in 1:2 soil water suspension was measured with the help of solubridge conductivity meter.

3.11.3 Free $CaCO_3$

It was estimated by Puri's (1949) rapid titration method using Bromo thymol blue and boromo cresol green as an indicator (Piper, 1950).

3.11.4 Organic carbon

The modified method of Walkley and Black (1934) as described by Jackson (1967) was used for estimation of organic carbon.

3.11.5 Available nitrogen

It was determined by digesting soil with alkaline potassium permangamate solution described by Subbiah and Asija (1956).

3.11.6 Available P_2O_5

The soil extracted with 0.5 sodium bicarbonate and phosphorus was estimated with the method suggested by Olsen (1954).

3.11.7 Available Boron (hot water soluble)

The boron was determined colorometrically using curucumin as coloring agent as described by Jackson (1967).

3.12 Plant analysis

3.12.1 Preparation of plant samples

The plant samples collected were washed with tap water in fresh condition. Drying is carriedout under shed and oven dried.

Grinding was done with electrically operated grinder. The ground plant samples were stored in labelled paper bags and used for analysis purpose.

3.12.2 Total nitrogen

The nitrogen from plant samples was determined by mickokjeldahl's method (Jackson, 1967).

3.12.3 Phosphorus

The plant sample was digested in tri acid mixture (nitric acid, sulphuric acid and perchloric acid) and phsophorus was determined colorimetrically (yellow colour method) as suggested by Jackson (1967).

3.12.4 Boron

The plant boron was estimated asking the plant sample. The ash further dissolved in 0.1 N Hcl to prepare the extract. Two ml of extract was taken in a flask. To this few drops of concentration Hcl and 10 ml of H_2SO_4 were added the acid solution was allowed to cool. Boron was determined colorometrically using curcumin solution as a coloring agent (Jackson, 1958).

3.13 Uptake of nutrients

Uptake of nutrients was completed by multiplying the respective nutrient concentration by dry matter yield obtained/plot and further converted to uptake on hectare basis.

3.14 Statistical analysis

Results obtained were statistically analysed as per the method given in the book 'Statistical methods for Agricultural Worker's by Panse and Sukhatme (1967). Appropriate standard errors (SE) were worked out and critical differences (CD) at 5 per cent level were given wheneever necessary.

Chapter IV

RESULTS AND DISCUSSION

The cotton crop interact with phosphorus indifferently under vèrtisols. Some times it respond to the added phosphorus and many times no response is recorded. Thus, the soil-crop association is a very significant parameter in understanding the behaviour of cotton crop growth under vertisol. Similarly, sources of phosphorus also showed differential response to cotton. In view of these observations, studies on the sources and graded levels of phàsphorus on yield attributes, concentration and uptake of nutrients and availability of nutrients were planned during 1987 and 1988 in medium black soil identifical to that of Parbhani series (Malewar, 1976) at departmental Farm College of Agriculture, Parbhani. Subsequently, sources and levels of phosphorus on summer groundnut was tested. The results of these experiments were compiled and presented under appropriate topics and discuss in light of the advancement in the subject :

4.1 Influence of sources and levels of P on biometric characters and seed cotton yield

4.2 Influence of sources and levels of P on quality characters of cotton.

4.3 Influence of sources and levels of P on the nutrients concentrations and their uptake by cotton

4.4 Influence of sources and levels of P on the availability of nutrients in soil

4.5 Subsequent (residual) and direct effect of sources and levels of P on root and nodule characteristics of <u>summer</u> groundnut

4.6 Subsequent (residual) and direct effect of sources and levels of P on dry matter and grain yield of <u>summer</u> groundnut

4.7 Subsequent (residual) and direct effect of sources and levels of P on the nutrients concentrations and their uptake by <u>summer</u> groundnut

4.8 Subsequent and direct effect of sources and levels of P on the availability of nutrients in cotton-groundnut crop rotation.

4.1.1 <u>Effect of sources and levels of P on the branching in cotton</u>

These results presneted in Table 7(a) and (b) indicate that application of phosphorus significantly increased the branches/plant due to increasing levels of phosphorus at 80 and 115 DAS of cotton crop. The advanced

Table 7(a): Effect of sources and levels of P on the branching in cotton, at 80 DAS.

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	9.66	10.82	11.46	12.00	10.99
BSSP	8.92	11.20	12.44	13.00	11.39
DAP	9.34	11.66	13.02	14.00	12.01
B+SSP	9.45	11.33	12.00	12.82	11.40
Mean	9.34	11.25	12.23	12.96	

	Source	Level	Source x level
S.E.	0.437	0.437	0.8874
C.D.at 5%	0.1262	0.1262	0.2524

Table 7(b): Effect of sources and levels of P on the branching in cotton at 115 DAS

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	12.07	13.97	14.21	15.97	14.06
BSSP	13.74	15.20	16.34	17.82	15.78
DAP	13.24	15.78	16.82	17.69	15.88
B+SSP	13.56	15.00	16.52	17.52	15.65
Mean	13.15	14.99	15.97	17.25	

	Source	Level	Source x level
S.E.	0.069	0.069	0.1382
C.D. at 5%	0.119	0.119	0.3989

age of the crop has also contributed towards increase in branches/plant in cotton which is evidenced from the said table at 115 DAS. The mean branches/plant affected due to phosphorus was ranged between 9.34 to 12.96 and 13.15 to 17.25 at 80 and 115 DAS. Ismail (1987), in his experiment observed that graded levels of P helps to improve the branching and no.of branches/plant in cotton as recorded in this experiment.

Sources of phosphorus differed significantly in no.of branches/plant in cotton, though, the differences were of lower magnitude (Table 7a). At 80 DAS, di-amonium phosphate source of phosphorus gave maximum no.of branches/plant whereas Boronated superphoshate and di-ammonium phosphate were on par in branching with each other at 115 DAS. Zanzan (1987) and Ismail (1987) reported similar results on the influence of P and number of branches/plant in cotton.

Source X level indicated significant and positive effect of these combined factors on the no.of branches/plant in cotton. The maximum mean branching was recorded in DAP + 75 kg P_2O_5/ha and BSSP + 75 kg P_2O_5/ha and additive effect of sources and levels of P interaction was recorded by Ismail (1987).

By and large, it is summarised that there was significant and positive influence of graded P levels on the bearing of mean branches/plant in cotton. Among the sources of P, boronated superphosphate and di-amonium phosphate were superior over other P sources and proved better in increasing the mean branches/plant in cotton. It seemed that source level interaction worked mutually and added in mean no.of branching due to their presence in the growing medium.

4.1.2 Effect of sources and levels of P on the square formation in cotton

Data pertaining to the effect of source and levels of P on the periodical square formation in cotton are summarised in Table 8(a) and (b). These results revealed that the application of phosphorus is beneficial for square formation process in cotton. The increasing levels of phosphorus resulted in significant increase in number of square/plant at 50 and 80 DAS. The critical study of the Table 8a indicate that increasing levels of P proportionately and significantly increased the no.of squares/plant in cotton of 50 DAS. However, no significant increase in no.of square/plant was noticed beyond 50 kg P_2O_5/ha. These results are corresponding to those of Samudrale (1986).

Sources of P showed their significant effect on the square formation in cotton (Table 8b). Among the sources, BSSP and B+SSP performed well in square formation

Table 8(a): Effect of sources and levels of P on the square formation in cotton.

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
			50 DAS		
SSP	13.0	12.6	14.46	14.46	13.63
BSSP	12.06	21.0	22.20	24.96	15.30
DAP	13.00	14.13	15.34	16.50	14.74
B+SSP	12.00	15.26	20.80	24.47	18.13
Mean	12.51	15.82	18.20	20.09	

	Source	Level	Source x level
S.E.	0.5740	0.5740	1.1480
C.D. at 5%	1.6574	1.6574	3.3148

Table 8(b) Effect of sources and levels of P on the square formation in cotton.

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
			80 DAS		
SSP	27.60	40.23	45.10	47.10	40.00
BSSP	32.66	51.58	59.91	60.46	51.15
DAP	32.06	46.80	49.33	50.83	44.75
B+SSP	32.80	48.30	55.10	60.13	49.08
Mean	31.28	46.72	52.36	54.63	

	Source	Level	Source x level
S.E.	2.3305	2.3305	4.6610
C.D. at 5%	6.7290	6.7290	N.S.

and both the sources were on par in square formation process. On the other ahand, DAP could not show its superiority or SSP alone in no.of square/plant in cotton.

Though, relatively higher values of no.of squares/plant in cotton was noticed due to combined effect of sources and levels of P, it would not reach to the level of significance.

Thus, it is clearly depicted that P sources with boron had significantly higher squares/plant over phosphorus alone. This suggests the role of boron in reproductive phase or system in plant.

4.1.3 Effect of sources and levels of P on the boll formation in cotton

Results on the effect of sources and levels of P on boll formation in cotton are recorded in Table 9(a) and (b). This parameter, i.e. boll formation was influenced favourably and significantly due to addition of phosphorus to cotton (Table 9(a). However, application of phosphorus beyond 50 kg P_2O_5/ha did not affect the boll formation significantly of 80 and 115 DAS. The boll formation process was enhanced due to phosphorus application up to 50 kg P_2O_5/ha and further increment, though, showed little increase, they were, statistically on par with each other. Samudrale (1986) recorded significant number of bolls/plant due to phosphorus application.

Table 9 (a): Effect of sources and levels of P on the boll formation in cotton.

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
		80 DAS			
SSP	21.33	25.91	28.88	30.70	26.70
BSSP	23.00	32.16	37.83	41.72	33.67
DAP	23.32	28.88	30.52	31.88	28.65
B+SSP	23.27	31.88	34.18	35.48	31.20
Mean	22.73	29.70	32.85	34.94	

	Source	Level	Source x level
S.E.	1.9645	1.9645	3.9291
C.D. at 5%	5.6724	5.6724	11.3447

Table 9 (b): Effect of sources and levels of P on the boll formation in cotton.

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
		115 DAS			
SSP	27.04	33.10	41.19	45.79	36.60
BSSP	31.88	52.28	58.98	66.02	52.29
DAP	30.52	38.20	45.74	53.06	41.88
B+SSP	29.88	46.44	55.53	58.35	47.05
Mean	29.83	42.50	49.86	55.80	

	Source	Level	Source x level
S.E.	2.4408	2.4408	4.8817
C.D. at 5%	7.0488	7.0488	N.S.

Different sources of phosphorus did show significant differences in the no.of bolls/plant in cotton of 80 and 115 DAS. Among the sources of phosphorus, BSSP proved its superiority in boll formation followed by B+SSP.

Combined effect of sources of P and levels though indicated relatively higher values in respect of boll formation, but it could not reach to the level of statistical significance.

It is, thus, inferred that sources of P containing boron help to increase the boll formation process as against P sources with boron. Thus further included to draw conclusion that there is a specific role of boron in reproductive system of plant.

4.1.4 Effect of sources and levels of P on stamen count/flower

Data tabulated in Table 10 show the influence of sources and levels of P on the mean number of stamen/flower in cotton. The increasing levels of P up to 62.5 kg P_2O_5/ha showed significant increase in stamen count/flower. However, further increment in P dose could not influence the stamen count/flower in cotton. The graded levels of P influenced the stamen count which was in the range of 80.42 to 90.69 per flower. In his studies Ismail (1987) observed no significant increase in stamen count beyond 50 kg P_2O_5/ha.

The data in (Table 10) further depict that sources of phosphorus influenced the stamen count significantly. The range of stamen count affected due to sources of P was 83.85 to 99.74. Comparision between P sources indicated superiority of BSSP and B+SSP in increasing stamen count over other phosphorus sources tried in the experiment. Agarwala and Sharma (1976) pinpointed the involvement of boron in reproductive phase of crops. The results obtained in the present investigation on sources of P support the hypothesis of role of boron in reproductive system of crops.

Table 10 : Effect of sources and levels of P on the stamen/flower in cotton.

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	76.16	84.93	85.93	88.40	83.85
BSSP	80.60	92.13	95.66	94.60	90.74
DAP	82.73	86.86	87.53	87.46	86.14
B+SSP	82.20	84.86	92.86	92.33	88.06
Mean	80.42	87.19	90.49	90.69	

	Source	Level	Source x level
S.E.	0.5105	0.5105	1.0210
C.D. at 5%	1.4740	1.4740	2.9479

Interaction between sources x levels of P was significant and additive in increasing the stamen count/flower in cotton.

Thus, it is concluded that P helps to increase stamen count/flower and further improved by coupling P with boron.

4.1.5 Effect of sources and levels of P on the dry matter and seed cotton yield.

The data on the effect of sources and levels of P on seed cotton and dry matter yield are given in Table 11(a) and 11(b). It is seen from data (Table 11(a) that application of phosphorus significantly increased the seed cotton of yield which was in the range of 19.7 to 31.6 q/ha. Though, there was increase in seed cotton due to graded levels of P, beyond 50 kg P_2O_5/ha did not show significant differences in seed cotton. Dastur and Dabir (1962) and Thakre and Patle (1979) critically evaluated the fertilizer requirement of cotton and reported that phosphorus application helps to a greater extent for increasing seed cotton yield. More or less similar trend in dry matter production was noticed as that of seed cotton. Yield due to phosphorus levels. Samudrale (1986) endorsed similar observations in dry matter production influenced due to phosphorus addition to the growing medium.

Table 11 (a) : Effect of sources and levels of P on the seed cotton yield (g/ha)

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
			Seed cotton		
SSP	18.0	21.4	24.1	27.5	22.7
BSSP	22.2	32.2	33.1	36.4	31.0
DAP	19.0	23.5	27.5	29.2	24.8
B+SSP	19.8	27.6	30.4	33.2	27.7
Mean	19.7	26.3	28.8	31.6	26.6

	Source	Level	Source x level
SE ±	1.1398	1.13988	2.2717
CD at 5%	3.2912	3.2912	6.5813

Table 11 (b) : Effect of sources and levels of P on the dry matter yield (g/ha)

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
		Dry matter			
SSP	34.31	41.26	48.47	48.50	43.13
BSSP	34.03	46.41	51.16	54.31	46.70
DAP	33.70	49.61	50.23	53.08	46.70
B+SSP	33.32	45.00	47.27	48.33	43.45
Mean	34.03	45.56	49.26	51.02	

	Source	Level	Source x Level
SE ±			
SE ±	0.4679	0.4679	0.9358
CD at 5%	1.3512	1.3512	1.91

Further scruting of Table 11(a) and (b) revealed that phosphorus sources differed significantly in seed cotton and dry matter yield. The seed cotton and dry matter yield were in the range of 22.7 to 31 q/ha and 43.1 to 46.7 q/ha, respectively. Among the sources of phosphorus, BSSP showed higher seed cotton yield followed by B+SSP indicating the superiority of SSP blend boron or handmix borax with SSP. Smithson and Heathkote (1976) and Zanzan (1987) concluded that boronated superphosphate proved to be better in yielding highest seed cotton and dry matter over other sources. Interaction between sources and levels of P was indicative of their positive effect on the seed cotton and dry matter yield. Highest seed cotton and dry matter yield was noted under BSSP + 75 kg P_2O_5/ha.

In short, it can be concluded that phosphorus has responded to seed cotton and dry matter on vertisols containing available P and hot water soluble boron at the deficient levels. Further BSSP blend was proved superior in raising the seed cotton yield followed by handmixed borax with SSP.

4.2.1 <u>Effect of sources and levels of P on the lint percentage.</u>

The quality of cotton wool, like lint percentage, lint index and staple length depends upon the nutrition of crops. These quality parameters were estimated. The results on lint percentage are presented in Table 12. The data (Table 12) revealed that application of phosphorus showed significant increase in lint percentage of cotton which improve its quality. The lint percentage influenced due to phosphorus was in the range of 29.67 to 31.79 %. Further scrutiny of the data indicate that phosphorus beyond 50 kg P_2O_5 did not prove beneficial in improving lint percentage of cotton. Though, phosphorus sources with boron showed higher values of lint percentage over other P sources, the results are not statistically comparable. The results are in accordance with those of Gill *et al.*(1985). No interaction between sources and levels of P was identified.

Table 12 : Effect of sources and levels of P on the lint percentage (%) of cotton.

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	29.37	30.57	31.49	32.05	30.87
BSSP	28.85	31.56	32.06	31.82	31.07
DAP	30.47	31.76	31.17	30.25	30.91
B+SSP	30.02	30.75	31.73	33.05	31.38
Mean	29.67	31.16	31.61	31.79	

	Source	Level	Source x level
S.E.	0.4346	0.4346	0.8692
C.D. at 5%	N.S.	1.2548	N.S.

4.2.2 Effect of sources and levels of phosphorus on lint index of cotton.

Data presented in Table 13 on the effect of P sources and their levels on lint index point out that phosphorus levels have favourably increased the lint index. The increasing levels of phosphorus added significantly to the improvement of lint index upto 75 kg P_2O_5/ha The lint index varied from 3.17 to 3.38 indicating favourable effect of phosphorus addition. The results on lint index reported by Ismail (1987) are idential to that of present findings. Sources showed differential response in improving the lint index of cotton. Further source x level interaction was positive and combined effect was significant indicating adequate improvement over single factor.

Table 13 : Effect of sources and levels of P on the lint index of cotton.

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	3.14	3.25	3.33	3.39	3.27
BSSP	3.19	3.30	3.34	3.37	3.30
DAP	3.18	3.31	3.40	3.37	3.31
B+SSP	3.17	3.29	3.36	3.37	3.29
		Source			
Mean	3.17	3.28	3.35	3.38	
		Source	Level	Source x level	
S.E.		0.0045	0.0045	0.0089	
C.D. at 5%		0.0129	0.0129	0.0258	

4.2.3 Effect of sources and levels of P on the staple length of cotton.

It is observed from data (Table 14) that increasing levels of phosphorus upto 62.5 kg P_2O_5/ha helped to increase the staple length of cotton significantly. The magnitude of increase in staple length was from 24.05 to 26.41 mm due to phosphorus addition to the cotton crop. Such favourable effects of phosphorus were also noted by Ismail (1987) and Samudrale (1986).

Sources had favourable and significant effect on the staple length of cotton. Interaction between sources and levels of P was significant, indicating positive effect of combined parameters rather than individual.

Thus, it is inferred that phosphorus has great bearing on the improvement of quality of cotton wool interms of lint percentage, lint index and staple length. Further, sources of P with boron further added to the improvement in the quality parameters.

4.3.1 Effect of sources and levels of P on the nitrogen content in cotton.

Nitrogen concentration in plant and cotton seed influenced due to phosphorus are presented in Table 15(a) and 15(b). The N concentration varied from 1.07 to 1.54 and 3.31 to 3.39 per cent in plant and cotton seed, respectively. These results are clearly indicated significant

Table 14 : Effect of sources and levels of P on the staple length of cotton (mm).

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	24.13	25.41	25.63	26.28	25.43
RSSP	23.96	27.01	26.87	25.06	25.72
DAP	24.02	25.91	26.27	25.48	25.21
B+SSP	24.10	26.35	26.87	25.75	25.76
Mean	24.05	26.17	26.41	25.64	

	Source	Level	Source x level
S.E.	0.1056	0.1056	0.2112
C.D. at 5%	0.3050	0.3050	0.6099

Table 15 (a): Effect of sources and levels of phosphorus on the nitrogen content in cotton (%).

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	1.06	1.24	1.36	1.45	1.28
BSSP	1.06	1.33	1.44	1.64	1.37
DAP	1.08	1.27	1.40	1.55	1.33
B+SSP	1.07	1.25	1.39	1.51	1.31
Mean	1.07	1.27	1.40	1.54	

	Source	Level	Source x level
S.E.	0.0086	0.0086	0.0171
C.D. at 5%	0.0248	0.0248	0.0495

Table 15(b): Effect of sources and levels of phosphorus on the nitrogen content in cotton seed (%).

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	3.31	3.35	3.36	3.37	3.35
BSSP	3.31	3.40	3.42	3.42	3.39
DAP	3.30	3.34	3.35	3.35	3.34
B+SSP	3.31	3.41	3.41	3.43	3.39
Mean	3.31	3.38	3.39	3.39	

	Source	Level	Source x level
S.E.	0.0060	0.0060	0.0119
C.D. at 5%	0.0172	0.0172	0.0345

influence of graded levels of phosphorus on the content of nitrogen in cotton. These observations pointed out the beneficial effect of phosphorus on nitrogen absorption by plant. Phosphorus, thus probably works mutually to increase the availability of N in soil and inturn adequately high absorption of N by plant. Samudrale (1986) also depicted the fact that phosphorus helps to increase the concentration of nitrogen in cotton.

Sources of phosphorus showed significant effect on the concentration of N in cotton seed and plant. The concentration of N varied between 1.28 to 1.37 and 3.34 to 3.39 per cent in plant and cotton seed, respectively. Among the sources, BSSP and B+SSP were superior in nitrogen concentration over other phosphorus sources. Combined effect of sources and levels of phosphorus was positive and significant in increasing concentration of N in plant and cotton seed. The maximum N in plant and cotton seed was in BSSP and B+SSP treatment, respectively.

In nutshell, it is summarised that application of phosphorus helped to increase N concentration in plant and cotton seed. This further indicated synergistic effect of phosphorus on N concentration.

4.3.2 Effect of sources and levels of P on the concentration of phosphorus and boron in cotton.

Table 16(a) and (b) consist of data on the influence of sources and levels of phosphorus on P and concentration in cotton. A personal or results indicated that graded levels of phosphorus showed significant increase in phosphorus and boron concentration in cotton plant. The concentrationof phosphorus and boron varied from 0.40 to 0.49 per cent and 7.70 to 10.05 ppm, respectively. Samudrale (1986) also observed significant increase in P concentration due to phosphorus levels. Further, P application favourably increased the boron concentration in cotton plant. This favourable effect of phosphorus on boron concentration in cotton plant may probably be attributed to the mutual and positive interaction between these two elements.

Sources of phosphorus also resulted in significant increase in boron and phosphorus concentration in cotton. The range of phosphorus and boron influenced due to P addition was from 0.42 to 0.48 per cent and 8.38 to 10.30 ppm, respectively. Among the sources of phosphorus, BSSP exerted greatest influence on improving the P and B status of cotton plant followed by B+SSP.

Table 16 (a): Effect of sources and levels of P on the concentration of phosphorus (%).and

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
		Phosphorus			
SSP	0.40	0.42	0.42	0.45	0.42
BSSP	0.39	0.45	0.52	0.56	0.48
DAP	0.40	0.43	0.44	0.46	0.43
B+SSP	0.41	0.43	0.46	0.47	0.44
Mean	0.40	0.43	0.46	0.49	

	Source	Level	Source x level
S.E.	0.0206	0.0206	0.0413
C.D. at 5%	0.0596	0.0596	0.1192

Table 16(b): Effect of sources and levels of P on the concentration of Boron (ppm), in plant.

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
		Boron			
SSP	7.7	8.2	8.6	9.0	8.38
BSSP	7.7	10.6	11.2	11.7	10.30
DAP	7.8	8.3	8.9	9.0	8.50
B+SSP	7.7	9.7	10.5	10.5	9.60
Mean	7.70	9.70	9.80	10.05	

	Source	Level	Source x level
S.E.	0.1265	0.1265	0.2530
C.D. at 5%	0.3563	0.3563	0.7306

Positive interaction between sourced and level of P was recorded which was showing increasing trend in concentration of phosphorus and boron in cotton.

It is concluded that phosphorus application helps to increase its concentration and concentration of boron in cotton. This suggests positive and significant relationship between the behavour of two elements.

4.3.3 Effect of sources and levels of P on the uptake of nitrogen, phosphorus and boron by cotton.

The absorption of nitrogen, phosphorus and boron by cotton influenced due to sources and levels of phosphorus are given in Table 17, Table 18 and 19. The table shows that phosphorus application significantly increased the uptake of nitrogen, phosphorus and boron by cotton. The uptake of nitrogen varied from 35.62 to 78.76 kg N/ha due to graded levels of phosphorus indicating proportional increase in uptake of N with increasing levels of phosphorus. The pattern of N uptake followed similar trend that of concentration of N in cotton plant. The addition of phosphorus helps to inc ease the uptake of N which is indicative of synergistic relationship between N and P. Samudrale (1986) and Zanzan (1987) showed that application of phosphorus helps to absorb sufficient nitrogen by facility the availability of more nitrogen

Table 17 : Effect of sources and levels of P on the uptake of nitrogen in cotton (kg/ha).

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
		Nitrogen (kg/ha)			
SSP	32.83	51.47	66.23	70.78	55.32
BSSP	37.24	61.71	73.70	89.02	65.41
DAP	36.64	63.02	70.29	82.11	63.01
B+SSP	35.78	56.38	65.54	73.15	57.71
Mean	35.62	58.14	68.84	78.76	

	Source	Level	Source x level
S.E.	0.7423	0.7423	1.4845
C.D. at 5%	2.1432	2.1432	4.2864

Table 18 : Effects of sources and levels of P on the uptake of phosphorus in cotton (kg/ha).

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
		Phosphorus (kg P_2O_5/ha)			
SSP	13.73	17.35	20.36	22.12	18.39
BSSP	13.63	24.27	26.59	30.24	23.68
DAP	13.50	21.35	22.09	24.37	20.32
B+SSP	13.66	19.33	21.73	22.71	19.35
Mean	13.63	16.26	22.69	24.86	

	Source	Level	Source x level
S.E.	.87,4027	.87,4027	124,8050
C.D. at 5%	252,3660	252,3660	504,7310

Table 19 : Effect of sources and levels of P on the uptake of boron on the uptake of cotton (g/ha):

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{70}	
			Boron (g/ha)		
SSP	28.85	37.14	44.59	44.60	38.79
BSSP	30.12	47.49	62.26	64.98	51.21
DAP	29.07	43.84	46.70	49.80	42.35
B+SSP	28.01	45.94	54.31	57.59	46.51
Mean	29.01	43.60	51.96	54.24	

	Source	Level	Source x level
S.E.	1.1064	1.1064	2.2128
C.D. at 5%	3.1946	3.1947	6.3992

for N utilization. Sources exerted significant influence on the increase in N uptake by cotton. The uptake of N affected due to sources of P was in between 55.32 to 65.41 kg N/ha. Among the sources of P, BSSP showed highest N uptake by cotton. Interaction between source level of P also inclined to show favourable and significant effect on N absorption by cotton.

Further, it is seen that application of phosphorus brings the uptake values of phosphorus to the level of statistical significance. Uptake of P by cotton, more or less followed similar trend that of concentration of phosphorus in cotton. The phosphorus uptake varied between 13.63 to 24.86 kg P_2O_5/ha due to graded P levels indicating the highest P uptake under application of 75 kg P_2O_5/ha treatment. Similar results are also recorded by Samudrale (1986). Sources of phosphorus are also favourable in increasing P uptake by cotton which was ranged between 18.39 to 23.68 kg P_2O_5/ha. Among the sources, phosphorus blend with boron and SSP mixed with borax performed significantly in improving the uptake status of phosphorus. This observation helps to draw conclusion that presence of adequate boron along with phosphorus encourage the more absorption of phosphorus by crop. Source x level interaction effect further strengthen the hypothesis of positive relationship between phosphorus and boron.

Critical examination of the data (Table 19) further spell out that increasing levels of phosphorus added to the boron uptake by cotton crop. The uptake values of boron ranged between 29.01 to 54.24 g/ha which were affected due to graded P levels. Increasing levels of phosphorus found to increase the uptake of boron which is indicative of synergistic relationship between these two elements. This indication was further obtained strengthened by the significant values of boron uptake obtained due to sources of phosphorus. The maximum boron uptake was recorded in the treatment through 75 kg P_2O_5/ha was applied in the form of boronated superphosphate. This also further indicate the positive interaction between sources and levels of P.

Thus, it is inferred that phosphorus addition helps not only to increase P uptake but also faciliatated the absorption of N and B by cotton, when phosphorus coupled with boron there was more enhancement in uptake of N, P and B by cotton.

4.4.1 Effect of sources and levels of P on the availability of N P and B in soil at harvest :

The total N, available P_2O_5 and hot water soluble boron content influenced due to sources and levels of P are presented in Table 20, 21 and 22. It would be seen from the data that application of phosphorus favourably influenced the total N content in the soil at the end of the experiment. The mean total N varied from 0.055 to 0.060% due to phosphorus addition. Further insight of data revealed that sources of phosphorus also contributed to the improvement in total N status in soil. Source-level interaction, however, did not prove its significance in altering N status. The available phosphorus status of soil found to increase in the range of 11.98 to 24.6 kg P_2O_5 per ha due to phosphorus application. The increasing levels of phosphorus application. The increasing levels of P resulted in improvement in P status of soil at the end of harvest of cotton crop. Sources further added to the more availability of phosphorus. Maximum available P_2O_5 was recorded in BSSP treated plot while minimum available phosphorus was noted in SSP treatment. Thus, phosphorus when coupled with boron containing fertilizer, help to increasing availability of phosphorus. Interaction was non significant.

Boron status in soil was ranged between 0.31 to 0.43 ppm due to phosphorus application. This datashowed significant effect on the availability of boron due to presence of phosphorus. Sources of phosphorus further exerted positive influence on boron availability in soils at the end of harvest of experiment.

By and large, phosphate is intimately associated with the availability of N,P and B in soil. Phosphorus also showed positive relationship with N and B availability.

Table 20: Effect of sources and levels of P on the content of nitrogen in soil at harvest (%).

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
			Total N (%)		
SSP	0.052	0.055	0.058	0.056	0.055
BSSP	0.056	0.057	0.058	0.062	0.058
DAP	0.054	0.056	0.059	0.057	0.057
B+SSP	0.058	0.058	0.063	0.058	0.059
Mean	0.055	0.057	0.060	0.058	

	Source	Level	Source X level
S.E.	0.0009	0.0009	0.0017
C.D. at 5%	0.0025	0.0025	0.0050

Table 21 : Effect of sources and levels of P on the content of phosphorus in soil at harvest(kg/ha)

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
	Available P_2O_5(kg/ha)				
SSP	11.8	22.4	23.2	24.0	20.35
BSSP	12.2	23.7	24.9	25.8	21.65
DAP	12.0	23.2	23.9	24.6	20.93
B+SSP	11.9	23.4	24.0	24.0	20.82
Mean	11.98	23.18	24.0	24.6	

	Source	Level	Source x level
S.E.	0.3692	0.3692	0.7384
C.D. at 5%	1.0660	1.0660	2.1320

Table 22 : Effect of sources and levels of P on the content of boron in soil at harvest(ppm)

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
	Hot water B (ppm)				
SSP	0.31	0.34	0.35	0.35	0.33
BSSP	0.32	0.40	0.47	0.52	0.42
DAP	0.32	0.33	0.36	0.37	0.34
B+SSP	0.31	0.37	0.44	0.50	0.40

	Source	Level	Source x level
S.E.	0.0992	0.0992	0.0185
C.D. at 5%	0.0267	0.0267	00534

4.5 Groundnut

4.5.1 Direct and residual effect of sources and levels of phosphorus on the nodulation of groundnut and root characteristics

Nodule counts at 30 and 50 DAS in groundnut as influenced by P sources and their levels are presented in Table 23(a),(b) and 24(a),(b).

The data clearly revealed that increasing levels of P significantly increased the nodule number at 30 and 50 DAS observations. Further it was depicted that, there was considerable increase in nodule count at 50 days when compared to 30 days observations. The increase in nodule per plant was in the range of 29.14 to 47.26 and 94.4 to 133.6 at pre flowering and midbloom stages, respectively. Beneficial effect of P application on the significant increase in groundnut was also reported by Karle (1978); Patel et al. (1981); Zanzan (1987 and Syed (1987).

Sources of P had influenced the nodulation in groundnut favourably and significantly at 30 and 50 DAS observations. The differences in nodulation due to sources of P were relatively wide at 30 days where as they were narrowed at 50 days observations. Among the sources boronated super phosphate was better for increasing the nodualation in groundnut followed by Borax + SSP. Statistically SSP and DAP were found to be

Table 23(a): Direct effect of sources and levels of P on the nodule count at 30 DAS

Source	Levels of phosphorus				
	P_0	P_{50}	$P_{62.5}$	P_{75}	Mean
			30 DAS		
SSP	30.72	40.23	41.37	42.20	38.63
BSSP	30.13	49.49	49.83	52.27	45.43
DAP	24.45	40.45	42.18	43.63	39.00
B +SSP	29.29	46.68	49.26	50.94	44.04
Mean	29.14	44.21	45.66	47.26	

	Source	Level	Source x level
SE ±	0.6474	0.6474	1.2948
C.D. at 5%	1.8692	1.8692	3,7385

Table 23(b) : Direct effect of sources and levels of P on the nodule count at 50 DAS

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
			50 DAS		
SSP	97.57	113.09	123.72	127.56	115.48
BSSP	98.23	126.93	136.50	145.57	126.80
DAP	97.16	115,87	122.27	124.43	114.93
B+SSP	100.66	124.31	132.73	136.98	123.67
			50 DAS		
Mean	98.40	120.05	128.80	133.63	

	Source	Level	Source x level
S.E.±	0.4634	0.4634	0.9268
C.D.at 5%	1.3381	1.3381	2.6761

Table 24(a) : Residual effect of sources and levels of P on the nedule count at 30 DAS

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
			30 DAS		
SSP	34.54	43.07	45.23	48.25	42.77
BSSP	34.08	51.03	62.46	68.52	54.02
DAP	33.69	44.83	45.38	48.15	43.01
B+SSP	34.88	47.29	52.94	60.42	48.88
Mean	34.29	46.55	51.50	54.02	

	Source	Level	Source x level
S.E. ±	0.5375	0.5375	1.0750
C.D. at5%	1.5520	1.5520	3.1040

Table 24(b) : Residual effect of sources and levels of P on the nodule count at 50 DAS

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
			50 DAS		
SSP	106.62	123.29	130.30	131.26	122.99
BSSP	104.93	139.50	147.27	152.74	136.11
DAP	106.90	120.59	123.86	126.93	119.57
B+SSP	108.42	132.52	138.06	139.78	129.69
Mean	106.71	129.10	134.87	136.67	

	Source	Level	Source x level
S.E. ±	0.4208	0.4208	0.8416
C.D. at 5%	1.2150	1.2150	2.4301

at par with each other in the formation of nodules at both stages. Maximum nodule acount (45.43 and 146.8 at 30 and 50 DAS, respectively) was registered in boronated superphosphate. The results obtained on nodulation are in accordance with those of Singh (1972); Barbose de Mattose (1975) and Zanzan (1987). Interaction had positive and significant affect on nodulation process. The highest nodulation due to interaction was recorded at 75 kg P_2O_5/ha through boronated superphosphate.

Residual effects of P levels and sources on nodulation of summer groundnut are recorded in Table 24(a),(b). From the results given in Table 24(a),(b) it is seen that there was significant and positive effect on the nodule count due to residual fertility of P sources and levels added to preceeding crop. The nodule count affected due to residual was in the range of 34.2 tc 54.0 and 106.7 to 136.6 at preflowering and mid bloom stages respectively. Further examination of the data indicate that P application through various sources had also significant affect on nodulation in groundnut. Highest nodulation at both stages was observed in boronated superphosphate treatments. The interaction effect of levels and sources of P was found to be significant to enhance nodulation at both stages. The nodulation was increased with age of the crop.

It is evident from the literature that there is indirect involvement of phosphorus in the nodulation process.

Bulbule (1983) and Zanzan (1987) while working on nutritional requirement of groundnut reported that P and boron when applied in combination proved better for increasing the nodulation count.

The above results indicate that increasing levels of P showed significant increase in nodule count of groundnut as a residual value on direct applications. Among the sources BSSP proved it's superiority in improving nodule count over other P sources. Further, sources x levels of P also resulted in significant increase in nodule count.

Nodule weight as influenced by sources and levels of phosphorus as direct and residual application are presented in Table 25(a),(b) and 26(a),(b).

A perusal of the data (Table 25 and 26) reveal that the nodule weight was increased with increasing levels of P at the pre flowering and mid bloom stage under direct and residual effect conditions. Nodule weight varied b between 29.9 to 79.6 and 25.6 to 103.4 at 30 and 50 days after application. It is also noticed that increasing P levels proportionately increased the nodule weight under residual effect condition. Similarly sources of P under both conditions (Direct and residual). Boronated superphosphate enhanced nodulation under both conditions with increasing levels of P.

The combined effect of sources x levels was found to be significant at preflowering and mid-bloom stage

Table 25(a) : Direct effect of sources and levels of P on the nodule weight at 30 DAS (mg)

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
			30 DAS		
SSP	30.10	56.17	64.58	73.43	56.07
BSSP	29.52	66.71	76.18	90.55	65.74
DAP	29.80	59.87	72.14	81.58	60.84
B+SSP	30.56	58.80	71.30	73.03	58.42
Mean	29.99	60.38	71.05	79.64	

	Source	Level	Source x level
S.E. ±	0.4608	0.4608	0.9216
C.D. at 5%	1.3305	1.3305	2.6610

Table 25(b): Direct effect of sources and levels of P on the nodule weight at 50 DAS (mg)

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
			50 DAS		
SSP	25.68	54.29	78.45	90.28	62.15
BSSP	26.82	65.84	106.84	122.87	80.59
DAP	25.93	51.07	78.09	94.23	62.33
B+SSP	24.17	62.42	99.65	106.52	73.19
Mean	25.62	58.40	90.75	105.47	

	Source	Level	Source x level
S.E. ±	0.6280	0.6280	1.2561
C.D. at 5%	1.8134	1.8134	3.6268

Table 26(a) : Residual effect of sources and levels of P on the nodule weight at 30 DAS (mg)

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
			30 DAS		
SSP	31.34	61.49	64.76	77.46	58.76
BSSP	34.32	72.57	85.67	82.82	68.84
DAP	30.84	64.48	74.04	76.82	61.65
B+SSP	65.60	76.05	76.88	762.88	62.88
Mean	32.37	66.03	75.13	78.49	

	Source	Level	Source x level
S.E. ±	0.4459	0.4459	0.8918
C.D. at 5%	1.2875	1.2875	2.5750

Table 26(b) : Residual effect of sources and levels of P on the nodule weight at 50 DAS (mg)

Sources	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
			50 DAS		
SSP	30.11	61.63	76.58	93.98	65.57
BSSP	31.71	73.89	106.85	120.03	83.12
DAP	30.35	60.62	80.73	91.94	65.91
B+SSP	32.49	70.54	97.16	104.47	76.16
Mean	31.16	66.67	90.33	102.60	

	Source	Level	Source x level
S.E. ±	0.4364	0.4364	0.8727
C.D. at 5%	1.2599	1.2599	2.5199

under both conditions (Direct and residual). The higher magnitude of nodule weight due to residual P may be attributed to the release of native was P which was made available to the nodulation process. Kongale (1986) and Syed (1987) showed increased nodule weight of groundnut fertilized with boronated superphosphate. From the above discussion it can be concluded that phosphorus and boron incombination on helped to increase nodule weight of groundnut. Residual effect of P levels and sources was prominent than it's direct effect on nodulation and nodule weight.

4.5.2 Effect of P sources and their levels on their root weight and root volume of groundnut

The data on root weight and volume 30 and 50 DAS of growth period as influenced by P sources and their levels are compiled in Table 27,28,29 and 30.

Application of P at graded levels through it's various sources significantly increased the root weight and volume of groundnut at preflowering and mid bloom stage under direct and residual conditions. Similarly various sources of P also significantly increased the root growth of groundnut at 30 and 50 days of observations. Among the sources of P, boronated superphosphate showed significant increase in root growth over other sources. Admixture of B + SSP was next to BSSP in increasing the root weight and volume at preflowering and mid bloom stages of crop growth in groundnut under both conditions.

Table 27(a) : Direct effect of sources and levels of P on the root weight at 30 DAS.

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
		30 DAS			
SSP	0.30	0.35	0.39	0.43	0.36
BSSP	0.30	0.40	0.48	0.50	0.42
DAP	0.29	0.34	0.38	0.39	0.35
B+SSP	0.30	0.38	0.42	0.44	0.38
Mean	0.29	0.36	0.41	0.44	

	Source	Level	Source x level
S.E.±	0.0046	0.0046	0.0091
C.D. at 5%	0.0132	0.0132	0.0264

Table 27(b) : Direct effect of sources and levels of P on the root weight at 50 DAS.

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
		50 DAS			
SSP	0.46	0.59	0.70	0.75	0.62
BSSP	0.45	0.76	0.86	0.91	0.74
DAP	0.44	0.54	0.62	0.71	0.57
B+SSP	0.45	0.69	0.78	0.86	0.69
Mean	0.44	0.64	0.73	0.80	

	Source	Level	Source x level
S.E. ±	0.0032	0.0032	0.0065
C.D. at 5%	0.0094	0.0094	0.0187

Table 28(a) : Residual effect of sources and levels of P on the root weight at 30 DAS.

Source	Levels of phosphorus				
	P_0	P_{50}	$P_{62.5}$	P_{75}	Mean
			30 DAS		
SSP	0.39	0.49	0.54	0.59	0.50
BSSP	0.40	0.54	0.64	0.71	0.57
DAP	0.37	0.45	0.50	0.55	0.46
B+SSP	0.39	0.55	0.58	0.65	0.54
Mean	0.39	0.50	0.56	0.62	

	Source	Level	Source of level
S.E. ±	0.0067	0.0067	0.0134
C.D. at 5%	0.0193	0.0193	0.386

Table 28(b): Residual effect of sources and levels of P on the root weight at 50 DAS.

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
			50 DAS		
SSP	0.50	0.66	0.73	0.79	0.67
BSSP	0.49	0.81	0.92	0.97	0.79
DAP	0.50	0.59	0.71	0.74	0.63
B+SSP	0.50	0.75	0.80	0.84	0.72
Mean	0.49	0.70	0.79	0.83	

	Source	Level	Source x level
S.E. ±	0.0026	0.0026	0.0052
C.D. at 5%	0.0075	0.0075	0.0149

Table 29(a) : Direct effect of sources and levels of P on the root volume at 30 DAS.

Source	P_0	P_{50}	$P_{62.5}$	P_{75}	Mean
	Levels of phosphorus				
			30 DAS		
SSP	1.14	1.40	1.86	1.91	1.57
BSSP	1.14	2.04	2.24	2.26	1.92
DAP	1.10	1.42	1.75	1.86	1.53
B+SSP	1.09	1.98	2.23	2.27	1.89
Mean	1.11	1.71	2.02	2.07	

	Source	Level	Source x level
S.E. ±	0.0166	0.0166	0.0333
C.D. at 5%	0.0481	0.481	0.0961

Table 29(b): Direct effect of sources and levels of P on the root volume at 50 DAS.

Source	P_0	P_{50}	$P_{62.5}$	P_{75}	Mean
	Levels of phosphorus				
			50 DAS		
SSP	0.93	1.09	1.26	1.40	1.17
BSSP	0.94	1.49	1.79	1.92	1.53
DAP	0.94	1.26	1.47	1.58	1.31
B+SSP	0.96	1.41	1.70	1.85	1.48
Mean	0.99	1.31	1.55	1.68	

	Source	Level	Source x level
S.E. ±	0.0035	0.0035	0.0070
C.D. at 5%	0.0101	0.0101	0.0202

Table 30(a) : Residual effect of sources and levels of P on the root volume at 30 DAS.

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
		30 DAS			
SSP	1.11	1.42	1.85	1.92	1.57
BSSP	1.12	2.00	2.29	2.29	1.92
DAP	1.08	1.44	1.78	1.88	1.54
B+SSP	1.09	1.98	2.14	2.16	1.84
Mean	1.10	1.71	1.81	2.06	

	Source	Level	Source x level
S.E. ±	0.0231	0.0231	0.0462
C.D. at 5%	0.0667	0.0667	0.1334

Table 30(b) : Residual effect of sources and levels of P on the root volume at 50 DAS.

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
		50 DAS			
SSP	1.04	1.35	1.41	1.46	1.31
BSSP	1.04	1.60	1.80	1.91	1.58
DAP	1.05	1.34	1.42	1.44	1.30
B+SSP	1.05	1.55	1.64	1.77	1.50
Mean	1.04	1.46	1.56	1.64	

	Source	Level	Source x level
S.E. ±	0.0036	0.0036	0.0072
C.D. at 5%	0.0104	0.0104	0.0207

The interaction effect of sources and levels to enhance root weight and volume at preflowering and mid bloom stage under direct and residual conditions was found to be statistically significant. Root weight was comparatively higher under residual condition as compared to direct condition at both stages. Highest root weight was recorded with boronated superphosphate treatment. Koteswara Rao (1979); Kongale (1986) and Zanzan (1987) reported increased root weight and volume of groundnut due to P application through various sources.

4.6 Direct and residual effect of sources and levels of phosphorus on dry matter and pod yield of summer groundnut

The data presented in Table 31 and 32, give an indication for the significant differences in pod and halum yield resulting from various levels of phosphorus through different sources. P fertilization exhibited progressive substantial pod and halum yield with it's levels under direct and residual conditions. Phosphorus at 75 kg P_2O_5/ha recorded highest pod (30.8 q/ha) and halum 3051 kg/ha) as a direct effect. How every the pod and halum yields were reduced under residual conditions. Sources of phosphorus also exhibited significant differences in pod and halum yield under both direct and residual conditions. Boronated superphosphate exerted greater effect to increase pod and halum yield followed by B+SSP under direct and residual

Table 31(a): Direct effect of sources and levels of P on the pod yield of groundnut.

Source	Levels of Phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	19.79	23.64	26.32	27.02	24.19
BSSP	20.38	29.77	32.85	35.21	29.55
DAP	20.54	24.83	27.51	28.53	25.35
B+SSP	20.22	27.72	31.56	32.44	27.98
Mean	20.23	26.49	29.56	30.8	

	Source	Level	Source x level
S.E.±	0.1459	0.1459	0.2917
C.D. at 5%	0.4212	0.4212	0.8424

Table 31(b): Direct effect of sources and levels of P on dry matter yield of groundnut.

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	2304	2543	2747	2864	2614.5
BSSP	2366	2619	2862	3310	2789.25
DAP	2385	2595	2685	2877	2635.5
B+SSP	2329	2587	2897	3155	2742.0
Mean	2346	2586	2797.75	3051.5	

	Source	Level	Source x level
S.E.±	16.11	16.11	32.23
C.D. at 5%	46.53	46.53	93.05

Table 32(a): Residual effect of sources and levels of P on pod yield of groundnut.

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	20.40	23.28	25.79	26.49	23.99
BSSP	19.97	27.03	30.42	32.79	27.55
DAP	20.74	25.62	28.09	28.85	25.82
B+SSP	20.58	26.39	29.91	30.68	26.89
Mean	20.42	25.58	28.55	29.70	

	Source	Level	Source x level
S.E.±	0.4429	0.4429	0.8857
C.D. at 5%	1.2787	1.2787	2.5575

Table 32 (b): Residual effect of sources and levels of P on dry matter yield of groundnut.

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	2390	2616	2795	2914	2678.75
BSSP	2349	2831	2976	3203	2840.00
DAP	2332	2716	2824	2925	2699.00
B+SSP	2352	2808	3013	3006	2795.00
Mean	2356	2743	2902	3012	

	Source	Level	Source x level
S.E.±	8.50	8.50	17.00
C.D. at 5%	24.55	24.55	49.09

conditions. This may be attributed to the combined effect of P and B from boronated superphosphate. Higher yields due to P fertilization might be due to vigorous crop growth of crop and translocation of nutrients for better pod development. Further analysis of the data revealed that P sources blended with boron performed well in yielding pod and halum over non boron P sources.

A critical study of the data regarding sources x levels interaction on pod and halum yield revealed that the interaction effect was significant to enhanced pod and halum yield with levels of P application through various sources. In general interaction effects gave significantly higher pod and halum yields under direct condition than residual condition. Maximum pod (35.21 q/ha) and halum (3310 kg/ha) yield was recorded with treatment of 75 kg P_2O_5/ha through boronated superphosphate.

It is evident from above disBaussion that application of P through a source blended with boron is beneficial to exploit the production potentiality of groundnut grown as a direct or residual crop. The favdurable effect of P to increase the halum yield could very well be attributed to higher photosynthetic activity developed on account of P application. However, combined effect of P and B on halum and pod yield could be due synergistic relation of P and B. Large no.of workers emphasized the phosphorus application to groundnut significantly increased the pod yield

(Karle, 1982; Ajay Kumar and Venkatachari, 1971 and Syed, 1987) combined application of P and B is also advocated by Mehta (1985); Patil (1984); Kongale (1986) and Syed (1987).

4.7 <u>Direct and residual effect of sources and levels of P on nutrient concentration and their uptake by summer groundnut</u>.

Data regarding the content and uptake of N by groundnut as influenced by P through various sources under direct and residual conditions are presented in Table 33 and 34. The concentration of N in kernel, and plant at harvest increased with increasing levels of P application. The concentration of N was greater in seed than plant and relatively higher in direct effect condition than residual effect. The nitrogen content in seed varied from 5.0 to 5.3% and 4.9 to 5.2% in the direct and residual conditions respectively. Residual P effect on content of N was also significant indicating the increasing level of N content. The presence of phosphorus helped to increase the availability of N which inturn increased the N concentration of seed and plant at harvest (Patel, 1981 and Zanzan, 1987).

From the critical evaluation of the data (Table 33(a) and (b), it was depicted that the source of P used in the experiment showed positive and significant effect on the concentration of N in the plant under direct and residual conditions. Among the sources BSSP and B+SSP showed significant increase in N content of seed and plant at harvest under both management conditions. Zanzan (1987) and Syed (1987) also noted similar observations.

Sources and levels of P interacted positively, showing significant increase in N concentration in groundnut plant. Phosphorus at the rate of 75 kg/ha through B+SSP showed highest N concentration (5.26 to 5.19) in seed.

From these positive interactions it was clear that sources of P coupled with B proved to be effective to increase the N concentration. Thus phosphorus and boron appear to improve the status of N in plant. Patil (1974) and Mehta (1986) showed that combined application of B and P have significant effect on uptake of Nitrogen in plant.

Data recording the direct and residual effect of sources and levels of P by groundnut presented in Table 33(b) and 34(b) indicate that direct as well as residual P levels were associated with the uptake of N favourably. The uptake of N was linear with increasing levels of P. Uptake of N varied from 40.1 kg/ha to 70.7 kg/ha and 54.4 to 65.9 kg/ha under direct and residual conditions respectively.

Critical evaluation of the data (Table 33 and 34) signify that phosphorus sources under both modes of P management influenced the uptake of N by groundnut.

Table 33(a); Direct effect of sources and levels of P on the nitrogen content of the plant (%).

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	1.28	2.07	2.56	2.72	2.16
BSSP	1.30	2.65	3.35	3.52	2.71
DAP	1.30	2.02	2.55	2.78	2.16
B+SSP	1.29	2.32	3.02	3.32	2.49
Mean	1.29	2.27	2.87	3.09	

	Source	Level	Source x level
S.E.±	0.0513	0.0513	0.1027
C.D. at 5%	0.1483	0.1483	0.2965

Table 33(b): Direct effect of sources and levels of P on nitrogen by dry matter (kg/ha).

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	29.48	52.80	70.43	77.73	40.11
BSSP	30.91	69.16	95.79	116.50	78.09
DAP	30.93	52.51	68.66	80.00	58.02
B+SSP	30.52	59.93	87.37	104.98	70.70
Mean	30.46	58.60	80.56	94.80	

	Source	Level	Source x level
S.E.±	125.0740	125.0740	250.1470
C.D. at 5%	361.1360	361.1360	722.2730

Table 34(a) : Residual effect of P levels and sources in nitrogen content of plant (%)

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	1.30	1.41	2.56	2.66	1.98
BBSP	1.32	2.54	2.98	3.29	2.53
DAP	1.30	1.65	2.60	2.76	2.08
B+SSP	1.31	2.30	2.62	2.98	2.30
Mean	1.31	1.98	2.69	2.92	

	Source	Level	Source x level
S.E.±	0.0071	0.000	0.0071
C.D. at 5%	0.0706	0.000	0.0206

Table 34(b) : Residual effect on nitrigeon uptake in dry matter

Source	Levels of phosphorus				Mean
	P_0	P_{50}	P_6	P_{75}	
SSP	31.07	36.89	72.42	77.52	54.47
BSSP	31.00	72.32	88.70	94.79	71.70
DAP	30.29	44.69	73.43	80.73	57.28
B+SSP	30.81	64.59	78.94	89.59	65.98
Mean	30.79	54u62	78.37	85.65	

	Source	Level	Sourme x level
SE ±	.2754	.2754	.5509
CD at 5%	.7953	.7953	1.5906

Table 35(a): Direct effect of sources and levels of P on the nitrogen content of seed (%).

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	5.05	5.15	5.22	5.27	5.17
BSSP	5.08	5.23	5.32	5.34	5.24
DAP	5.10	5.10	5.24	5.26	5.18
B+SSP	5.10	5.25	5.32	5.35	5.26
Mean	5.08	5.18	5.28	5.31	

	Source	Level	Source x level
S.E.±	0.0059	0.0059	0.0118
C.D. at 5%	0.0171	0.0171	0.0341

Table 35(b): Residual effect of sources and levels of P on the nitrogen content of seed (%).

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	4.92	5.10	5.24	5.22	5.12
BSSP	4.85	5.21	5.28	5.32	5.17
DAP	4.89	5.06	5.20	5.24	5.10
B+SSP	4.98	5.22	5.77	5.30	5.19
Mean	4.91	5.15	5.25	5.27	

	Source	Level	Source x level
S.E.±	0.0064	0.0064	0.0128
C.D. at 5%	0.0185	0.0185	0.0370

4.8 Direct and residual effect of sources and levels of P on it's concentration and uptake by summer groundnut

Data pertaining to phosphorus uptake by dry matter of groundnut as effected by various levels of P through different sources under direct and residual management conditions are presented in Table 35 and 36.

It is evident from Table 35 and 36 that uptake of P was significantly increased with levels of applied phosphorous. Treatment of 75 kg P_2O_5/ha accumulated highest phosphorus in the plant i.e. 23.6 and 21.4 kg/ha under direct and residual conditions respectively. Similar trend was also observed in the concentration of P in plant fertilized with various levels of phosphorus. Similarly, various sources of phosphorus showed differential behaviour on the concentration and absorption of P by groundnut at harvest under direct and residual management conditions. Among the sources boronated superphosphate depicted greater concentration of P and its uptake followed by B+SSP, SSP and DAP. The interaction effect of sourses x levels was also significant to increase the content and uptake of P under different P management conditions. The above results show that a good vegetative growth and root development of the crop as a result of P fertilization resulted in better absorption and translocation P within the plant system. Besides this, groundnut being an oilseed crop had a higher

Table 36 (a): Direct effect of sources and levels of P on it's content of the plant (%).

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
		Phosphorus %			
SSP	0.40	0.49	0.58	0.72	0.55
BSSP	0.42	0.64	0.80	0.86	0.68
DAP	0.40	0.52	0.62	0.76	0.58
B+SSP	0.39	0.58	0.77	0.62	0.59
Mean	0.40	0.56	0.69	0.74	

	Source	Level	Source x level
S.E.±	0.0072	0.0072	0.0145
C.D. at 5%	0.0209	0.0209	0.0418

Table 36(b): Direct effect of sources and levels of P on it's uptake by the dry matter (kg/ha).

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
		Phosphorus (kg/ha)			
SSP	9.13	12.45	15.88	20.62	14.52
BSSP	9.92	16.72	22.90	28.46	19.50
DAP	9.54	13.49	16.65	21.86	15.38
B+SSP	9.32	14.97	22.12	23.57	17.49
Mean	9.47	14.40	19.38	23.62	

	Source	Level	Source x level
S.E.±	0.1871	0.5403	0.3743
C.D. at 5%	0.1871	0.5403	1.0807

Table 37(a): Redicual effect of sources and levels of P on it's content of the plant (%).

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	0.35	0.52	0.56	0.61	0.51
BSSP	0.34	0.61	0.73	0.82	0.63
DAP	0.33	0.50	0.58	0.62	0.51
B+SSP	0.34	0.56	0.67	0.78	0.59
Mean	0.34	0.55	0.64	0.71	

	Source	Level	Source x level
S.E.±	0.0057	0.0057	0.0113
C.D. at 5%	0.0163	0.0163	0.0327

Table 37(b): Residucal effect of sources and levels of P on it's uptake by the dry matter (kg/ha).

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	8.37	13.60	15.84	17.77	13.89
BSSP	7.98	17.37	21.43	26.27	18.26
DAP	7.69	13.58	16.38	18.13	13.94
B+SSP	7.99	16.01	20.18	23.45	16.90
Mean	8.00	15.14	18.45	21.40	

	Source	Level	Source x level
S.E.±	0.1723	0.1723	0.3447
C.D. at 5%	0.4976	0.4976	0.9953

P requirement when grown in summer under irrigated condition. Hence with increasing levels of applied P through various sources blended with B, the P removed from soil by groundnut crop also increased. Singh and Saxena (1973) also showed greater uptake of phosphorus in oilseed crops by phosphorus application.

4.9 Direct and residual effect of sources and levels of P on boron concentration and boron uptake

Data on content and uptake of boron at harvest in groundnut as affected by levels of P through various sources under different P management conditions are presented in Table 37 and 38.

It could be noticed from Table 37 and 38 that increased levels of P proportionately increased the content and uptake of boron at harvest in groundnut in direct and residual management conditions. Boron concentration varied from 24.6 to 29.8 and 22.8 to 26.1 ppm in direct and residual conditions respectively. Similar trend was observed with uptake of boron in both management conditions. The sources of phosphorus showed positive and significant influence on the concentration and uptake of boron under direct and residual P management. The sources found to differ significantly in both the modes of fertilizer application. Further scrutiny of the data (Table 37(b) and 38(b) reveal that there was significant effect of

Table 38(a): Direct effect of sources and levels of P on boron content of the plant (ppm).

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	24.5	25.5	25.5	26.2	25.43
BSSP	24.9	30.1	34.1	34.6	30.93
DAP	25.1	25.1	26.4	26.2	25.70
B+SSP	24.0	27.9	32.2	32.3	29.10
Mean	24.63	27.15	29.55	29.83	

	Source	Level	Source x level
S.E.±	0.3251	0.3251	0.6801
C.D. at 5%	0.9386	0.9386	1.8771

Table 38(b): Direct effect of sources and levels of P on boron uptake by the dry matter (gm/ha).

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	55.78	63.84	70.13	75.58	66.33
BSSP	58.97	78.64	97.60	114.52	87.43
DAP	50.88	65.14	70.88	75.39	67.82
B+SSP	56.52	70.52	92.99	101.57	80.40
Mean	57.78	69.53	82.90	91.76	

	Source	Level	Source x level
S.E.±	0.8804	0.8804	1.7608
C.D. at 5%	2.5420	2.5420	5.0841

Table 39(a): Residual effect of sources and levels of P on boron content of the plant (ppm).

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	23.3	23.8	24.2	24.3	23.90
BSSP	23.1	26.6	28.2	29.0	26.73
DAP	22.4	23.0	23.9	24.2	23.38
B+SSP	22.6	25.0	26.9	27.2	25.43
Mean	22.85	24.60	25.80	26.18	

	Source	Level	Source x level
S.E.±	2.1230	2.1230	4.2460
C.D. at 5%	6.1299	6.1299	12.2599

Table 39(b): Residual effect of sources and levels of P on boron uptake by the dry matter (gm/ha).

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	54.25	75.30	83.90	92.93	61.37
BSSP	55.70	62.27	68.46	68.46	78.48
DAP	52.22	46.79	67.50	70.78	59.32
B+SSP	53.16	70.20	81.05	81.78	71.54
Mean	53.83	63.64	75.22	78.48	

	Source	Level	Source x level
S.E.±	0.6912	0.6912	1.3823
C.D. at 5%	1.9956	1.9956	3.9912

source x level interaction on the content and uptake of boron under both the modes of P application. Increasing P levels proportionately added to the uptake of boron by groundnut under both the modes of P application. The above discussion leads to conclude that presence of phosphorus in growing medium helps to increase in the concentration of boron and subsequently add to its uptake. Thus it can be mentioned that P and B acted synergistically to fecilitate the absorption of both the nutrients in plants. Further boron blended P sources proved superior in increasing the boron uptake over non-boron P sources. Similar observations were also noted by Mehta (1985) and Kongale (1986).

4.10 Direct and residual effect of sources and levels of phosphorus on the content of nitrogen in soil at harvest

The data presented in Table 39 and 40 gives an insight into the influence of sources and levels of phosphorus on total nitrogen content in soil after harvest of groundnut in direct and residual fertilizer management. Scrutiny of the data indicated that phosphorus has no bearing on the total nitrogen content of soil under both the modes of fertilizer management.

Sources of phosphorus could not improve the total nitrogen status of the experimental soil after cotton-

Table 40(a): Direct effect of sources and levels of P on total nitrogen content in soil at harvest (%).

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	0.05	0.062	0.061	0.063	0.059
BSSP	0.058	0.061	0.060	0.063	0.060
DAP	0.057	0.060	0.062	0.061	0.060
B+SSP	0.056	0.062	0.059	0.060	0.059
Mean	0.055	0.061	0.061	0.062	

	Source	Level	Source x level
S.E.±	0.0008	0.0008	0.0016
C.D. at 5%	N.S.	0.0023	0.0046

Table 40(b): Residual effect of sources and levels of P on total nitrogen content in soil at harvest (%).

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	0.060	0.061	0.059	0.06	0.060
BSSP	0.061	0.060	0.062	0.063	0.062
DAP	0.060	0.062	0.060	0.062	0.061
B+SSP	0.061	0.061	0.061	0.063	0.062
Mean	0.061	0.061	0.060	0.062	

	Source	Level	Source x level
S.E.±	0.0087	0.0007	0.0015
C.D. at 5%	N.S.	N.S.	N.S.

groundnut and groundnut system alone. But the levels of phosphorus seem to have a slightly enhancing influence on the soil N content in direct application. The interaction effect of phosphorus levels and sources was non-significant in residual fertilizer management.

This it can be inferred that though phosphorus relationship in plant was synergistic in nature, phosphorus addition with different sources did not show a positive effect on the total nitrogen content in soil.

4.11 Direct and residual effect of sources and levels of phosphorus on the available phosphorus in soil at harvest of groundnut

The results presented in Table 41 and 42 indicates that direct as well as residual P management had a significant influence on the phosphorus content in the soil after harvest of groundnut crop. The levels and the sources showed significant increase in available phosphorus. The availability of phosphorus ranged from 10.95 to 22.58 kg P_2O_5/ha and 8.45 to 14.29 kg P_2O_5/ha influenced due to direct and residual P levels respectively. Similarly the phosphorus content showed significant differences with the various P sources. A casual study of the data depicts that values of available phosphorus ranged between 17.75 to 19.38 kg P_2O_5/ha in direct P management and 12.36 to 12.52 kg P_2O_5/ha in case of rewidual management.

Table 41(a): Direct effect of sources and levels of P on available phosphorus content in soil at harvest (kg/ha).

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	11.0	17.6	19.2	21.2	17.75
BSSP	10.8	20.1	22.7	23.9	19.38
DAP	10.9	18.1	20.2	22.2	17.85
B+SSP	11.1	19.2	21.8	23.0	18.78
Mean	10.95	18.75	20.98	22.58	

	Source	Level	Source x level
S.E.±	0.0875	0.0875	0.1749
C.D. at 5%	0.2525	0.2525	0.5051

Table 41(b): Residual effect of sources and levels of P on available phosphorus content in soil at harvest (kg/ha).

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	8.40	13.40	14.00	14.04	12.46
BSSP	8.30	13.00	13.80	14.26	12.34
DAP	8.60	13.32	13.49	14.02	12.36
B+SSP	8.50	13.20	13.56	14.82	12.52
Mean	8.45	13.23	13.71	14.29	

	Source	Level	Source x level
S.E.±	0.0309	0.0309	0.0618
C.D. at 5%	0.0893	0.0893	0.@1786

The interaction between sources and levels proved significant which are in accordance with the views of Syed (1987). It is obvious that application of a particular element on soil inturn increases its availability and makes the nutrients available to the plants. The results obtained on the availability of phosphorus due to varied phosphate levels showed similar pattern particularly under direct management and their interaction. Syed (1987) recently reported similar findings on the availability of phosphorus affected due to source and levels of phosphorus.

4.12 Direct and residual effect of sources and levels of phosphorus on the availability of boron in soil after groundnut

A perusal of data in Table 43 and 44 reveal that application of P showed relative differences in availability of boron with the sources and levels under direct and residual P management.

Graded doses of phosphorus added to more availability of boron in soils under both the sets of conditions. The available boron in soil ranged from 0.33 to 0.44 and 0.32 to 0.38 ppm as affected due to P levels under direct and residual P management respectively.

Table 42 (a): Direct effect of sources and levels of P on boron content in soil at harvest (ppm).

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	0.32	0.33	0.32	0.33	0.33
BSSP	0.33	0.45	0.50	0.56	0.46
DAP	0.33	0.32	0.33	0.33	0.33
B+SSP	0.32	0.43	0.47	0.54	0.44
Mean	0.33	0.38	0.41	0.44	

	Source	Level	Source x level
S.E.±	0.0096	0.0096	0.0193
C.D. at 5%	0.0278	0.0278	0.0551

Table 42(b): Residual effect of sources and levels of P on boron content in soil at harvest (ppm).

Source	Levels of phosphorus				Mean
	P_0	P_{50}	$P_{62.5}$	P_{75}	
SSP	0.31	0.33	0.33	0.34	0.33
BSSP	0.32	0.43	0.45	0.45	0.42
DAP	0.32	0.32	0.33	0.32	0.32
B+SSP	0.31	0.39	0.40	0.41	0.38
Mean	0.32	0.37	0.38	0.38	

	Source	Level	Source x level
S.E.±	0.0064	0.0064	0.0127
C.D. at 5%	0.0184	0.0184	0.0368

Phosphate sources also proved their superiority in increasing available boron in soil under both the modes of P application. The availability of boron showed the specificant pattern due to varied P sources under both sets of conditions available boron was in the range of 0.33 to 0.46 and 0.32 to 0.42 ppm under direct and residual P management respectively. Among the sources of P boronated superphosphate and B+SSP showed highest availability of boron in soils.

Two factor interaction between source and level indicated positive and significant effect on the availability of boron. Highest availability of 0.56 and 0.45 ppm was observed due to combination of 75 kg P_2O_5/ha through boronated superphosphate.

From the foregoing discussion it is concluded that P application alone or its blend/hand mix with boron helps to improve the availability of boron in soils. Malewar (1987) also reported relatively higher availability of boron in soil due to addition of phosphorus as BSSP or B+SSP.

Chapter VI

SUMMARY AND CONCLUSIONS

Field experiments were conducted to study the efficacy of different levels and sources of phosphorus as direct and residual effects on the root characteristics, dry matter and grain yield and uptake of nutrients in cotton-groundnut cropping system during 1987-88 at the departmental farm, College of Agriculture, Parbhani, on medium black soils classified as typic chromostert identical to that of Parbhani series. The experiments were planned in a factorial randomised block design using four levels of phosphorus (Control, Recommended, Recommended + 25% P_2O_5, Recommended + 50% more P_2O_5) with four sources (SSP, BSSP, DAP and Borax + SSP). There were sixteen treatment combinations replicated three times. The field and analytical data were subjected to statistical analysis. The salient findings emanating from the study and conclusions are briefly summarized below.

Cotton

1. Direct application of P levels showed significant positive increase in no.of branches, in cotton at 80 and 115 days. Among the phosphorus sources boronated superphosphate and di-ammonium phosphate were at par in branching was at 115 DAS. Maximum mean branching was depicted in DAP + 75 kg P_2O_5/ha and BSSP + 75 kg P_2O_5/ha.

2. Mean number of squares in cotton was influenced significantly due to P application, However, P dose beyond 50 kg P_2O_5/ha did not show any effect on square formation. Phosphorus sources blended with boron had significantly higher squares/plant over non born P sources.

3. Application of P beyond 50 kg P_2O_5 did not show any effect on boll formation. However, BSSP proved its superiority in boll formation followed by B+SSP.

4. Mean number of stamens/flower in cotton was influenced due to sources and levels of phosphorus and ranged from 83.8 to 99.7 stamens/flower. The interaction between B blended sources and levels of P was beneficial to increase the stamen count/flower in cotton.

5. Dry matter and seed cotton yield was significantly increased from 19.7 to 31.6 quintals seed cotton/ha. Among the source BSSP proved beneficial in increasing the dry matter production and seed cotton yield at harvest.

6. Among the various quality parameters of kapas, P levels significantly increased the lint percentage, lint index and staple length. However, interaction effect was non significant.

7. Application of graded levels of P through various sources increased the content and uptake of N, P and boron

by cotton crop. Blending of P sources with born was found beneficial to increase the availability of N, P and B in soil.

8. A significant increase in the uptake of N, P and B by cotton was observed with graded levels of phosphorus. Boronated superphosphate proved to be better source to increase the uptake of nutrients (NP and B) followed by B+SSP.

9. Fertilization of cotton at graded levels through various B blended P sources did not influence the total nitrogen status of soil. However, the status of P and B was influenced.

Groundnut

10. Residual effect of P sources was also distinct and significant in increasing the yield parameters of groundnut after cotton crop. Nodulation, nodule weight in groundnut increased with increasing levels of phosphorus. However, BSSP showed its superiority as compared to other P sources. Maximum nodulation was recorded with 75 kg P_2O_5/ha at midbloom stage.

11. Graded levels of P found to increase the root weight and root volume ~~and~~ groundnut crop were significantly increased due to P levels. Higher magnitude of root wt. and root volume due to sources x level interaction was

observed under residual P management rather than direct management.

12. Direct and residual effects of P levels and their sources significantly increased the halum yield of groundnut. However residual value of P sources and their levels on halum yield of groundnut was of higher order than direct management. Phosphorus at 75 kg P_2O_5/ha as BSSP proved to be the best source for improving the dry matter production of groundnut crop.

13. Pod yield of groundnut was linear with levels of phosphorus. Among the sources BSSP was superiar to enhance the pod yield. Direct effect of P was of higher order than the residual P management system on pod yield of groundnut.

14. The concentration and uptake of N, P and B were significantly increased due to P levels and their sources under both the mode of P application. Source x level interaction under residual P management showed beneficial effect on the content and uptake of N, P and Boron.

15. The concentration of N, P and B in soil was increased due to P levels and their sources under direct P management system than residual P management system.

It can be concluded that application of phosphorus blended into B helps to increase the root characteristics, yield parameters and absorption of N, P and B by cotton-groundnut cropping system. Among the sources BSSP showed its superiority over other P sources followed by B+SSP . Coupling of P and B found to improve all the yield and quality parameters of cotton and groundnut over non boron sources. Thus single application of different sources of P to cotton-groundnut cropping system leave the residual effect of its application which subsequently utilized by the succeeding crop.

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