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Effects of different phosphorus levels and frequency of boron levels on growth and yield of greengram

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ABSTRACT : Pulse production is very low and become challenging problem against the requirement of increasing population of our country. Moreover, it has a numerous utilities and used primarily as a food crop because it is a major source of protein in cereal based diets for its high lysine content. Among the different phosphorus levels and frequency of boron levels under in treatment T_{11} *i.e.*, N_3 (20:60:20NPK) + 0.2% foliar spray of borax at 35DAS (pre-flowering) recorded maximum plant height (53.60cm), number of leaves plant^{-1} (21.16), number of branches plant^{-1} (6.76), no. of nodules plant^{-1} (8.80), dry weight (24.82g), crop growth rate (0.53g m^{-2} day^{-1}), relative growth rate (0.04g g^{-1} day^{-1}), number of pods plant^{-1} (42.46), average number of grain pod^{-1} (13.40), pod length (10.80 cm), test weight (47.00g) , grain yield (1.62 t ha^{-1}), straw yield (2.85 t ha^{-1}), protein content (24.56%) and harvest index (36.15%). Whereas the lowest value (48.26 cm,18.93 plant^{-1},6.20 plant^{-1}, 5.53 plant $^{-1}$, 20.02 g, 0.39g m^{-2} day^{-1}, 0.03g g^{-1} day^{-1}, 30.40 plant^{-1}, 7.73 pod^{-1}, 8.13cm, 41.06g, 0.99 t ha^{-1}, 2.06 t ha^{-1}, 20.36 % and 32.58 %, respectively) in the treatment T_1 *i.e.*, N_1 (20:40:20 NPK). The highest gross return (Rs.78795.00 ha^{-1}), net return (Rs. 57222.00 ha^{-1}) and benefit cost ratio (2.65) were registered in treatment T_{11} *i.e.*, N_3 (20:60:20NPK)+ 0.2% foliar spray of borax at 35DAS (pre-flowering). Whereas the lowest value (Rs.48925.50 ha^{-1}), (Rs.30075.50 ha^{-1}) and (1.59), respectively in the treatment T_1 *i.e.* N_1 (20:40:20 NPK).

KEY WORDS : NPK, Greengram, FsB, DAS, RGR

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Pulses are the main source of protein particularly for vegetarian and contribute about 14 per cent of the total protein of average Indian diet. Production of pulses in the country is far below the requirement to meet even the minimum level per capita consumption. The per capita availability in pulses dwindling fast from 35.0 g/capita per day in 2005 as against the minimum requirement of 84 g per day per capita prescribed by ICMR, which is causing malnutrition among the growing people (Anonymous, 2005-06). Pulse production is very low and become challenging problem against the requirement of increasing population of our country. Moreover, it has a numerous utilities and used primarily as a food crop because it is a major source of protein in cereal based diets for its high lysine content. Mung bean [*Vigna radiata* (L.) Wilczek] is of ancient cultivation in India. It was Introduction early in to Southern China, Indochina and Java. In recent times it has been introduced into east and central Africa, the West Indies and United States. In India mung bean is grown in almost all parts of the country. It is grown in India during *Kharif*, but is also grown in spring or summer season in irrigated northen plains as a *Rabi* crop in southern and south-easten parts where is winter is mild. Greengram locally called as moong or mung [*Vigna radiata* (L.) Wilczek]. It is a self-pollinated and drought tolerent crop which is belongs to the family leguminaceae so it has the capacity to fix atmospheric nitrogen. It's one of the important *Kharif* pulse crops of India which can be grown as catch crop between *Rabi* and *Kharif*-seasons. India alone accounts for 65 per cent of its world acreage and 54 per cent of the total production. It is grown on about 3.50 mha in the country mainly in Rajasthan, Maharashtra, Andhra Pradesh, Karnataka, Orissa and Bihar. A phenomenal increase in area, production and productivity has occurred since 1964-65. The area has increased from 1.99 million ha in 1964-65 to 3.54 million ha in 2010-2011. The production has increased from 0.60 million tonnes to 1.81 million tonnes during the same period. Throughout the India, the mung bean is used for different purposes. The major portion is utilized in making dal, soup, sweets and snacks (Anonymous, 2012). Mung bean is an excellent source of protein (25%) with high quality of lysine (460 mg/ g) and tryptophan (60mg /g). It also has remarkable quantity of ascorbic acid when sprouted and also have riboflavin (0.21mg/ 100g) and minerals (3.84g/ 100g). The total area under pulses is 23.63 mha with an annual production of 14.76 M tonnes in the country. In India green gram occupies 3.4 million hectare area and contributes to 1.4 million tonnes in pulse production (Anonymous, 2011). Mung bean contributes 14 per cent in total pulse area and 7 per cent in total pulse production in India. The low productivity of mung bean may be due to nutritional deficiency in soil and imbalanced external fertilization (Awomi *et al.*, 2012). Greengram is one of the important short season grain legumes in the conventional farming system of tropical and temperate regions. It can be grown on a variety of soil and climatic conditions, as it is tolerant to drought. It is mostly grown under dry land farming system where erratic rains often fetch the crop under moisture stress (Malik *et al.*, 2006). Nitrogen requirement of pulse crops is very low than other crops because nitrogen needed only for establishment of plant after that plants fulfill their requirement through symbiotic nitrogen fixation. Phosphorus is an important plant nutrient for greengram. Indian soils are poor to medium in available phosphorus. Only about 30 per cent of the applied phosphorus is available for crops and remaining part converted into insoluble phosphorus (Sharma and Khurana, 1997). Phosphorus fertilization occupies an important place amongst the non-renewable inputs in modern agriculture. Crop recovery of added phosphorus seldom exceeds 20 per cent and it may be improve by the judicious management. As the concentration of available P in the soil solution is normally insufficient to support the plant growth, continual replacement of soluble P from inorganic and organic sources is necessary to meet the P requirements of crop (Tisdale *et al.*, 2010). Additional application of P is Increase nodule formation which increases nitrogen fixation and finally productivity of greengram (Prasad *et al.*, 2014). It plays an important role in virtually all major metabolic processes in plant including photosynthesis, energy transfer, signal transduction, macromolecular biosynthesis and respiration. Phosphorus, the master key element is known to be involved in a plethora of functions in the plant growth and metabolism. The cellular machinery is difficult to be imagined without phosphorus being involved in its metabolic continuity and even perpetuation. Such key functions include cell division and development, photosynthesis, breakdown of sugars, energy transfer, nutrient transfer within the plant and expression. The phosphorus is present at levels of 4001200 mg kg^{-1} of soil (Begon *et al.*, 1990). Its deficiency is the most important single factor, which is responsible for poor yield of mung bean in all types of soil. It is a indispensable constituent of nucleic acid, ADP and ATP. Nitrogen and phosphorus alone or in combination play a remarkable role in increasing yield and improving the quality of mung bean. Phosphorus plays a vital role in the formation and translocation of carbohydrates, root development, crop maturation and resistance to disease pathogens. Thus, increase the mung bean yield and improves its quality (Arya and Kalara, 1988). P is needed in relatively large amounts by legumes for growth and nitrogen fixation and has been reported to promote leaf area, biomass, yield, nodule number, nodule mass, etc., in a number of legumes (Berg and Lynd, 1985; Pacovsky, *et al.*, 1986 and Kashturikrishna and Ahlawat, 1999). Phosphorus deficiency can limit nodulation by legumes and P fertilizer application can overcome the deficiency (Carsky *et al.*, 2001). Large amount of P applied as fertilizer enters into the immobile pools through precipitation reaction with highly reactive aluminium (Al^{+})

and iron (Fe^{3+}) in acidic and calcium (Ca^{2+}) in calcareous or normal soils (Gyaneshwar *et al.*, 2002 and Hao *et al.*, 2002). Efficiency of P fertilizer throughout the world is around 10-25 per cent (Isherword, 1998). In addition to major nutrients use of micronutrient is also important and required for higher productivity of pulses. Among the micronutrients, boron deficiency in plant is second after zinc and about 33 per cent of soil samples tested was found deficient in boron. Available boron content in Indian soil ranges from trace to 12.2ppm. Boron is mainly required for reproduction of plant and germination of pollen grain. Primary role concerned with Ca metabolism, keeps Ca in soluble form within the cell and act as a regulator of K/Ca ratio, constituent of cell membrane and essential for cell division. It is also primarily needed to maintain the growth of apical growing point. Among the various factors responsible for maximizing the yield of greengram, phosphorus levels and frequency of boron levels is most important. It is essential that greengram should not suffer due to inadequate mineral especially phosphorus. Since chemical fertilizers are scare and costly. It is necessary to use them economically in combination with phosphorus and boron, as greengram shows high response to high phosphorus levels and frequency of boron levels. Therefore, keeping the above facts in view, the present investigation on effects of different phosphorus levels and frequency of boron levels on growth and yield of greengram during the *Kharif* season of 2016, with the following objectives: To study the effects of different phosphorus levels and frequency of boron levels on growth and yield of greengram and to work out the economics of treatments.

RESEARCH PROCEDURE

The materials, methodology and techniques adopted during the course of investigation on effects of different phosphorus levels and frequency of boron levels on growth and yield of greengram are described in this chapter under the following heads:

Soil of the experimental field:

The soil samples were collected randomly from 0 to 15cm depth from 5 spots of the experimental field before layout of experiment. A representative homogenous composite sample was drawn by mixing all these soil samples together, which was analyzed to determine the physico-chemical properties of the soil. The result of analysis along with the methods used for determination is presented under the following heads.

Climate and weather condition:

The climate of this region is typically sub-tropical and semi-arid with monsoon commencing by the third week of June and withdrawing by end of September. The temperature reaches upto 48°C and in winter it goes down to as low as 2-3°C. During the summer hot scorching winds known as "Loo" and frost during winter months are common features.

Treatments:

Factor I: Fertilizer:

20:40:20 NPK-N_1, 20:50:20 NPK-N_2 and 20:60:20 NPK -N_3 .

Factor II: Boron:

(Frequency levels) No application, 20DAS (0.2% foliar spray of borax), 35DAS (0.2% foliar spray of borax) and 20 and 35DAS (0.2% foliar spray of borax) .

Table A : Treatment combinations

Treatments	Description
T_1	N_1 (20:40:20 NPK)
T_2	N_1 (20:40:20 NPK) +20 DAS (0.2% foliar spray of borax)
T_3	N_1 (20:40:20 NPK)+35DAS (0.2% foliar spray of borax)
T_4	N_1 (20:40:20 NPK)+20 and 35 DAS (0.2% foliar spray of borax)
T_5	N_2 (20:50:20 NPK)
T_6	N_2 (20:50:20 NPK)+20 DAS (0.2% foliar spray of borax)
T_7	N_2 (20:50:20 NPK)+35 DAS (0.2% foliar spray of borax)
T_8	N_2 (20:50:20 NPK) +20 and 35 DAS (0.2% foliar spray of borax)
T_9	N_3 (20:60:20 NPK)
T_{10}	N_3 (20:60:20NPK) + 20DAS (0.2% foliar spray of borax)
T_{11}	N_3 (20:60:20NPK) + 35 DAS(0.2% foliar spray of borax)
T_{12}	N_3 (20:60:20NPK) + 20 and 35 DAS (0.2% foliar spray of borax)

Source of NPK through urea, SSP and MOP, source of boron through borax, 0.2 per cent foliar spray of borax at branching stage (20DAS), 0.2 per cent foliar spray of borax at pre-flowering stage (35DAS) and 0.2 per cent foliar spray of borax at both stages (20 and 35DAS).

Details of raising the test crop:

Fertilizer application :

Total quantity of nitrogen , phosphorus and potassium as per treatment in the form of urea (46%), single super phosphate (16%) and MOP (60%), respectively were applied below the seeds at the time of sowing of crop.

Boron spray:

0.2 per cent solution of borax was prepared and spraying was done at 20, 35 and both 20 and 35 days after sowing.

Seed rate and sowing method:

Greengram variety samrat was selected for sowing which takes around 60-65 days to mature. Seeds of the crop were sown at 20 kg ha^{-1} in lines at the spacing of 25 cm row to row and 10 cm plant to plant. The sowing was done by drilling method in open furrow on 26th March.

Post-sowing operations:

Various post-sowing operations carried out during the course of investigation during both the experimental years are summarized below in tabular form.

Cultural operations:

Thinning:

Thinning was done in greengram at 20DAS for both to maintain a single plant at a point and to avoid competition. Sunflower was maintained at plant to plant spacing of 10cm.

Intercultural operation:

Weeding was done at 30 and 45 days after sowing, to maintain a proper weed free environment during the initial crop growth stages.

Irrigation:

Since, there was no sufficient rainfall during the crop growing season, irrigation was provided three times and the source of irrigation was tube-well.

Harvesting and threshing:

The crop was harvested at complete maturity as judged by visual observations. The border rows were harvested first and kept aside. Thereafter, the net plots were harvested by hand picking of the pods when nearly 80 per cent pods were matured and harvested crop was left in the field for drying for a period 3-4 days. Thereafter, small bundles were made and taken to the threshing floor. Bundle weight (grain and straw) was recorded before threshing which was done by beating the plant material with stick.

Observation recorded:-

Pre-harvest observation: Plant height (cm):

Five plants were selected randomly from each plot and tagged. The height (cm) of these plants was measured from base of the greengram to tip of the main axis. Plant height was recorded at 15, 30, 45 and 60.

Number of branches plant^{-1}:

From the five-tagged plants of each plot, number of branches at different growth stages was recorded at 45 and 60 DAS and the average number of branches plant^{-1} was calculated for each observation.

Number of nodules plant^{-1}:

After digging out five plants randomly from each plot the no of nodules were counted at regular intervals of 15, 30, 45 and 60 DAS.

Dry weight plant^{-1} (g):

Five plants were randomly uprooted without damaging the root from each plot at 15, 30, 45 and 60 DAS. The samples were air dried and then kept in oven for 72 hours at 70^0 C, their dry weight was determined without root and the average dry weight plant^{-1} was calculated.

Crop growth rate (g m^{-2} day^{-1}):

It represents dry weight gained by a unit area of crop in a unit time expressed as g m^{-2} day^{-1} (Brown, 1984). The values of plant dry weight at 15, 30, 45 and 60DAS intervals were used for calculating the CGR. It was calculated with the help of following formula:

$$\textbf{Crop growth rate} = \frac{W_2 - W_1}{t_2 - t_1} (\text{g m}^{-2}\ \text{day}^{-1})$$

where, W_1 = Dry matter production per unit area at time t_1, W_2 = Dry matter production per unit area at time t_2, t_1 = Days to first sampling, t_2 = Days to second sampling.

Relative growth rate (g g^{-1}day^{-1}):

It was described by Radford (1967) which indicates the increase in dry weight per unit dry matter over any specific time interval and it was calculated by the following equation:

$$\textbf{Relative growth rate (RGR)} = \frac{\text{Log } W_2 - \text{Log } W_1}{t_2 - t_1} (\text{g g}^{1}\ \text{day}^{-1})$$

where, W_1 = Initial dry weight of plant (g), W_2 =

Final dry weight of plant (g), t_1 = Initial time period, t_2 = Final time period. It is also called efficiency index (y) and can be expressed in g g^{-1} day^{-1}. This parameter was calculated for the time intervals *i.e.*, 15, 30, 45 and 60 DAS intervals. Using the data obtained from dry weight of plants.

Yield and yield attributes:

Number of pods plant^{-1}:

For calculating no of pods per plant, pods of tagged plants were picked separately and then counted.

Number of grains pod^{-1}:

To calculate the average number of grains pod^{-1}, four or ten randomly selected mature pods from the harvest and then their seeds were counted.

Test weight (g):

Samples of thousand seeds were randomly collected from each plot and were weighed for further record by electronic balance, thus, test weight was finally estimated.

Seed yield (t ha^{-1}):

An area of 1.00 m^2 of the crop was harvested from the middle of the plot by leaving border rows. The harvested plants were collected, after sun dried threshing and winnowing grain yield was recorded in t ha^{-1}.

Straw yield (t ha^{-1}):

An area of 1.00 m^2 of the crop was harvested from the middle of the plot by leaving border rows. The harvested plant was collected, after sun dried and threshing straw yield was recorded in t ha^{-1}.

Biological yield :

Stover from harvest area 1.00 m^2 was dried in sun, bundled, tagged and weighed separately from each plot for calculating the biological yields t ha^{-1}.

Harvest index (%):

Harvest index was obtained by dividing the economic yield (grain yield) by the biological yield (grain + stover). It was calculated for each of the plots and was represented in percentage. The following formula was used (Donald, 1962).

$$\textbf{Harvest index (\%)} = \frac{\textbf{Economic yield (t/ha}^{-1}\textbf{)}}{\textbf{Biological yield (t/ha}^{-1}\textbf{)}} \textbf{x100}$$

Post harvest qualitative studies :

Approximately 100g seed samples were collected at the time of threshing from each plot and thereafter ground into powder with the help of electric mini grinder. The qualitative parameter, *viz.*, protein (%) in grains was evaluated. The methodology which was adopted is described below.

Protein (%) in grain:

It is calculated by the formula, protein (%) = N (%) x 6.25. The nitrogen content of grains was analyzed by Micro-Kjeldahl's method (AOAC, 1965). The Micro-Kjeldahl's method for total nitrogen content (%) essentially involves digestion of the sample to convert N compounds in the sample to NH_4 form. The grain sample was digested with sulphuric acid and catalyst mixture (K_2SO_4 + $CuSO_4$) was added to each digestion tube to raise the temperature of digestion and thereafter, cooled to room temperature. The digest was transferred to distillation flask with granulated zinc added to it (which acts as anti bumping agent). Thirty to 50 ml NaOH was poured into the distillation flask where NH_4 was captured in the flask containing boric acid and the ethylene blue indicator was mixed in receiving flask. Titration of the sample was done by using 0.05N HCl. Similar procedure for blank sample was followed. The N (%) content was calculated using the formula:

$$\textbf{Nitrogen (\%)} = \frac{\textbf{(Sample titre – Blank titre) x 0.05 N HCI x 14 x 100}}{\textbf{Weight of sample x 1000}}$$

Economics analysis:

Cost of cultivation, gross return, net return and benefit cost ratio was worked out to evaluate the economics of each treatment, based on the existing market prices of inputs and output.

Cost of cultivation (Rs. ha^{-1}) :

The cost of cultivation for each treatment was work out separately, taking into consideration all the cultural practices followed and costs of inputs used in the cultivation.

Gross return (Rs. ha^{-1}):

The gross return from each treatment was calculated. Gross return (Rs. ha^{-1}) = Income from grain + Income from stover.

Net return (*Rs. ha*$^{-1}$):

The net profit from each treatment was calculated separately, by using the following formula.

Net return = Gross return (Rs. ha^{-1}) – Cost of cultivation (Rs. ha^{-1}).

Benefit cost ratio:

The benefit cost ratio was calculated using the following formula :

$$\text{Benefit cost ratio} = \frac{\text{Gross return (Rs. ha}^{-1})}{\text{Total cost of cultivation (Rs. ha}^{-1})}$$

Post harvest soil fertility studies (preparation and analysis of soil samples):

Soil sampling:

The soil of experimental area falls in order of Inceptisol and in Experimental plot was alluvial soil. The soil samples were randomly collected from five different sites in the experiment plot prior to tillage operation from a depth of 0-15 cm. the size of the soil sample was reduced by conning and quartering the composites soil sample was air dried and passed through a 2 mm sieve by way of preparing the sample for physical and chemical analyses.

Determination of soil pH (*1:2*):

The soil pH determined in 1:2 soils water suspensions with the help of systronic digital electric pH meter (Jackson, 1958). The instrument being a potentiometer required to be calibrated before use with the help of buffers solution of known pH value of 4.0, 7.0 and 9.2 at 25^0 C.

Determination of electrical conductivity of soil:

After the determination of pH, the soil water suspension was kept overnight in undisturbed conditions and electrical conductivity measured by using electrical conductivity meter. The instrument was calibrated with 0.01 M standard KCI solution at 25^0 C.

Determination of organic carbon in soil:

Organic carbon was estimated by wet digestion method of Walkley and Black (1947). The method is mainly based on the principle of wet oxidation of organic carbon in an acid dichromate solution followed by Back titration of the remaining dichromate with ferrous ammonium sulphate.

Determination of available nitrogen in soil :

Available nitrogen was determined by using alkaline potassium permanganate method as given by Subbaih and Asija (1956). In this method soil distillated with alkaline potassium permanganate solution (0.32 %) and 2.5 per cent NaOH which give ammonia (NH_3) liberated, absorbed by boric acid solution with mixed indicator which is determined volumetrically and serve as an index of available nitrogen status.

Determination of available phosphorus in soil:

Available phosphorus is determined with the help of Olsen colorimetric method (1954). Phosphorus determination in soil is a two-step process *i.e.*, extraction of phosphorus from the soil by sodium bicarbonate. After extraction from the soil, phosphate in the extract measured by the reaction of phosphate with ammonium molybedate in an acid medium to form molybdo phosphoric acid. The molybdo phosphric acid is reduced to a blue colored complex (reduced phosphomolybenum blue) through reaction with ascorbic acid. The ascorbic acid method has provided to be reliable and less subjected to interference in color development than the $SnCl_2$ method. The colour is stable for 24 hours. The absorbance reading was taken at a 660 nm wavelength using a spectrophotometer. The standard curve constructed from absorbance reading standards is used to deduce phosphate concentration of sample.

Determination of available potassium in soil:

Available phosphorus is determined with the help of Toth and Prince Method (1949) Available potassium was extracted with natural ammonium acetate and estimation was carried out with the help of Flame photometer, the analysis of the flame photometer is based on the measurement of the intensity of characteristics wave length given by the element to be determined. When a solution of salt is sprayed into a flame, the solid gets separated into its component atoms because of high temperature. The energy provided by flame excites the atom unexcited state emitted radiation of characteristics wavelength (Line emission spectrum). The intensity of these radiations is proportional to the concentration of the particular element in solution, which is measured through a photocell in the flame photometer.

Statistical analysis:

The data recorded during the course of investigation was subjected to statistical analysis by "Analysis of variance technique". The significant and non-significant treatment effects were judged with the help of 'F' (variance ratio) table. The significant differences between the means were tested against the critical difference at 5 per cent probability level. If the variance ratio (F test) was found significant at 5 per cent level of significances, the Standard error of mean (S.E.±) and critical difference (CD) were calculated for further comparison. For testing the hypothesis, the following ANOVA table was used.

RESEARCH ANALYSIS AND REASONING

Data on pre-harvest (pertaining to growth attributes) and post-harvest (relating to yield and yield attributes) observations were analyzed and discussion on experiment findings in the light of scientific reasoning has been stated.

Growth parameters of greengram:

Pre-harvest observations (*at 15, 30, 45 and 60 DAS*): Plant height (cm):

The observations for plant height are being presented in the Table 1. A perusal of this table reveals that there was a steady increase in the plant height from 15 to 60DAS. At 45, 60DAS significant influence was observed in plant height due to different treatments; while at 15 and 30DAS the effects of the treatments were non-significant. At 45DAS, there was significant difference between the treatments and maximum plant height (47.46 cm) was observed by the application of T_{11} *i.e.*, N_3 (20:60:20 NPK) +(0.2% foliar spray of borax) at 35 DAS, whereas the lowest value 41.06 cm was observed in treatment T_1 *i.e.*, N_1 (20:40:20 NPK). However, treatments T_7 *i.e.*, N_2 (20:50:20 NPK) + 35DAS (0.2% foliar spray of borax), T_{12} *i.e.*, N_3 (20:60:20 NPK) + 20 and 35 DAS (0.2% foliar spray of borax),T_8 *i.e.*, N_2 (20:50:20 NPK) + 20 and 35 DAS (0.2% foliar spray of borax), T_6 N_2 (20:50:20 NPK) + 20DAS (0.2% foliar spray of borax) and T_4 *i.e.*, N_1 (20:40:20 NPK) +20 and 35DAS (0.2% foliar spray of borax) were found statistically at par with T_{11} *i.e.*, N_3 (20:60:20 NPK) + 35DAS (0.2% foliar spray of borax). At 60 DAS, there was significant difference between the treatments and maximum plant height (53.60cm) was observed by the application of T_{11} *i.e.*, N_3 (20:60:20 NPK) + (0.2% foliar spray of borax) at 35DAS, whereas the lowest value 48.26 cm was observed in treatment T_1 *i.e.*, N_1 (20:40:20 NPK). Further, treatments, T_{10} *i.e.*, N_3 (20:60:20 NPK) +20DAS (0.2% foliar spray of borax), T_7 *i.e.*, N_2 (20:50:20 NPK) +35DAS (0.2% foliar spray of borax), T_6 *i.e.*, N_2 (20:50:20 NPK) + 20DAS (0.2% foliar spray of borax), T_8 *i.e.*, N_2 (20:50:20 NPK) +20 and 35DAS

Table 1: Effect of phosphorus levels and frequency of boron levels on plant height (cm) at different stages of crop growth in greengram

Treatments	Plant height (cm)			
	15DAS	30DAS	45DAS	60DAS
(T_1) N_1 (20:40:20 NPK)	10.98	20.04	41.06	48.26
(T_2) N_2 (20:40:20 NPK) +20DAS (0.2% FsB)	12.30	20.92	41.93	50.63
(T_3) N_1 (20:40:20 NPK)+35DAS (0.2% FsB)	11.48	21.86	43.70	48.33
(T_4) N_1(20:40:20 NPK) +20 and 35DAS (0.2% FsB)	11.63	20.46	44.30	50.66
(T_5) N_2 (20:50:20 NPK)	12.08	20.38	41.36	50.46
(T_6) N_2 (20:50:20 NPK)+20DAS (0.2% FsB)	11.64	21.72	44.33	52.00
(T_7) N_2 (20:50:20 NPK)+35DAS (0.2% FsB)	13.00	24.20	46.86	52.66
(T_8) N2(20:50:20 NPK) +20 and 35DAS (0.2% FsB)	12.36	20.61	44.66	51.53
(T_9) N_3 (20:60:20 NPK)	12.73	20.62	43.86	50.83
(T_{10}) N_3(20:60:20NPK) + 20DAS (0.2% FsB)	12.27	20.59	43.80	52.66
(T_{11}) N_3(20:60:20NPK) + 35DAS (0.2% FsB)	12.96	24.82	47.46	53.60
(T_{12}) N_3(20:60:20NPK) + 20 and 35DAS (0.2% FsB)	12.54	20.46	45.66	51.30
F- test	NS	NS	S	S
S.E.±	1.12	1.37	1.53	1.31
C. D. (P = 0.05)	-	-	3.18	2.72

(FsB –Foliar spray of boron) NS= Non-significant S= Significant

(0.2% foliar spray of borax), T_{12} *i.e.*, N_3 (20:60:20 NPK) + 20 and 35DAS (0.2% foliar spray of borax) and T_9 *i.e.*, N_3 (20:60:20 NPK) were found statistically at par with T_{11} *i.e.*, N_3 (20:60:20 NPK) + 35DAS (0.2% foliar spray of borax). The probable reason for increase in plant height of T_{11} N_3 (20:60:20 NPK) +35DAS (0.2% foliar spray of borax), could be attributed to better proliferation of roots and increased nodulation due to increased phosphorus availability. Phosphorus encourages formation of new cells, promotes plant vigour and hastens leaf development, which helps in harvesting more solar energy and better utilization of nitrogen, which promotes higher growth attributes. Foliar application 0.2 per cent of borax increased the total dry matter production and nodules weight in greengram.

Number of leaves plant^{-1}:

The observations of number of leaves plant^{-1}are being presented in the Table 2. A perusal of the table reveals that there was a steady increase in the number of leaves plant^{-1} from 15 to 60DAS. At 60DAS was significant influence in number of leaves plant^{-1} due to different treatments, while at 15, 30 and 45DAS the effect of the treatment was non- significant. At 60DAS, there was significant difference between the treatments and maximum number of leaves plant^{-1} (21.16 plant^{-1}) was observed by the application of T_{11} *i.e.*, N_3 (20:60:20 NPK) + (0.2% foliar spray of borax) at 35DAS, whereas the lowest value 18.93 plant^{-1} was observed in treatment T_1 *i.e.*, N_1 (20:40:20 NPK). The probable reason for increasing branches plant^{-1} of T_{11} *i.e.*, N_3 (20:60:20 NPK) + 35DAS (0.2% foliar spray of borax), could be due to stimulation of root growth and increased metabolic activities. Foliar application 0.2 per cent of borax increase the total dry matter production and nodules weight in greengram.

Number of branches plant^{-1}:

Observations regarding the response of different levels of phosphorus and frequency of boron levels on number of branches plant^{-1} of greengram are given in Table 3. It was noticed that successive stage there was an increasing trend. At 60DAS was significant influence in number of branches plant^{-1} due to different treatments, while at 30 and 45DAS the effects of treatments were non-significant. At 60DAS, there was significant difference between the treatments and maximum number of branches (6.76 plant^{-1}) was observed by the application of T_{11} *i.e.*, N_3 (20:60:20 NPK) + (0.2% foliar spray of borax) at 35DAS, whereas the lowest value 6.20 plant^{-1} was observed in treatment T_1 *i.e.*, N_1 (20:40:20 NPK). However, treatments T_{10} *i.e.*, N_3 (20:60:20 NPK) + 20DAS (0.2% foliar spray of borax), was found statistically at par with T_{11} *i.e.*, N_3 (20:60:20 NPK) +35DAS (0.2% foliar spray of borax), However, T_{10} *i.e.*, N_3 (20:60:20 NPK) +20DAS (0.2% foliar spray of borax),

Table 2 : Effect of phosphorus levels and frequency of boron levels on leaves plant^{-1} at different stages of crop growth in greengram

Treatments	Leaves plant^{-1}			
	15DAS	30DAS	45DAS	60DAS
(T_1) N_1 (20:40:20 NPK)	2.66	13.40	22.00	18.93
(T_2) N_2 (20:40:20 NPK) +20DAS (0.2% FsB)	3.13	15.80	22.20	20.03
(T_3) N_1 (20:40:20 NPK)+35DAS (0.2% FsB)	3.20	16.20	22.20	19.36
(T_4) N_1(20:40:20 NPK) +20 and 35DAS (0.2% FsB)	3.00	14.60	22.60	19.53
(T_5) N_2 (20:50:20 NPK)	2.86	15.20	22.40	19.40
(T_6) N_2 (20:50:20 NPK)+20DAS (0.2% FsB)	3.13	15.20	22.00	19.10
(T_7) N_2 (20:50:20 NPK)+35DAS (0.2% FsB)	3.26	17.60	22.20	19.80
(T_8) N2(20:50:20 NPK) +20 and 35DAS(0.2% FsB)	2.93	15.40	22.20	19.06
(T_9) N_3 (20:60:20 NPK)	2.93	15.40	22.20	19.43
(T_{10}) N_3(20:60:20NPK) + 20DAS (0.2% FsB)	2.86	16.40	22.20	19.40
(T_{11}) N_3(20:60:20NPK) + 35DAS (0.2% FsB)	3.80	17.80	23.20	21.16
(T_{12}) N_3(20:60:20NPK) + 20 and 35DAS (0.2% FsB)	3.13	14.60	22.40	19.70
F- test	NS	NS	NS	S
S.E.±	0.26	1.33	0.39	0.49
C.D. (P = 0.05)	-	-	-	1.02

NS= Non-significant S= Significant

T_9 *i.e.*, N_3 (20:60:20 NPK), T_4 *i.e.*, N_1 (20:40:20 NPK) +20 and 35DAS (0.2% foliar spray of borax, T_6 *i.e.*, N_2 (20:50:20 NPK) + 20DAS (0.2% foliar spray of borax) and T_7 *i.e.*, N_2 (20:50:20 NPK) + 35DAS (0.2% foliar spray of borax) were found statistically at par with T_{11} *i.e.*, N_3 (20:60:20 NPK) + (0.2% foliar spray of borax) at 35DAS .The probable reason for increase in branches plant^{-1} of T_{11} *i.e.*, N_3 (20:60:20 NPK) + 35DAS (0.2% foliar spray of borax), could be due to stimulation of root growth and increased metabolic activities. The foliar spray of borax at 0.2 per cent at branching and pre-flowering being at par with 0.2 per cent spray of borax at pre-flowering (35DAS) + T_{11} *i.e.*, N_3 (20:60:20 NPK) recorded the maximum number of branches in greengram.

Number of nodules plant^{-1}:

Observations regarding the response of different phosphorus levels and frequency of boron levels on number of nodules plant^{-1} of greengram are given in Table 4. It was noticed that successive stage there was an incremental trend. At 45, 60 DAS were significant influence in number of nodules plant^{-1} due to different treatments, while at 30DAS was non- significant. At 45 DAS, there was significant difference between the treatments and maximum number of nodules (32.26 plant^{-1}) was observed by the application of T_{11} *i.e.*, N_3 (20:60:20 NPK) + (0.2% foliar spray of borax) at 35DAS, whereas the lowest value 26.00 plant^{-1} in T_1 *i.e.*, N_1 (20:40:20 NPK). However, T_7 *i.e.*, N_2 (20:50:20 NPK) +35 DAS (0.2% FsB), T_8 *i.e.*, N_2 (20:50:20 NPK) + 20 and 35 DAS (0.2% FsB), were found statistically at par with T_{11} *i.e.*, N_3 (20:60:20 NPK) + (0.2% foliar spray of borax) at 35 DAS. At 60 DAS, there was significant difference between the treatments. Maximum number of nodules (8.80 plant^{-1}) was obtained by the application of T_{11} *i.e.*, N_3 (20:60:20 NPK) + (0.2% foliar spray of borax) at 35DAS, whereas the lowest value 15.33 plant^{-1} was observed in treatment T_1 *i.e.*, N_1 (20:40:20 NPK). The probable reason for increasing nodules of T_{11} *i.e.* N_3 (20:60:20 NPK) + 35DAS (0.2% foliar spray of borax), could be due to different levels of phosphorus. Foliar application of 0.2 per cent borax at branching and pre flowering was at par with 0.2 per cent spray of borax at pre-flowering (35DAS) + T_{11} *i.e.* N_3 (20:60:20 NPK) with respect to total number of root nodules per plant. Nodule number, weight and nitrogenase activity are positively correlated with the nitrogen fixation. Increase in nodule number, weight and nodule development also observed with foliar spray of 0.2 per cent borax at pre-flowering stage. Improvement in nodule development with foliar boron spray was due to its role in formation of nodule in leguminous plants concerned with precipitation of excess cation, buffer action and regulatory effect on other nutrient element. Help in vascular system in root to give out branches to supply nodule bacteria with carbohydrate

Table 3: Effect of phosphorus levels and frequency of boron levels on number of branches plant^{-1} at different stages of crop growth in greengram

Treatments	Number of branches plant^{-1}		
	30DAS	45DAS	60DAS
(T_1) N_1 (20:40:20 NPK)	0.20	5.46	6.20
(T_2) N_2 (20:40:20 NPK) +20DAS (0.2% FsB)	0.40	5.60	6.36
(T_3) N_1 (20:40:20 NPK)+35DAS (0.2% FsB)	0.46	5.66	6.33
(T_4) N_1(20:40:20 NPK) +20 and 35DAS (0.2% FsB)	0.80	5.66	6.53
(T_5) N_2 (20:50:20 NPK)	0.60	5.66	6.30
(T_6) N_2 (20:50:20 NPK)+20DAS (0.2% FsB)	0.66	5.53	6.53
(T_7) N_2 (20:50:20 NPK)+35DAS (0.2% FsB)	0.66	5.60	6.53
(T_8) N2(20:50:20 NPK) +20 and 35DAS(0.2% FsB)	0.33	5.53	6.36
(T_9) N_3 (20:60:20 NPK)	0.33	5.60	6.70
(T_{10}) N_3(20:60:20NPK) + 20DAS (0.2% FsB)	0.33	5.60	6.73
(T_{11}) N_3(20:60:20NPK) + 35DAS (0.2% FsB)	0.80	5.73	6.76
(T_{12}) N_3(20:60:20NPK) + 20 and 35DAS (0.2% FsB)	0.73	5.66	6.36
F- test	NS	NS	S
S.E.±	0.33	0.13	0.16
C. D. (P = 0.05)	-	-	0.33

NS= Non-significant S= Significant

food that bacteria may not become parasitic. Such beneficial effect of boron with better edaphic environment available to the crop, might have improved all the growth attributes.

Plant dry weight (*g plant^{-1}*):

Observations regarding the response of different phosphorus levels and frequency of boron levels on plant dry weight of greengram are given in Table 5. It was noticed that successive stage there was an incremental trend. At 45, 60DAS were significant influence in plant height due to different treatments, while at 15, 30DAS were non- significant. At 45DAS, there was significant difference between the treatments and maximum dry weight (10.03g plant^{-1}) was observed by the application of T_{11} *i.e.*, N_3 (20:60:20 NPK) +(0.2% foliar spray of borax) at 35DAS, whereas the lowest value 7.20g plant^{-1} was observed in treatment T_1 *i.e.*, N_1 (20:40:20 NPK). However, treatments T_7 *i.e.*, N_2 (20:50:20 NPK) + 35DAS (0.2% foliar spray of borax) and T_5 *i.e.*, N_2 (20:50:20 NPK) were found statistically at par with T_{11} *i.e.*, N_3 (20:60:20 NPK) + (0.2% foliar spray of borax) AT 35 DAS. At 60 DAS, there was significant difference between the treatments and maximum dry weight (24.82 g plant^{-1}) was observed by the application of T_{11} *i.e.*, N_3 (20:60:20 NPK) + (0.2% foliar spray of borax) at 35 DAS, whereas the lowest value 20.04 g plant^{-1} was observed in treatment T_1 *i.e.*, N_1 (20:40:20 NPK). However, treatment T_7 *i.e.*, N_2 (20:50:20 NPK) + 35DAS (0.2% foliar spray of borax) were found statistically at par with T_{11} N_3 (20:60:20 NPK) + (0.2% foliar spray of borax) at 35DAS. The probable reason for increase in dry matter accumulation of T_1 *i.e.*,N_3 (20:60:20 NPK) + (0.2% foliar spray of borax) at 35 DAS, could be attributed to better proliferation of roots and increased nodulation due to increased phosphorus availability. Phosphorus encourage formation of new cells, promote plant vigour and hastens leaf development, which help in harvesting more solar energy and better utilization of nitrogen, which help towards higher growth attributes. Foliar application of 0.2 per cent borax at branching and pre-flowering was at par with 0.2 per cent spray of borax at pre-flowering (35DAS) + T_{11} *i.e.*, N_3 (20:60:20 NPK) with respect to total dry weight per plant. This might be due to quick availability of boron to crop during the entire growing season. The boron plays an important role in tissue differentiation and carbohydrate metabolism. It is also a constituent of cell membrane and essential for cell division, maintenance of conducting tissue with regulatory effect on other element. It is also necessary for sugar translocation in plant and development of new cell in meristamestic tissue.

Yield and yield attributes :

Observations regarding the response of different levels of phosphorus and frequency of boron levels on yield and yield attributes of greengram are given in Table 2. The observation showed that at yield and yield attributes

Table 4: Effect of phosphorus levels and frequency of boron levels on number of nodules plant^{-1} at different stages of crop growth in greengram

Treatments	Number of nodules plant^{-1}		
	30DAS	45DAS	60DAS
(T_1) N_1 (20:40:20 NPK)	8.63	26.00	5.53
(T_2) N_2 (20:40:20 NPK) +20DAS (0.2% FsB)	8.73	28.60	6.40
(T_3) N_1 (20:40:20 NPK)+35DAS (0.2% FsB)	8.83	28.26	6.46
(T_4) N_1(20:40:20 NPK) +20 and35DAS (0.2% FsB)	9.40	27.13	6.66
(T_5) N_2 (20:50:20 NPK)	10.13	28.66	6.00
(T_6) N_2 (20:50:20 NPK)+20DAS (0.2% FsB)	8.96	28.20	6.86
(T_7) N_2 (20:50:20 NPK)+35DAS (0.2% FsB)	9.60	30.26	7.40
(T_8) N2(20:50:20 NPK) +20 and 35DAS(0.2% FsB)	9.00	29.40	5.66
(T_9) N_3 (20:60:20 NPK)	8.80	28.13	6.13
(T_{10}) N_3(20:60:20NPK) + 20DAS (0.2% FsB)	9.20	28.80	6.80
(T_{11}) N_3(20:60:20NPK) + 35DAS (0.2% FsB)	10.86	32.26	8.80
(T_{12}) N_3(20:60:20NPK) + 20 and 35DAS (0.2% FsB)	9.13	28.00	6.20
F- test	NS	S	S
S.E.±	0.57	1.10	0.59
C. D. (P = 0.05)	-	2.29	1.21

NS= Non-significant S= Significant

there was significant difference between treatments, except to straw yield (t ha^{-1}).

Number of pods plant^{-1}:

The result revealed that there was significant difference between the treatments and maximum number of pods (42.46 plant^{-1}) was observed by the application of T_{11} *i.e.*, N_3 (20:60:20 NPK) + (0.2% foliar spray of borax) at 35 DAS, whereas the lowest value 30.40 plant^{-1} was observed in treatment T_1 *i.e.*, N_1 (20:40:20 NPK). However, treatment, T_7 *i.e.*, N_2 (20:50:20 NPK) + 35DAS (0.2% foliar spray of borax) was found statistically at par with T_{11} *i.e.*, N_3 (20:60:20 NPK) + 35DAS (0.2% foliar spray of borax).

Pod length (cm):

The result revealed that there was significant difference between the treatments and maximum pod length (10.80cm) was obtained by the application of T_{11} *i.e.*, N_3 (20:60:20 NPK) + (0.2% foliar spray of borax) at 35DAS, whereas the lowest value 8.13 cm was observed in treatment T_1 *i.e.*, N_1 (20:40:20 NPK). However, treatments, T_7 *i.e.*, N_2 (20:50:20 NPK) + 35DAS (0.2% foliar spray of borax), T_{10} *i.e.*, N_3 (20:60:20 NPK) + 20DAS (0.2% foliar spray of borax), T_8 *i.e.* N_2 (20:50:20 NPK) + 20 and 35DAS (0.2% foliar spray of borax), T_9 *i.e.*, N_3 (20:60:20 NPK), T_{12} *i.e.*, N_3 (20:60:20 NPK) + 20 and 35DAS (0.2% foliar spray of borax), T_4 *i.e.*, N_1 (20:40:20 NPK) + 20 and 35DAS (0.2% foliar spray of borax), T_6 *i.e.*, N_2 (20:50:20 NPK) + 20DAS (0.2% foliar spray of borax) and T_3 *i.e.*, N_1 (20:40:20 NPK) + 35DAS (0.2% foliar spray of borax), were found statistically at par with T_{11} *i.e.*, N_3 (20:60:20 NPK) + 35DAS (0.2% foliar spray of borax).

Number of grains pod^{-1}:

The result revealed that there was significant difference between the treatments and maximum number of grains (13.40 pod^{-1}) was observed by the application of T_{11} *i.e.*, N_3 (20:60:20 NPK) + (0.2% foliar spray of borax) at 35 DAS, whereas the lowest value 7.73 pod^{-1} was observed in treatment T_1 *i.e.*, N_1 (20:40:20 NPK). However, treatment, T_7 *i.e.*, N_2 (20:50:20 NPK) + 35DAS (0.2% foliar spray of borax) was found statistically at par with T_{11} *i.e.*, N_3 (20:60:20 NPK) + 35DAS (0.2% foliar spray of borax).

Test weight (*g*):

The result revealed that there was significant difference between the treatments and maximum test weight (47.00g) was observed by the application of T_{11} *i.e.*, N_3 (20:60:20 NPK) + (0.2% foliar spray of borax) at 35 DAS. Whereas the lowest value 41.06g was observed in treatment T_1 *i.e.*, N_1 (20:40:20 NPK).

Grain yield (*t ha^{-1}*):

The result revealed that there was significant difference between different treatments and maximum

Table 5 : Effect of phosphorus levels and frequency of boron levels on dry weight (g) at different stages of crop growth in greengram

Treatments	Dry weight (g)			
	15DAS	30DAS	45DAS	60DAS
(T_1) N_1 (20:40:20 NPK)	0.23	1.45	7.20	20.04
(T_2) N_2 (20:40:20 NPK) +20DAS (0.2% FsB)	0.24	1.58	8.30	21.34
(T_3) N_1 (20:40:20 NPK)+35DAS (0.2% FsB)	0.33	1.75	8.16	21.43
(T_4) N_1(20:40:20 NPK) +20 and 35DAS (0.2% FsB)	0.28	1.55	8.41	20.46
(T_5) N_2 (20:50:20 NPK)	0.34	1.83	9.00	20.59
(T_6) N_2 (20:50:20 NPK)+20DAS (0.2% FsB)	0.27	1.65	7.91	21.72
(T_7) N_2 (20:50:20 NPK)+35DAS (0.2% FsB)	0.42	1.50	9.25	24.20
(T_8) N_2 (20:50:20 NPK) +20 and 35DAS(0.2% FsB)	0.36	1.58	8.11	20.61
(T_9) N_3 (20:60:20 NPK)	0.30	1.58	8.71	20.62
(T_{10}) N_3 (20:60:20NPK) + 20DAS (0.2% FsB)	0.33	1.86	7.86	20.38
(T_{11}) N_3 (20:60:20NPK) + 35DAS (0.2% FsB)	0.36	1.90	10.03	24.82
(T_{12}) N_3 (20:60:20NPK) + 20 and 35DAS (0.2% FsB)	0.24	1.48	8.10	20.46
F- test	NS	NS	S	S
S.E.±	0.08	0.22	0.58	1.30
C. D. (P = 0.05)	-	-	1.19	2.69

NS= Non-significant S= Significant

grain yield (1.62 t ha^{-1}) was observed by the application of T_{11} *i.e.*, N_3 (20:60:20 NPK) + (0.2% foliar spray of borax) at 35 DAS, whereas the lowest value 0.99 t ha^{-1} was observed in treatment T_1 *i.e.*, N_1 (20:40:20 NPK).

Straw yield (*t* ha^{-1}):

The result revealed that there was no significant difference between the treatments.

Harvest index (*%*):

The result revealed that there was significant difference between the treatments and maximum harvest index (36.15%) was observed by the application of T_{11} *i.e.*, N_3 (20:60:20 NPK) + (0.2% foliar spray of borax) at 35 DAS, whereas the lowest value 32.58% in T_1 *i.e.*, N_1 (20:40:20 NPK). However, treatments, T_5 *i.e.*,N_2 (20:50:20 NPK), T_{10} *i.e.*,N_3 (20:60:20 NPK) + 20DAS (0.2% foliar spray of borax), T_9 *i.e.*, N_3 (20:60:20 NPK), T_7 *i.e.*, N_2 (20:50:20 NPK) + 35DAS (0.2% foliar spray of borax), T_3 *i.e.*, N_1 (20:40:20 NPK) + 35DAS (0.2% foliar spray of borax), T_4 *i.e.*, N_1 (20:40:20 NPK) + 20 and 35DAS (0.2% foliar spray of borax) and T_6 *i.e.*, N_2 (20:50:20 NPK) + 20DAS (0.2% foliar spray of borax) were found statistically at par with T_{11} *i.e.*, N_3 (20:60:20 NPK) + 35DAS (0.2% foliar spray of borax). The probable reason for increase in yield and yield attributes of T_{11} *i.e.*, N_3 (20:60:20 NPK) + (0.2% foliar spray of borax) at 35 DAS, because Phosphorus play a primary role in photosynthesis by way of energy transfer and thereby increase photosynthetic efficiency resulting in increased availability of photosynthetic. These all different levels resulted in overall increase in yield attributes. The increment in seed yield by phosphorus application was due to increase in growth attributes and yield attributes over control, which is finally contributes in seed yield. The increase of seed yield may be due to increase in P availability through SSP. Yield attributing characters, grain and stover yield were increased with increasing cumulative favorable effect of phosphorus. Better growth and development of crop plants due to phosphorus supply and nitrogen uptake might have increased the supply of assimilates to seed, which ultimately gained more weight. Foliar application of 0.2 per cent borax at pre-flowering (35DAS) + T_{11} *i.e.*, N_3 (20:60:20 NPK) was found to enhance yield and yield attributes of greengram significantly over control. This is might due to application of borax at 0.2 per cent foliar spray at pre flowering significantly increased all yield attributing character in greengram *viz.*, number of pod /plant, seed/pod, test weight, seed and straw yield. Enhanced vegetative growth in terms of number of branches per plant provided more sites for translocation of photosynthates and ultimately resulted in increment in yield attributes. The beneficial effect of boron on yield attributes may be due to flower development pollen grain formation, pollen viability, pollen tube growth for proper pollination and seed development.

Conclusion :

The experiment was conducted to, "Study the effects of different phosphorus levels and frequency of boron levels on growth and yield of greengram". The experimental findings based on parameters are summarized below.

To study the effects of different phosphorus levels and frequency of boron levels on growth and yield of greengram:

Among the different phosphorus levels and frequency of boron levels under in treatment T_{11} *i.e.*,N_3 (20:60:20NPK) + 0.2% foliar spray of borax at 35DAS (pre-flowering) recorded maximum plant height (53.60cm), number of leaves $plant^{-1}$ (21.16), number of branches $plant^{-1}$ (6.76), number of nodules $plant^{-1}$ (8.80), dry weight (24.82g), crop growth rate (0.53 g m^{-2} day^{-1}), relative growth rate (0.04 g g^{-1} day^{-1}), number of pods $plant^{-1}$ (42.46), average number of grain pod^{-1}(13.40), pod length (10.80 cm), test weight (47.00g), grain yield (1.62 t ha^{-1}), straw yield (2.85 t ha^{-1}), protein content (24.56%) and harvest index (36.15%). Whereas the lowest value (48.26 cm,18.93 $plant^{-1}$,6.20 $plant^{-1}$,5.53 $plant^{-1}$, 20.02 g, 0.39 g m^{-2} day^{-1}, 0.03 g g^{-1} day^{-1},30.40 $plant^{-1}$, 7.73 pod^{-1}, 8.13 cm, 41.06 g, 0.99 t ha^{-1}, 2.06 t ha^{-1}, 20.36 % and 32.58 %, respectively) in the treatment T_1*i.e.*, N_1 (20:40:20 NPK).

Economics of different treatment combinations:

The highest gross return (Rs.78795.00 ha^{-1}), net return (Rs. 57222.00 ha^{-1}) and benefit cost ratio (2.65) were registered in treatment T_{11} *i.e.*, N_3 (20:60:20NPK)+ 0.2% foliar spray of borax at 35DAS (pre-flowering). Whereas the lowest value (Rs. 48925.50 ha^{-1}), (Rs. 30075.50 ha^{-1}) and (1.59), respectively in the treatment T_1 *i.e.*, N_1 (20:40:20 NPK). It may be concluded that among the different levels of phosphorus and frequency of boron levels under in treatment T_{11} *i.e.*, N_3 (20: 60:

20NPK) + 0.2% foliar spray of borax at 35DAS (pre-flowering) was found to be the best for obtaining highest seed yield (1.62 t ha^{-1}), net return (Rs. 57222.00 ha^{-1}) and benefit cost ratio (2.65) in greengram. Since, this result is based on one year experiment; further trials may be done to confirm the finding.

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