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Morphological, physiological and yield analysis of black gram under different levels of FYM, PSB and phosphorus

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Abstract
Grain legumes are important source of protein for a large section of vegetarian population of the developing countries in general, and India in particularly. Black gram (*Vigna mungo. L Hepper)* traditionally grown in *Kharif* season by the farmers is one of the most cultivated legume crop with high nutritive value and agricultural importance. In the present study, morphological, physiological and yield analysis of black gram was estimated under different levels of FYM, PSB and phosphorus during both the consecutive years 2010-11. The crop benefited during the growth and development period by temperature and day light etc. in growth, yield and yield attributes and quality of grain in the said season. Application of 5 tonnes FYM ha^{-1} had no significant effect on plant population at 30 days and at harvest, and on mortality percentage but Growth characters were found increased during both the years. Length and weight, Number and weight of nodules $plant^{-1}$, Dry matter production ha^{-1} and harvest index, yield attributes namely number of pods $plant^{-1}$, length of pod, number of grains $plant^{-1}$, number and weight of grains pod^{-1} and 1000 grains weight were also increased when trated with 5 tonnes of FYM ha-^{1}. The study recommends that the addition of FYM, PSB and phosphorus for in Agra region during summer season were significantly increases the yield and quality of the legume crop black gram and this will become the base for better cop production.

Keywords: Soil, farmyard manure, phosphate solubilizing bacteria, yield, black gram

Introduction
Due to increasing population pressure, the demand for food, feed, fodder, fiber, fuel, pulse and oilseed products is rapidly increasing. The present situation though comfortable, but to meet the future demand, we would need better planning and resource management as well as intensification of crop production. (Kumar and Singh, 2010) [24]. Indian agriculture contributes to 8% global agricultural gross domestic product to support 18% of world population on only of world's arabal land and 2.3% geographical area. (ICAR vision 2030).
Grain legumes are important source of protein for a large section of vegetarian population of the developing countries in general, and India in particularly. This play on equally important role in rainfed and irrigated agriculture by improving physical, chemical and biological properties of soil and are considered excellent crops for natural resources management, environment security, crop diversification and consequently for viable agriculture. According to FAO/WHO's recommendations currently 85g of pulses per capita per day required to meet protein requirement but at present, the availability of pulses in India, is only 40g per capita per day. Black gram is gorwn about 31 lakh hectares in India. Black gram traditionally grown in *Kharif* season by the farmers but with the introduction of short duration, photo-intensive, thermo tolerant varieties of black gram, it has been possible to grow black gram during summer season without dislocating the area of major cereal in intensive cropping system areas. Among the commonly grown pulses, black gram (*Vigna mungo. L Hepper)* is highly level of protein contents, about 24 percent. Black gram as pulses also contain 10.9 percent moisture, 1.4 percent fats, 60.3 percent carbohydrates and 3.4 percent ash. It is supposed to be richest amongst various pulses in phosphoric acid more (5 to 10 times) than other pulses.
The integrated nutrient management is one of the most important components of the production technology to sustain soil fertility and crop productivity in the future. Plant nutrients can be supplied from different sources i.e. organic manures, vermicompost, crop residues, green manure, biofertilizers, PROM and chemical fertilizers.

The combined use of organic and inorganic sources of plant nutrient not only pushed the production and profitability of field crops, rather it helps in maintaining the permanent fertility status of the soil. (Dubey, S.K *et al*, 1996; Kumar and Singh, 2010) [3, 24].

Phosphorus is the most important nutrient for pulses. Its application is known for the response in presently available black gram cultivars. Judicious use of phosphorus application increase root biomass, nodulation biomass production and grain yield. It plays a key role information of energy rich ATP molecules, nucleo-protein and phospholipids. The synthesis of sulfur containing amino acids and protein content in seeds has also been reported to influence positively by increasing phosphorous levels (Dwivedi, 1982) [4, 5]. The problem of phosphorus nutrients is in three folds; First- this element is present in relatively smaller quantities; Second- major part of phosphorus present in soil is not readily available (hardly 16-18%) and Third- it has got fixing capacity in soil after its application. Thus, the phosphorous fertilization deserves careful management in different ways under various crops grown in cropping systems. Mainly, in Agra region of western U.P (AESR 4.1) where available phosphorus (P) status is medium (around 10-12 kg ha^{-1}) in soil.

Biofertilizers are cost effective, ecofriendly and renewable sources of plant nutrients to supplement fertilizer for sustainable agriculture development. Hence, the use of biofertilizers becomes an integral part of plant nutrient management for maximizing crop production. Among biofertilizer, symbiotic, asymbiotic, BGA, azola, mycorhiza and phosphorus solubilisers and mobilizers bacteria play an important role in maintaining soil fertility. (kumar and Singh 2010) [24]. Enhancing phosphorous availability to crop through phosphate solublising bacteria [PSB] holds a great promise in enhancing growth and yield of pulses (Dwivedi, G.K. *et al*, 1988) [6]. In recent years the research work on biofertilizers carried out in different parts of India indicated the effectiveness of biofertilizers in boosting the production and maintaining the soil fertility (Guar and Sunita, 1992) [7]

Farm Yard manure (FYM) is though not useful as a sole source of nutrients but a good complimentary and supplementary source with mineral fertilizers. The application of FYM not only provides nutrition to crop on decomposition but also increases the nutrient and water holding capacity of soil. Addition of FYM also restricts the phosphate depletion from soil and maintains phosphate balance by reducing its fixation. Since quite inadequate information is available on the response of the black gram to PSB, with or without application of phosphorus and FYM under Agra region during summer season.

This agro technology developed to the response of the black gram to PSB with or without application of phosphorus and FYM under Agra region. The application phosphorus increases root biomass and yield of black gram. Keeping environmental pollution in mind and cost of chemical fertilizers. Use of bio-fertilizers (PSB) and FYM is considered best. It is well known that FYM provides nutrient and increases water holding capacity of soil and also restricts phosphorus depletion from the soil on other hand PSB enhances phosphorus availability and crop yield and reducing cost of production in pulses. Keeping in view the facts mentioned above the present study entitled (2010-2011) was conducted in two consecutive summer season, at the research farm of RBS College, Agra representing Western UP that lies in semi arid condition and Agro-Eco Sub Region (AESR).

Material and Method

Details of the experimental materials

The investigation reported here in were carried out during two summer seasons of 2010 and 2011. The experimental crop of black gram was raised after mustard and toria in *rabi* season during first and second year, respectively.

Experimental site

The present study was carried-out at the Raja Balwant Singh College Agricultural Research Farm, Bichpuri (Agra). During summer season of 2010 and 2011 on Black gram (*Vigna mungo. L Hepper*). A composite soil sample from the surface soil (0-30 cm) was taken during both the years before sowing the experimental crop of black gram and was subjected to chemical analysis. The mechanical analysis was done during first year only. The experimental location was situated at latitude of 27.2° north, longitude of 77.9° East and altitude of 168 m from mean sea level.

Experimental details

The details of the experiment conducted for the two years are given below:

Treatments

A. FYM levels

(tonnes ha^{-1}): i) 0 ii) 5

B. Phosphate solubilizing Bacteria (PSB) *Pseudomonas striata*. (Strain MFE), the seed was inoculated @ 250 ml culture/10 kg seed with no inoculation and PSB inoculation

C. Phosphorus levels

(P_2O_5 kg ha^{-1}) through DAP

1. 0
2. 20
3. 40
4. 60

Note: 25 kg starter dose of N to be applied. The N available from DAP in the all treatments deducted and rest N to be applied by urea.

Design of the experiment

The experiment was laid out in factorial randomized block design with three replications. The treatments were randomly allotted to different plots as per procedure given by Panse and Sukhatme (1978) [29]. Thus, each replication having 16 treatment combinations. The gross plot size was 5.0 m ×3.0 m^2. While the net plot size was 4.0 m ×2.0 m^2.

Seed Sowing

A recommended seed rate of 35kg ha^{-1} in black gram variety (Pant U-35) used during summer season of both the years of experimentation. As per treatment, seed were inoculated with PSB culture (*Pseudomonas striata*). The culture was mixed jaggery solution (10%) to make slurry and then this slurry was manually mixed with the seed and kept for drying under shade, just before sowing. Treated seeds were sown manually in the furrows as per treatment.

Details of methods

Nodule study, Length of root, Weight of root, Number of nodule plant$^{-1,}$ Dry weight of nodules, Shoot root ratio, Post-harvest studies, Yield attributes, Number of pods plant$^{-1,}$ Pod length, Number of grains pod$^{-1,}$ 1000, Grains weight and straw yield per plant treatment during both the years were done at 30 days after sowing and continued at an interval of 30 days till the harvesting.

A respective sample of 200 grains irrespective of shape and size was taken from threshed produce of each plot and its weight was recorded and converted to 1000 grains weight. The five tagged plants were weighted and pods from these plants were threshed, their grains were cleaned and sun dried to estimate grain yield plant^{-1}(g). Grain yield plant^{-1} was subtracted from total yield plant^{-1} to obtain straw yield plant^{-1}.

Yield studies

Grain, Straw yield and Biological

After threshing and winnowing, the grain yield of individual net plot was weighed separately and converted into kilograms per hectare. The grain yield was subtracted from total produce of corresponding plot to get straw yield per plot and it was converted into kilograms per hectare. The produce of each plot (grain and straw) was allowed to air dry in respective plots after harvesting and weighed to record biological yield per plot which was converted into kilograms per hectare.

Result and Discussion

The results of various study carried out in course of this investigation on the growth and development, yield and yield attributes, quality of grain and straw with different treatments of FYM, PBS and phosphorus on summer black gram are presented in this chapter and expressed with the help of suitable tables and figures, wherever necessary

Growth and development studies

Progressive data on growth and development characters of black gram in terms of plant stand, plant height, number of branches plant^{-1}, dry matter accumulation in plant, days to 75 percent flowering and days to maturity, crop growth rate (CGR) and relative growth rate (RGR) as affected by levels of FYM, phosphorus and solublising bacteria (PSB) have been discussed below with regard to time and treatment effects.

Plant stand

The data pertaining to plant population at 30 days of sowing and at harvest are presented in Table-4.1. The analysis of variance of crop stands at 30 days after sowing and at harvest.

Effect of FYM, PSB and phosphorus

The data presented in Table 1 show that the effect of FYM on plant population at 30 days and at harvest was not significant in both the years. Application of PSB had no significant effect on crop stand at 30 *days* and at harvest in both the crop seasons. Effect of plant population at 30 days and at harvest did not modify appreciably due to levels of phosphorus in both the years.

Table 1: Crop stand (1000 plants ha^{-1}) at 30 days and at harvest as influenced by levels of FYM, PSB and phosphorus fertilization

Treatments	Plant population (1000 plant ha^{-1})			
	30 days		at Harvest	
	2010	2011	2010	2011
Levels of FYM (tonnes ha^{-1})				
0	263.21	271.29	238.72	251.33
5	269.54	276.17	246.31	257.67
SEm±	4.27	4.55	3.55	3.44
CD (p=0.05)	NS	NS	NS	NS
Levels of PSB				
No inoculation	265.42	272.75	240.78	253.23
Inoculation	267.33	274.71	244.45	255.77
SEm±	4.27	4.55	3.55	3.44
CD (p=0.05)	NS	NS	NS	NS
Levels of phosphorus(kg P_2O_5 ha^{-1})				
0	261.17	171.70	235.43	250.80
20	265.67	273.92	242.30	253.55
40	268.59	274.42	245.60	256.04
60	270.69	275.42	247.15	257.63
SEm±	6.03	6.44	5.02	5.15
CD (p=0.05)	NS	NS	NS	NS

NS – Not significant

Mortality percentage

Mortality percentage was calculated at harvest in both the years. The respective data were presented in table 2. The analysis of variance of mortality percentage is also described.

Effect of FYM, PSB and Phosphorus

The effect of FYM on mortality percentage was not influenced significantly in both the years. However, mortality percentage was decreased with 5 tonnes FYM ha^{-1} over no FYM. Mortality percentage was not affected significantly in both the crop seasons. However, mortality percentage was decreased with PSB inoculation over without inoculation. Mortality percentage was decreased with every increase in the rate of phosphorus application; however, differences were not appreciable either in any year of study.

Table 2: Mortality percentage at harvest as influenced by different treatments

Treatments	Mortality Percentage	
	2010	2011
Levels of FYM (tonnes ha^{-1})		
0	9.13	8.72
5	8.70	8.46
SEm±	0.17	0.16
CD (p=0.05)	NS	NS
Levels of PSB		
No inoculation	9.15	8.80
Inoculation	8.68	8.38
SEm±	0.17	0.16
CD (p=0.05)	NS	NS
Levels of phosphorus (kg P_2O_5 ha^{-1})		
0	9.28	9.14
20	8.75	8.55
40	8.43	8.44
60	8.35	8.23
SEm±	0.24	0.23
CD (p=0.05)	NS	NS

NS – Not significant

Plant Height

The progressive data on plant height (cm) as influenced by levels of FYM, PSB and phosphorus fertilization are given in table 3 and analysis of variance of plant height at various stages of crop growth is also described.

Table 3: Plant height (cm) of black gram at various stages of crop growth as influenced by levels of FYM, PSB and phosphorus fertilization

Treatments	Plant height (cm)					
	Days after sowing					
	30	60	At Harvest	30	60	At Harvest
	2010			2011		
Levels of FYM (tonnes ha^{-1})						
0	7.30	25.60	32.87	7.75	27.48	33.72
5	7.68	27.06	35.02	8.15	28.72	35.84
SEm±	0.12	0.37	0.44	0.13	0.40	0.46
CD (p=0.05)	0.35	1.06	1.27	0.38	1.15	1.32
Levels of PSB						
No inoculation	7.28	25.62	32.98	7.74	27.52	33.85
Inoculation	7.70	27.04	34.91	8.16	28.68	35.71
SEm±	0.12	0.37	0.44	0.13	0.40	0.46
CD (p=0.05)	0.35	1.06	1.27	0.38	1.15	1.32
Levels of phosphorus(kg P_2O_5 ha^{-1})						
0	6.76	24.22	31.53	7.15	28.89	32.42
20	7.39	25.98	33.48	7.80	27.64	34.32
40	7.89	27.54	35.30	8.40	29.33	36.16
60	7.92	27.59	35.48	8.45	29.55	36.22
SEm±	0.17	0.52	0.62	0.18	0.56	0.65
CD (p=0.05)	0.50	1.50	1.79	0.53	1.63	1.87

The curves of plant height were almost of the same shape during both the crop seasons, but plant height was relatively more in 2011 than 2010 at all the stages of crop growth. In general, plant height increased slowly up to 30 days of sowing and thereafter rate of increase was quite high up to harvest of the crop.

Effect of FYM, PSB and Phosphorus

It is clear from table 3 that the plant height was increased appreciably with the application of 5 tonnes FYM ha^{-1} over no FYM at all the stages of crop growth in both the years. at harvest, the increase in plant height was 6.54 and 6.29 percent with 5 tonnes FYM ha^{-1} over no FYM during 2010 and 2011, respectively.

Phosphate solubilizing bacteria (PSB) had significant effect on plant height at all the stages of crop growth in both the crop seasons (Dubey, 1997) [2]. Plant height significantly higher due to seed inoculation with PSB than that of no inoculation. At harvest, the respective increase in plant height with inoculation was 5.85 and 5.50 per –cent over without inoculation in 2010 and 2011. The data presented in table 4.3 reveal that the application of phosphorus increased appreciably plant height over the control at all the stages of crop growth during both the crop seasons. Further, plant height increased appreciably with every increase in the rate of phosphorus application up to 40 kg P_2O_5 ha^{-1}. When the rate of phosphorus was increased from 40 to 60 kg P_2O_5 ha^{-1}, plant height increased marginally in both the years. At harvest, the increase in plant height with 20, 40 and 60 kg P_2O_5 ha^{-1} was to the tune of 6.18, 11.96 and 12.53 percent in 2010 and 5.86, 11.54 and 11.72 percent in 2011, respectively over the control.

Number of Branches Plant^{-1}

The data recorded for number of branches plant^{-1} at successive stages of crop growth are summarized in table 4.

The data so obtained were subjected to statistical analysis. The number of branches plant^{-1} during both the crop seasons increased from 30 days of sowing irrespective of the treatments and reached the maximum level at 60 days of seeding. Thereafter, the number of branches plant^{-1} were declined marginally.

Effect of FYM, PSB and Phosphorus

A close study of table 4 reveals that the number of branches plant^{-1} were increased significantly with the application of 5 tonnes FYM ha^{-1} over no FYM at all the stages of crop growth during both the years and at harvest, the magnitude of increase was to the tune of 8.47 and 8.33 percent in 2010 and 2011, respectively. Effect of seed inoculation with PSB on the number of branches plant^{-1} were significant at all the stages of crop growth in both the seasons (Table 4). The number of primary branches plant were increased appreciably with seed inoculation with PSB over no inoculation. At harvest, the magnitude of increase in number of branches plant^{-1} with inoculation was to the tune of 7.77 percent in 2010 and 7.64 percent in 2011 over no inoculation.

Table 4: Number of branches plant^{-1} at various stages of crop growth as influenced by levels of FYM, PSB and phosphorus fertilization

Treatments	Number of branches plant^{-1}					
	Days after sowing					
	30	60	At Harvest	30	60	At Harvest
	2010			2011		
Levels of FYM(tonnes ha^{-1})						
0	3.06	6.02	5.90	3.12	6.20	6.00
5	3.42	6.48	6.40	3.60	6.78	6.50
SEm±	0.05	0.10	0.10	0.05	0.11	0.10
CD (p=0.05)	0.15	0.28	0.28	0.16	0.31	0.28
Levels of PSB						
No inoculation	3.02	6.00	5.92	3.08	6.18	6.02
Inoculation	3.46	6.50	6.38	3.64	6.80	6.48
SEm±	0.05	0.10	0.10	0.05	0.11	0.10
CD (p=0.05)	0.15	0.28	0.28	0.16	0.31	0.28
Levels of phosphorus (kg P_2O_5 ha^{-1})						
0	2.98	5.47	5.46	3.02	5.65	5.48
20	3.24	6.14	6.03	3.31	6.37	6.13
40	3.46	6.66	6.56	3.54	6.93	6.65
60	3.48	6.74	6.65	3.58	7.02	6.74
SEm±	0.07	0.14	0.14	0.08	0.15	0.14
CD (p=0.05)	0.21	0.40	0.40	0.22	0.43	0.40

The data presented in table 4 reveal that the effect of phosphorus on number of branches plant^{-1} were found to be significant at various stages of crop growth in both the years when compared with control. Further, number of branches plant^{-1} were increased with every increase in the rate of phosphorus application up to 60 kg P_2O_5 ha^{-1}, however, significant differences were observed only up to 40 kg P_2O_5 ha^{-1}. At harvest, the magnitude of increase in the number of branches plant^{-1} with 20, 40 and 60 P_2O_5 ha^{-1} was to the tune of 10.44, 20.15 and 21.79 percent in 2010 and 11.86, 21.35 and 22.99 percent in 2011, respectively over the control.

Dry matter accumulation in plant

The data on dry matter accumulation in plant collected at various stages of crop growth during 2010 and 2011 are presented in table 4 with the statistical analysis of the data

It is clear that the dry matter in plant was accumulated continuously up to maturity of the crop. On the whole, the second year was favourable than the first year so far dry matter accumulation is concerned. On an average, whole plant accumulated dry matter to the tune of 16.0 percent in first 30 days, 49.4 percent in next 30 days and 34.6 percent in further 30 days (between 60 days to harvest of the crop).

Table 5: Dry matter accumulation in plant at various stages of crop growth as influenced by levels of FYM, PSB and phosphorus fertilization

Treatments	Dry matter accumulation in plant (g)					
	Days after sowing					
	30	60	At Harvest	30	60	At Harvest
	2010			2011		
Levels of FYM (tonnes ha^{-1})						
0	3.85	15.70	23.82	3.92	16.41	25.06
5	4.20	16.82	26.05	4.28	17.43	27.54
SEm±	0.06	0.26	0.30	0.07	0.27	0.33
CD (p=0.05)	0.18	0.75	0.88	0.19	0.79	0.95
Levels of PSB						
No inoculation	3.90	15.84	24.12	3.96	16.56	25.30
Inoculation	4.15	16.68	25.75	4.24	17.43	27.30
SEm±	0.06	0.26	0.30	0.07	0.27	0.33
CD (p=0.05)	0.18	0.75	0.88	0.19	0.79	0.95
Levels of phosphorus(kg P_2O_5 ha^{-1})						
0	3.62	14.58	22.60	3.58	15.25	24.03
20	3.96	15.97	24.43	4.03	16.70	25.87
40	4.24	17.21	26.26	4.37	17.96	27.58
60	4.28	17.29	26.45	4.42	18.06	27.72
SEm±	0.09	0.37	0.43	0.09	0.38	0.46
CD (p=0.05)	0.25	1.06	1.25	0.27	1.11	1.34

Effect of FYM, PSB and Phosphorus

The application of 5 tonnes FYM ha^{-1} accumulated significantly more dry matter in plant when compared with no FYM at all the stages of crop growth in both the years (Table 5). At harvest, the magnitude of increase in dry matter accumulation in plant with 5 tonnes FYM ha^{-1} was to the tune of 9.36 and 9.90 percent, respectively in 2010 and 2011 over no FYM.

A perusal of the data summarized in table 5 shows that the black gram grains treated with PSB accumulated appreciably higher dry matter accumulation in plant that that of untreated grains at all the stages of crop growth in both the years. At harvest, the magnitude of increase in dry matter accumulation in plant with PSB treated grains was to the tune of 6.76 and 7.91 percent over untreated grains in the first and second crop seasons, respectively.

An examination of data presented in table 5 indicate that the effect of phosphorus on dry matter accumulation in plant was statistically significant at all the stage of crop growth during both the crop seasons. The dry matter accumulation in plant was increased conspicuously with every increase in the rate of phosphorus application up to 40 kg P_2O_5 ha^{-1}. When the rate of phosphorus was increased from 40 to 60 kg P_2O_5 ha^{-1}, the dry matter accumulation in plant was increased marginally at all the stages of crop growth in 2010 and 2011. At harvest, the magnitude of increase in dry matter accumulation in plant with 30, 40 and 60 kg P_2O_5 ha^{-1} was to the tune of 8.10, 16.19 and 17.04 percent in 2010 and 7.66, 14.77 and 15.36 percent in 2011, respectively over the control.

Yield attributes

In case of black gram main yield attributing characters are number of pods $plant^{-1}$, length of pod, number of grains $plant^{-1}$, number and weight of grains pod^{-1} and 1000 grains weight. The variations in these yield attributes due to treatment effect were measured and results so obtained were subjected to statistical analysis. The data pertaining to main effects of all the yield attributes have been summarized in table 6(a and b).

Number of pods $plant^{-1}$

Effect of FYM, PSB and Phosphorus

A critical study of the data presented in table 6(a) reveals that the application of 5 tonnes FYM ha^{-1} produced significantly more number of pods $plant^{-1}$ by 6.4 and 7.0 percent respectively over no FYM in 2010 and 2011. Seed inoculation grains with PSB culture had appreciably higher number of pods $plant^{-1}$ by 8.2 and 9.4 percent in 2010 and 2011, respectively over uninoculated grains. The application of phosphorus significantly affected the number of pods $plant^{-1}$ in both the years (Table 6(a). Increasing rates of phosphorus application increased the number of pods $plant^{-1}$ up to the maximum level (60 kg P_2O_5 ha^{-1}), however, significant variations were observed only up to 40 kg P_2O_5 ha^{-1} in both the crop seasons. The magnitude of increase in number of pods $plant^{-1}$ with 20, 40 and 60 kg P_2O_5 ha^{-1} was to the tune of 9.8, 16.8 and 17.5 percent in 2010 and 9.9, 17.0 and 17.5 percent in 2011, respectively over the control.

Length of pod

Effect of FYM, PSB and Phosphous

The data summarized in table 6(a) reveal that the application of 5 tonnes FYM ha^{-1} increased significantly length of pod by 6.5 and 7.0 percent in 2010 and 2011, respectively over no FYM. The effect of seed inoculation with PSB on length of pod was significant in both the years (Table 6(a). Seed inoculation with PSB had appreciably more length of pod by 7.8 and 8.2 percent in 2010 and 2011, respectively than that of no inoculation. The data set out in table 6(a) indicate that the application of phosphorus increased significantly length of pod over the control. Further, length of pod increased appreciably with every increase in the rate of phosphorus application up to 40 kg P_2O_5 ha^{-1}, beyond that in was increased marginally in 2010 and 2011. The increase in length of pod with 20, 40 and 60 kg P_2O_5 was to the tune of 9.0, 17.3 and 18.6 percent in first crop season and 10.8, 19.4 and 20.7 percent in second crop season, respectively over the control.

Number of grains $plant^{-1}$

Effect of FYM, PSB and Phosphous

A glance of table 6(a) indicate that the application of 5 tonnes FYM ha^{-1} had conspicuously more number of grains $plant^{-1}$ by 6.3 and 7.0 percent over no FYM, respectively in 2010 and 2011. The data arrange in table 6(a) show that the grains treated with PSB increased significantly number of grains $plant^{-1}$ by 7.5 and 8.0 percent, respectively over no inoculation in first and second crop seasons.

An examination of the data presented in Table 6(a) pointed out that the application of phosphorus registered significantly higher number of grains $plant^{-1}$ when compared with control. Further, number of grains $plant^{-1}$ increased appreciably with every increase in the rate of phosphorus application up to 40 kg P_2O_5 ha^{-1}, beyond that it was increased marginally in both the crop seasons. The magnitude of increase in number of grains $plant^{-1}$ with, 20, 40 and 60 kg P_2O_5 ha^{-1} was to the tune of 8.7, 16.6 and 18.1 percent in 2010 and 8.9, 16.6 and 18.0 percent in 2011, respectively over the control.

Table 6(a): Yield attributing characters of black gram as influenced by levels of FYM, PSB and phosphorus fertilization

Treatments	Number of pods $plant^{-1}$		Length of pod (cm)		Number of grains $plant^{-1}$	
	2010	2011	2010	2011	2010	2011
Levels of FYM (tonnes ha^{-1})						
0	23.72	23.74	3.36	3.42	79.92	81.78
5	25.24	25.40	3.58	3.66	84.98	87.52
SEm±	0.36	0.37	0.06	0.06	1.42	1.46
CD (p=0.05)	1.04	1.07	0.17	0.19	4.09	4.23
Levels of PSB						
No inoculation	23.57	23.51	3.34	3.40	79.48	81.38
Inoculation	25.51	25.73	3.60	3.68	85.42	87.92
SEm±	0.36	0.37	0.06	0.06	1.42	1.46
CD (p=0.05)	1.04	1.07	0.17	0.19	4.09	4.23
Levels of phosphorus(kg P_2O_5 ha^{-1})						
0	22.05	22.14	3.12	3.14	74.40	76.38
20	24.21	24.34	3.40	3.48	80.85	83.20
40	25.75	25.90	3.66	3.75	86.72	89.05
60	25.91	26.01	3.70	3.79	87.83	90.15
SEm±	0.51	0.52	0.08	0.09	2.00	2.07
CD (p=0.05)	1.46	1.51	0.24	0.25	5.78	5.98

Table 6(b): Yield attributing characters of black gram as influenced by levels of FYM, PSB and phosphorus fertilization

Treatments	Number of grains pod^{-1}		Weight of grains pod^{-1} (mg)		1000 grains weight (g)	
	2010	2011	2010	2011	2010	2011
Levels of FYM (tonnes ha^{-1})						
0	4.54	4.68	32.34	35.04	30.32	32.20
5	4.82	4.96	34.42	37.36	32.04	34.10
SEm±	0.08	0.08	0.57	0.63	0.45	0.50
CD (p=0.05)	0.23	0.24	1.64	1.81	1.30	1.43
Levels of PSB						
No inoculation	4.52	4.66	32.28	35.04	30.26	32.20
Inoculation	4.84	4.98	34.48	37.36	32.10	34.10
SEm±	0.08	0.08	0.57	0.63	0.45	0.50
CD (p=0.05)	0.23	0.24	1.64	1.81	1.30	1.43
Levels of phosphorus(kg P_2O_5 ha^{-1})						
0	4.18	4.28	29.17	31.35	28.45	29.57
20	4.58	4.70	32.94	35.65	30.68	32.60
40	4.96	5.12	35.55	38.85	32.67	34.79
60	5.00	5.18	35.86	38.95	32.92	35.24
SEm±	0.11	0.12	0.80	0.89	0.64	0.70
CD (p=0.05)	0.33	0.34	2.32	2.56	1.83	2.02

Number of grains pod^{-1}

Effect of FYM, PSB and Phosphorus

It is obvious from the data presented in table 6(b) indicates that the number of grains pod^{-1} was significantly increased by 6.2 and 6.0 percnet over no FYM in 2010 and 2011, respectively. A perusal of the data summarized in table 6(b) indicates that the seed inoculation with PSB gave appreciably higher grains pod^{-1} than no inoculation by 7.1 and 6.9 percent, respectively over no inoculation in first and second crop seasons. A glimpse of table 6(b) reveals that the application of phosphorus increased appreciably more number of grains pod^{-1} over the control. Further, the number of grains pod^{-1} increased significantly with increasing rates of phosphorus application up to 40 kg P_2O_5 ha^{-1}. When the rate of phosphorus was increased from 40 to 60 kg P_2O_5 ha^{-1}, the number of grains pod^{-1} increased marginally in both the years. The magnitude of increase in the number of grains pod^{-1} with the application of phosphorus at 20, 40 and 60 kg P_2O_5 ha^{-1} was to the tune of 9.6, 18.7 and 19.6 percent in 2010 and 9.8, 19.6 and 21.0 percent in 2011, respectively over the control.

Weight of grains pod^{-1}

Effect of FYM, PSB and Phosphorus

The data summarized in table 6(b) reveal that the application of 5 tonnes FYM ha^{-1} produced significantly heavy grains pod^{-1} by 6.4 and 6.6 percent in 2010 and 2011, respectively than that of no FYM. During two years of study, seed inoculation with PSB resulted in significantly higher weight of grains pod^{-1} than that of no inoculation by 6.8 and 6.6 percent, respectively in first and second crop seasons. The data computed in table 6(b) indicate that the weight of grains pod^{-1} increased considerably with every increase in the rate of phosphorus application up to 40 kg P_2O_5 ha^{-1}, beyond that it was increased marginally in both the years. The magnitude of increase in weight of grains pod^{-1} with the application of 20, 40 and 60 kg P_2O_5 ha^{-1} was to the tune of 12.9, 21.9 and 22.9 percent in 2010 and 13.7, 23.9 and 24.2 percent in 2011, respectively over the control.

Test weight or 1000 grains weight

Effect of FYM, PSB and Phosphorus

The data set out in table 6(b) show that the application of 5 Tonnes FYM ha^{-1} improved significantly test weight by 5.7 And 5.9 percent in 2010 and 2011, respectively over no FYM. The data arrange in table 6(b) indicate that the inoculation with PSB had significantly higher test weight by 6.1 and 5.9 percent in 2010 and 2011, respectively than that of no inoculation. The data summarized in table 6(b) reveal that the increasing rates of phosphorus application increased significantly 1000 grains weight up to 40 kg P_2O_5 ha^{-1}. When the rate of phosphorus was increased from 40 to 60 kg P_2O_5 ha^{-1}, 1000 grains weight was improved marginally in both the crop seasons. The magnitude of increase in test weight with 20, 40 and 60 kg P_2O_5 ha^{-1} was to the tune of 7.8, 14.8 and 15.7 percent in 2010 and 10.2, 17.7 and 19.2 percent in 2011, respectively over the control.

Yield plant^{-1}

Grain yield plant^{-1}

The data on grain and straw yield plant^{-1} collected at harvest were subjected to statistical analysis for two crop seasons (2010 and 2011). The analysis of variance of said characters are given in appendix XIV. The data for main effects of levels of FYM, PSB and phosphorus fertilization have been summarized in table 7.

Effect of FYM, PSB and Phosphorus

The data computed in table 7 indicate that the application of 5 tonnes FYM ha^{-1} improved significantly higher grain yield plant^{-1} 15.4, 16.5 and 16.0 percent, respectively over no FYM in 2010 and 2011, and in pooled yields. The data set out in table 7 show that seed inoculation with PSB had appreciably higher grain yield plant^{-1} by 18.0, 18.9 and 18.5 percent, respectively than that of no inoculation in 2010 and 2011 and in pooled yields. A critical study of the data presented in table 7 reveals that the application of phosphorus brought out significant improvement in grain yield plant^{-1} over the control. Further, the grain yield plant^{-1} increased conspicuously with every increase in the rate of phosphorus application up to 40 kg P_2O_5 ha^{-1}. A further increase in rate of phosphorus application (60 kg P_2O_5 ha^{-1}) had depressing effect on the value of this character and differences were not appreciable in grain yield plant^{-1} due to 40 and 60 kg P_2O_5 ha^{-1} in both the crop seasons and in pooled yields. The magnitude of increase in grain yield plant^{-1} with the application of 20, 40 and 60 kg P_2O_5 ha^{-1} was to the tune of 39.8, 70.9 and 72.8 percent in 2010 and 37.9, 66.7 and 67.8 percent in 2011, and 38.9, 68.7 and 70.2 percent in pooled yields, respectively over the control.

Table 7: Grain and straw yield plant^{-1} as influenced by levels of FYM, PSB and phosphorus fertilization

Treatments	Grain yield plant^{-1} (g)			Straw yield plant^{-1} (g)		
	2010	2011	Mean	2010	2011	Mean
Levels of FYM (tonnes ha^{-1})						
0	4.28	4.60	4.44	7.72	8.28	8.00
5	4.94	5.36	5.15	8.76	9.44	9.10
SEm±	0.08	0.09	0.09	0.14	0.16	0.15
CD (p=0.05)	0.24	0.26	0.25	0.41	0.45	0.43
Levels of PSB						
No inoculation	4.23	4.55	4.39	7.62	8.26	7.94
Inoculation	4.99	5.41	5.20	8.86	9.46	9.16
SEm±	0.08	0.09	0.09	0.14	0.16	0.15
CD (p=0.05)	0.24	0.26	0.25	0.41	0.45	0.43
Levels of phosphorus(kg P_2O_5 ha^{-1})						
0	3.16	3.48	3.32	6.28	6.84	6.56
20	4.42	4.80	4.61	8.12	8.72	8.42
40	5.40	5.80	5.60	9.18	9.82	9.50
60	5.46	5.84	5.65	9.38	10.06	9.72
SEm±	0.12	0.13	0.12	0.20	0.22	0.21
CD (p=0.05)	0.33	0.36	0.35	0.58	0.64	0.61

Straw Yield plant^{-1}

Effect of FYM, PSB and Phosphorus

The data presented in table 7 indicate that the application of 5 tonnes FYM ha^{-1} produced significantly higher straw yield plant^{-1} by 13.5, 14.0 and 13.8 percent, respectively over no FYM in 2010 and 2011, and in mean yields. A perusal of the data presented in table 7 reveal that the straw yield plant^{-1} increased appreciably by 16.3, 14.5 and 15.4 percent with seed inoculation with PSB over no inoculation, respectively in 2010 and 2011 as well as in mean yields. An examination of the data summarized in table 7 shows that the straw yield increased with every increase in the rate of phosphorus application up to the maximum rate i.e. 60 kg P_2O_5 ha^{-1}, however, significant differences were noticed only up to 40 kg P_2O_5 ha^{-1} in both the years and in mean yields. The magnitude of increase in straw yield plant^{-1} with 20, 40 and 60 kg P_2O_5 ha^{-1} was to the tune of 29.3, 46.2 and 49.4 percent in 2010 and 27.5, 43.6 and 47.1 percent in 2011, and 28.4, 44.8 and 48.2 percent in mean yields, respectively over the control.

Conclusion

Effect of Season

As judged by climatic and adaphic conditions, the second season (2011) proved to be more conducive for the black gram crop than the first one (2010). The crop in general was benefited during the growth and development period by temperature and day light etc. in growth, yield and yield attributes and quality of grain in the said season.

Dry matter accumulation pattern

Dry matter in plant accumulated continuously and almost linearly up to maturity of the crop. The dry matter accumulation in pods was also increased linearly up to maturity of the crop. On an average, dry matter accumulated in plant was to the tune of 16.0 percent in first 30 days, 49.4 percent in next 35 days and 34.6 percent in further 35 days (between 65 to 100 days of seeding).

Effect of FYM in Crop and Growth and development studies

Application of 5 tonnes FYM ha^{-1} had no significant effect on plant population at 30 days and at harvest, and on mortality percentage during both the years. Growth characters such as plant height, number of branches plant^{-1} and dry matter accumulation in plant were increased significantly with the application of 5 tonnes FYM ha^{-1} over no FYM at all the stages of crop growth in both the years. The crop growth rate (CGR) and relative growth rate (RGR) increased appreciably with the application of 5 tonnes FYM ha^{-1} over no FYM at all the stages of crop growth in two crop seasons. Application of 5 tonnes FYM ha^{-1} required significantly more days for 75 percent flowering and maturity by 4 days than that of no FYM during both the years. Length and weight of root increased significantly with the application of 5 tonnes FYM ha^{-1} over no FYm at all the stages of crop growth in both the years. Number and weight of nodules plant^{-1} also increased appreciably with the application of 5 tonnes FYM ha^{-1} over no FYM at all the stages of crop growth during both the crop seasons.

Yield and yield attributes

Yield attributes namely number of pods plant^{-1}, length of pod, number of grains plant^{-1}, number and weight of grains pod^{-1} and 1000 grains weight increased significantly with the application of 5 tonnes FYM ha^{-1} over no FYM in both the years. Grain and straw yield plant^{-1} increased appreciably with the application of 5 tonnes FYM ha^{-1} over no FYM in both the crop seasons, and in pooled yields. Dry matter production ha^{-1} and harvest index increased appreciably with the application of 5 tonnes FYM over no FYM during two crop seasons of study and in pooled yields in case of dry matter yield.

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