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Effect of *Rhizobium*, phosphorus and nitrogen on growth, yield and yield attributes of summer black gram

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Abstract
Vigna mungo (L.) Hepper (= urad, mash bean, black gram) of the family Fabaceae (= Leguminaceae) is an important pulse crop grown throughout India in an area of about 1.33 million tons annually from an area of 3.17% million hectare. The number of pods plant-1 is (29.75) were recorded when seeds were inoculated with *Rhizobium* than that of un-inoculated (25.78) ones. Nitrogen application increased number of pods plant-1 per plant as compared to control plots and maximum number of pods plant-1 -1(30.37) were observed with 30 kg ha-1 nitrogen level. This was statistically at par with application of 15 kg N ha-1. Minimum number of pods plant-1 (28.86) was noted under control. Phosphorus application increased number of pods plant-1 as compared to control plots and maximum number of pods plant-1 (31.40) were observed with 60 kg ha-1 phosphorus level and significantly superior over control. Minimum numbers of pods (23.21) were noted under control. The interaction effect of P, N and *Rhizobium* inoculation was not significant for number of pods plant-1. Nitrogen application increased number of seeds plant-1 per plant as compared to control plots and maximum number of seeds plant-1 (42.9) were observed with 30 kg ha-1 nitrogen level. This was statistically at par with application of 15 kg N ha-1. Minimum numbers of seeds plant-1 (38.22) were noted under control.

Keywords: Black gram, *Rhizobium*, phosphorus, nitrogen

1. Introduction
Pulses "The wizard of the health'' symbolic to its nomenclature pulse (P= People U= Umbrella L= Livestock S= Soil E= Energy) is indeed a superb energy. Umbrella for people as dietary proteins for livestock as green nutrition fodder and feed for soil as mini nitrogen plant and green manure (Ali, 1988) [1]. Among these, *Vigna mungo* (L.) Hepper (= urad, mash bean, black gram) of the family Fabaceae (= Leguminaceae) is an important pulse crop grown throughout India in an area of about 1.33 million tons annually from an area of 3.17% million hectare as per report of (Anonymous, Annual Report, IIPR Kanpur 2016) [2]. Black gram contains about protein 24%, carbohydrate 60% and fat 1.3% reached of phosphoric acid. Black gram contributes 13% in total pulses area and 10% in total pulses production of India. India is largest production of pulse in the world with 25% shares in the global production.
The production is not sufficient to meet the per capita requirement. It has also been a serious concern to see a decrease in daily per capita availability of pulse from 69 g in 1961 to 37 g in 2004. To alleviate protein-energy malnutrition, a minimum of 50 g pulses/capita should be available in addition to other sources of proteins such as cereals, milk, meat and eggs Mehta *et al.*, (2005) [14]. Nitrogen being a major constituent of protein and chlorophyll must be adequately and timely supplied to the crop. Although pulses are capable of extracting nutrient from soil and fixing atmospheric nitrogen yet they need a small basal dose of nitrogen fertilizer for quick and better response. Nitrogen requirement of pulses is very low than other crops because nitrogen is needed only for establishment of plant, later on plants have their own potentiality to fulfill their requirement through symbiotic nitrogen fixation. Nitrogen is an essential element for proper plant growth and development. It imparts green color to leaves and stems and enables them for efficient photosynthesis. Mungbean is capable to meet its nitrogenous requirements by fixing the atmospheric nitrogen in the presence of compatible rhizobia, but the role of starter dose of nitrogen in increasing yield through rapid early growth resulting in better establishment of plants.

However, delay in nodule initiation and development Herridge *et al*., (1984) [9] and reduced nitrogenase activity have been observed in response to high soil NO3 content (Child, 1980) [6]. With this higher doses of nitrogen reduce nitrogen fixation on one hand and increase cost of production on the other. Rhizobial inoculation is a cheaper and usually more effective agronomic practice to improve nodulation, nitrogen fixation, crop growth and yield of leguminous crops (Henzell, 1988) [8].

Phosphorus is one of the essential macro nutrient for growth and development of plant. Phosphorus reaction in the soil has important implication for crop growth and fertilizer efficiency. Phosphorus provides the energy, however fixation of nitrogen required energy, therefore phosphorus enhance the nitrogen fixation. Bhal *et al.,* (2013) [4] in natural ecosystem, phosphorus availability in soil is governed by dynamic equilibrium that exist solid and solution phase vis-à-vis soil constituents affecting transformation of applied phosphorus. Both phosphorus status and P-fixing capacity of soil strongly influence the phosphorus availability. The supply of different level of phosphorus in mungbean and urdbean has enhanced the nodule formation.

Materials and Methods Threshing and recording of yield

The grain was separate the weight of total biological produce of each net plot was recorded after drying and before threshing. The threshing was done by wooden sticks and seed and straw weight of each net plot was recorded. To obtain straw yield, seed yield was subtracted from the total biological yield.

Yield parameters

Number of pods plant-1- The total number of pods on five plants selected for study was recorded and the average figures were calculated.

Number of grains pod-1- Five plants were selected randomly in each plot and five pods from each plant were selected to count number of grains per pod and the values were averaged.

Test weight plant-1- 1000-grains were counted from the samples of grains drawn from each net plot. These counted grains were weighed and recorded as test weight (g).

Yield

Grain yield- After taking the bundle weight of the harvest produce of each net plot, they were separated manually. The grains of each plot thus obtained air dried, weighed and recorded in kg plot-1 and converted into q ha-1.

Straw yield- Straw yield was recorded by subtracting the weight of grains from the weight of total harvested produce of each net plot. Thus the straw yield obtained in kg plot-1 was further converted in q ha-1.

Results and Discussion

Yield attributes and yield Number of pods plant -1

An examination of data presented in Table 1 shows that significantly more number of pods plant-1 is (29.75) were recorded when seeds were inoculated with *Rhizobium* than that of un-inoculated (25.78) ones. Nitrogen application increased number of pods plant-1 per plant as compared to control plots and maximum number of pods plant-1 -1(30.37) were observed with 30 kg ha-1 nitrogen level. Which was statistically at par with application of 15 kg N ha-1. Minimum number of pods plant-1 (28.86) were noted under control.

Phosphorus application increased number of pods plant-1 as compared to control plots and maximum number of pods plant-1 (31.40) were observed with 60 kg ha-1 phosphorus level. Significantly superior over control. Minimum number of pods (23.21) were noted under control. The interaction effect of P, N and *Rhizobium* inoculation was not significant for number of pods plant-1. Nitrogen application increased number of seeds plant-1 per plant as compared to control plots and maximum number of seeds plant-1 (42.9) were observed with 30 kg ha-1 nitrogen level. Which were statistically at par with application of 15 kg N ha-1. Minimum number of seeds plant- 1 (38.22) were noted under control.

Phosphorus application increased number of seeds plant-1 as compared to control plots

and maximum number of seeds plant-1 (10.30) were observed with 60 kg ha-1 phosphorus level. Significantly superior over control. Minimum number of seeds (4.17) were noted under control. The results finding supported by the finding of (Mir *et al*., 2013) [16] application of high levels of phosphorus, sulphur with or without bio-fertilizer inoculation. Application of 60 kg P2O5 ha-1 recorded maximum plant height (49.9 cm), number of leaves plant-1 (50.8), number of nodules plant-1(27.8), haulm yield (28.9 q ha-1), grain yield (8 q ha-1) and phosphorus, sulphur and protein content of grain (0.356% 0.253% and 22.64%, respectively. Jain *et al.,* (1999) [10], Meena *et al*., (2003)a [13], Asheesh Elamathi (2007) [3] and Singh *et al*., (2018) [20].

1000 Test weight (g)

The data on 1000 seed weight have been presented in Table 1 Study of table revealed that the treatments affected the 1000 seed weight non-significantly. Nitrogen application increased seeds weight as compared to control plots and maximum seeds weight (36.40) were observed with 30 kg ha-1 nitrogen level. Which were statistically non-significantly with application of 15 kg N ha-1. Minimum seeds weight (36.08) were noted under control. Phosphorus application increased seeds weight as compared to control plots and maximum number of seeds weight (36.50) were observed with 60 kg ha-1 phosphorus level. Non-significantly overall treatment. Minimum seeds weight (34.28) were noted under control. The interaction effect due to different treatments on 1000 seed weight was found non-significant. The similar results finding supported by the finding of Meena *et al.,* (2003)b [13] and Hakeem *et al.,* (2008), [7] Kant *et al*., (2016) [11].

Seed Yield (q ha-1)

Data pertaining to seed yield portrayed in Table 2 Indicates that different treatments have pronounced effect on seed yield of test crop. It is evident from the data that maximum seed yield q ha-1) respectively, were noted under *Rhizobium* inoculation treatment which were

significantly superior over uninoculated treatment. Nitrogen application increased seed yield per plant as compared to control plots and maximum seed yield (11.64 q ha-1) were observed with 30 kg ha-1 nitrogen level. Which were statistically at par with application of 15 kg N ha-1. Minimum seed yield (9.41q ha-1) were noted under control. Phosphorus application increased seed yield as compared to control plots and maximum seed yield (12.28 q ha-1) were observed with 60 kg ha-1 phosphorus level. The significantly superior over control. Minimum seed yield (8.56 q ha-1) were noted under

control. The interaction effect of P, N and *Rhizobium* inoculation was not significant for seed yield. The similar results found by Trivedi and Singh (1999) [23] and Kumar and Singh (2011) [12] also reported a linear increase in the yield upto 60 kg P2O5 ha-1 of black gram and pigeon pea crops, respectively. Seed and straw yield was more with *Rhizobium* inoculation as compared to control. These results are in close conformity with the finding of Mehrotra and
Lehari (1970) [14] and Raju and Verma (1984) [18].

Straw Yield (q ha -1)

Data pertaining to straw yield portrayed in Table 2 Indicates that different treatments have pronounced effect on straw yield of test crop. It is evident from the data that maximum straw yield (28.98 q ha-1) respectively, were noted under *Rhizobium i*noculation treatment which were significantly superior over uninoculated treatment (25.23 q ha-1). Nitrogen application increased straw yield per plant as compared to control plots and maximum straw yield (28.28q ha-1) were observed with 30 kg ha-1 nitrogen level. Which were statistically at par with application of 15 kg N ha-1. Minimum straw yield (25.94 q ha-1) were noted under control.

Phosphorus application increased straw yield as compared to control plots and maximum straw yield (30.09q ha-1) were observed with 60 kg ha-1 phosphorus level. Significantly superior over control. Minimum straw yield (24.86q ha-1) were noted under control. The result are in accordance with the finding of earlier research workers *viz*., Tomar *et al.* (2002), [22] Singh *et al*. (1994) [19] and Patel and Thakur (2003) [17] they have also reported that increase in yield with increase in applied phosphorus up to 30-60 kg P2O5 ha-1.

Harvest Index (%)

The data pertaining to harvest index is presented in Table 2 indicate data of maximum harvest index (28.51%) respectively, were noted under *Rhizobium i*noculation treatment which were significantly superior over inoculated treatment (27.54%). Nitrogen application increased harvest index as compared to control plots and maximum harvest index (29.15%) were observed with 30 kg ha-1 nitrogen level and which was statistically at par with application of 15 kg N ha-1.

Minimum harvest index (26.61%) was noted under control. Application of increasing levels of phosphorus increased the harvest index. The maximum harvest index (29.04%) was obtained at 60 kg P2O5 ha-1 and minimum (25.61%) with control. The results are in accordance with the finding of earlier research workers *viz*., Tomar *et al.* (2002), [22] Bhat *et al.* (2009) [5] and Tiwari *et al*. (2015) [21].

Table 1: Effect of *Rhizobium*, nitrogen and phosphorus on number of pods plant-1 of black gram

Treatments	Plant-1		
	Pods plant-1	Seeds pod-1	Test weight (g)
***Rhizobium* levels**			
Un-inoculated	25.78	6.34	35.00
Inoculated	29.75	7.04	36.79
S.Em±	0.56	0.29	-
CD (P=0.05)	1.67	0.85	NS
Nitrogen levels (kg ha-1)			
00	24.06	5.34	36.08
15	28.86	7.53	34.85
30	30.37	7.20	36.40
S.Em±	0.68	0.35	-
CD (P=0.05)	2.040.	1.04	NS
Phosphorus levels (kg ha-1)			
00	23.21	4.17	34.28
30	28.69	5.60	35.81
60	31.40	10.30	36.50
S.Em±	0.68	0.35	-
CD (P=0.05)	2.04	1.04	NS

Table 2 Effect of *Rhizobium*, nitrogen and phosphorus on yield q ha-1 and harvest index of black gram

Treatments	Yield q ha-1		
	Seed Yield q ha-1	Straw Yield q ha-1	Harvest index (%)
***Rhizobium* levels**			
Uninoculated	9.59	25.23	27.54
Inoculated	11.56	28.98	28.51
S.Em±	0.10	0.55	-
CD (P=0.05)	0.317	1.64	-
Nitrogen levels (kg ha-1)			
00	9.41	25.94	26.61
15	10.67	27.09	28.25
30	11.64	28.28	29.15
S.Em±	0.12	0.67	-
CD (P=0.05)	0.38	2.01	-
Phosphorus levels (kg ha-1)			
00	8.56	24.86	25.61
30	10.88	26.36	29.21
60	12.28	30.09	29.04
S.Em±	0.12	0.67	-
CD (P=0.05)	0.38	2.01	-

Conclusion

The plant height increased levels of nitrogen and significantly higher plant height at 30 kg ha-1 as compared to lower levels of nitrogen at all stages of crop growth. Number of branches plant increased with increasing levels of nitrogen and significant higher number of branches plant was recorded at 30 kg N ha-1 as compared to lower levels of nitrogen at all stages of crop growth. The number of nodules, fresh weight of nodules and dry weight of nodules were recorded at 15 kg N ha-1 as compared to lower levels of nitrogen at all stages of crop growth. The maximum number of pod plant, test weight (weight of 1000-seed), seed yield and straw yield were

recorded with 30 kg N h-1 however the minimum was noted at 0 kg N ha-1. The application of 30 kg N ha-1 recorded lower values of harvest index than without nitrogen.

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