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Influence of phosphorus and molybdenum on growth attributes and yield of black gram in typic haplustalf

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Abstract
A field experiment was conducted to appraise the effect of phosphorus (P) and molybdenum (Mo) on growth and yield of black gram (VBN-8) in Virudhunagar district. The treatment encompassed five levels of P_2O_5 (0, 25, 50, 75, 100 kg ha^{-1}) and four levels of Mo (0, 0.5, 1.0, 1.5 kg ha^{-1}). The results affirmed that incremental dose of P and Mo significantly influences the growth and yield of black gram. Application of P_2O_5 at 100 kg ha^{-1} showed transcendent effect on plant height, nodulation, number of pods, dry matter production and grain yield. Analogous to P, Mo fertilization at 1.5 kg ha^{-1} equivalently promotes plant height, nodulation, number of pods, dry matter production and seed yield. The conjoint effects of both the nutrients were also conducive in upgrading the productivity of black gram. Thus a synergetic interaction was contemplated between both the anions.

Keywords: Phosphorus, molybdenum, interaction, growth

Introduction
Black gram (*Vigna mungo*) is one of the important pulse crop originated in India. The important states that cultivates black gram are Maharashtra, Madhya Pradesh, Andhra Pradesh, Orissa, Tamil Nadu etc. It is a protein rich (26%) crop and contributes 10 percent of total pulse production in an country (Gowda *et al*., 2013). The most promising feature of pulses is their ability to fix atmospheric nitrogen. It has been reported that black gram produces 22.10kg N $ha^{-1}yr^{-1}$ which supplements 59 thousand tons of urea annually (Jat *et al*., 2017) [8]. Inorder to advance the growth virtue for better productivity of black gram, a proportionate amount of macro and micronutrients are decisive for sufficing bacterial activity to intensify nodulation. Phosphorus is an important macronutrient that plays a crucial role in root proliferation, cell division, energy currency of cell (ATP) production and protein metabolisms. It also plays pivotal role in nodule formation indirectly by supplying required energy necessary for nitrogen fixing bacteria through sugar and energy metabolism (Dotaniya *et al*., 2014) [7]. Molybdenum has been perceived as an important micronutrient as it paucity lead to poor seed yield in pulses. It is a structural component of nitrogenase and nitrate reductase enzymes which brings about oxidation- reduction reaction in plant cells (Yadav *et al*., 2017) [1]. Since both the nutrients play a pivotal role in improving the productivity of black gram, the optimum level at which both the anions exhibit synergism for improving growth and yield of black gram is deliberated.

Materials and Methods
The experiment was conducted in a farmer's field in Virudhunagar district located at $9^0$35' N latitude and $77^0$57'E longitude. The soil was sandy clay loam in texture, neutral in reaction (pH- 6.82), low in organic carbon (3 g kg^{-1}) with medium nitrogen (156 kg ha^{-1}) and potassium (312 kg ha^{-1}) and low in phosphorus (10kg ha^{-1}) respectively. The available Mo status of soil was low (0.03 kg ha^{-1}). Twenty treatmental combinations comprising five levels of phosphorus (0, 25, 50, 75 and 100 kg P_2O_5 ha^{-1}) and four levels of molybdenum (0, 0.5, 1.0, 1.5 kg Mo ha^{-1}) were examined in factorial randomized block design with three replications.
The Vamban 8 black gram seeds were sown at a spacing of 30cm x 10cm. Seed rate of 20kg ha^{-1} was adopted. Individual plots with the dimension of 4m x 5m were laid. Uniform fertilization was scheduled at the rate of 25:50:25 kg N P_2O_5 K_2O ha^{-1}.

Entire dose of Phosphorus were applied as basal and N and K were given each at 25 kg ha^{-1} in three splits (basal, 20 DAS, 40DAS). The growth and yield parameters were recorded from each plots separately. From each plot five plants were selected at random and growth and yield attributes were recorded at corresponding stages.

Results and Discussion

Effect of phosphorus in improving growth attributes of black gram

The outcome of the study revealed that incremental dose of phosphorus significantly influenced the growth characteristics of black gram. Growth attributes, viz. plant height, number of nodules $plant^{-1}$, root length and shoot length were maximized by P fertilization. Application of 75 kg P_2O_5 ha^{-1} recorded the maximum plant height, nodulation, root and shoot length and was found to be statistically on par with 100 kg P_2O_5 ha^{-1} (Table 1 and 2). This consummate effect of P fertilization on growth virtue of black gram might be due to it desicive role in voluminous root development which facilitate the crop to excerpt water and minerals from deeper zones. Moreover, P is required for mitochondrial and symbiome membrane synthesis during nodule development to enhance nitrogen fixation. Thus, the enhanced nutrient availability boosted up nutrient uptake which consequently prompts vigorous plant growth and development. These results corroborate with the findings of Singh *et al*., (2006) [16], Bhuiyan *et al.,* (2008) [5], Rotaru *et al.,* (2009), Kokani *et al*., (2013) and Tomar *et al*., (2013) [18].

Effect of molybdenum in improving growth attributes of black gram

Incremental dose of Mo positively affect the growth attributes of black gram. Application of Mo @1.5 kg ha^{-1} proportionately increased plant height, root nodules, root and shoot length of black gram (Table 1 and 2). It is conceivably due to its vital role in regulation and activation of enzyme systems especially nitrogenase and nitrate reductase that supply necessary energy required for nodulating bacteria to fix atmospheric nitrogen. Further, it improves the availability of nutrients and their utilization by black gram and possibly promotes crop growth. These results are in conformity with Singh *et al.,* (2006) [16], Biswas *et al*., (2009) [6] and Arti Yadav (2017) [1].

Effect of phosphorus in improving yield of black gram

Application of graded level of phosphorus significantly upgraded the number of pods, dry matter production and grain yield of black gram. Phosphorus application @ 75 kg ha^{-1} maintains superiority and was statistically equivalent with 100 kg P_2O_5 ha^{-1}(Table 3 & 4). The propitious outcome was due to regulatory function of P in photosynthesis that escalates carbohydrate accumulation and sugar metabolism. It also coordinates starch: sucrose ratio and governs proper mobilization of photosynthates that lead to increased flowering, fruiting, and seed formation. The energy obtained from photosynthesis This result was in accordance with Bhattacharya and Pal (2001) [4] Basu *et al.,* (2003) [3], Nadeem *et al*., (2004) [13], Sepat *et al*., (2005) [15], Biswas *et al.,* (2009) [6] and Khan *et al*., (2017) [10].

Effect of molybdenum in improving yield of black gram

The experimental results revealed that incremental dose of Mo emphatically influenced the yield attributes of black gram. The highest number of pods, dry matter and grain yield was observed with the application of 1.5 kg Mo ha^{-1}(Table 3 & 4). This might be due to increased availability of nitrogen due to biological nitrogen fixation that induces plant growth to produce huge biomass, pod and grain yield. The present outcome are in conformity with the findings of Shivkumar and Kumutha (2003), Togay *et al.,* (2008) [17], Biswas *et al.,* (2009) [6], Valenciano *et al*., (2011), Awomi *et al*., (2012) [2] and Karpagam *et al.,* (2014) [9].

Interaction effect of P and Mo in improving growth and yield attributes of black gram

Similar to the individual effect the conjoint application of P and Mo was found to be synergetic. The maximum nodulation, root and shoot length, plant height, pods, dry matter and grain yield were achieved with $P_{75}M_{1.5}$ and $P_{100}M_{1.5}$ treatments and were superior over the control (Graph 1 & 2). The phenomenal increase in growth and yield of black gram was due to mutual benefit of these ions in improving absorption and utilization of nutrients. The synergetic interaction of P and Mo also influence the availability of certain essential nutrients that employs better uptake and maintain source and sink relationship. The results are in harmonious with Bhuiyan *et al.,* (2008) [5], Kumar *et al*., (1980) [12] and Awomi *et al*., (2012) [2].

Conclusion

The experimental findings revealed that both macro and micronutrients play a vital role in improving the productivity of black gram. Application of Phosphorus in combination with molybdenum brings beneficial results for profitability in black gram. On the basis of the result, we conclude that P and Mo significantly improve growth and yield of black gram. Therefore P and Mo fertilization need to be promoted for the maximum output in black gram for the input we supply.

Table 1: Effect of different levels of Phosphorus and Molybdenum on plant height (cm) and root length (cm) of black gram

Phosphorus levels (kg ha^{-1})	Plant height (cm)					Phosphorus levels (kg ha^{-1})	Root length (cm)				
	Molybdenum levels (kg ha^{-1})						Molybdenum levels (kg ha^{-1})				
	0	0.5	1.0	1.5	Mean		0	0.5	1.0	1.5	Mean
0	21.29	22.95	23.83	24.53	23.15	0	9.19	9.60	9.82	10.51	9.78
25	24.01	24.38	24.96	25.44	24.70	25	9.99	10.57	11.45	12.26	11.07
50	25.28	25.67	26.49	27.35	26.20	50	12.00	12.46	12.87	13.56	12.72
75	26.94	27.23	28.28	30.86	28.33	75	12.61	12.95	13.75	15.05	13.59
100	27.02	27.33	29.59	30.95	28.72	100	12.65	13.04	14.41	15.19	13.82
Mean	24.91	25.51	26.63	27.83	26.22	Mean	11.29	11.72	12.46	13.31	12.20
	SEd		CD (p=0.05)				SEd		CD (p=0.05)		
P	0.28		0.43			P	0.12		0.25		
Mo	0.25		0.38			Mo	0.11		0.22		
PxMo	0.56		0.85			PxMo	0.25		0.50		

Table 2: Effect of different levels of Phosphorus and Molybdenum on shoot length (cm) and number of nodules of black gram

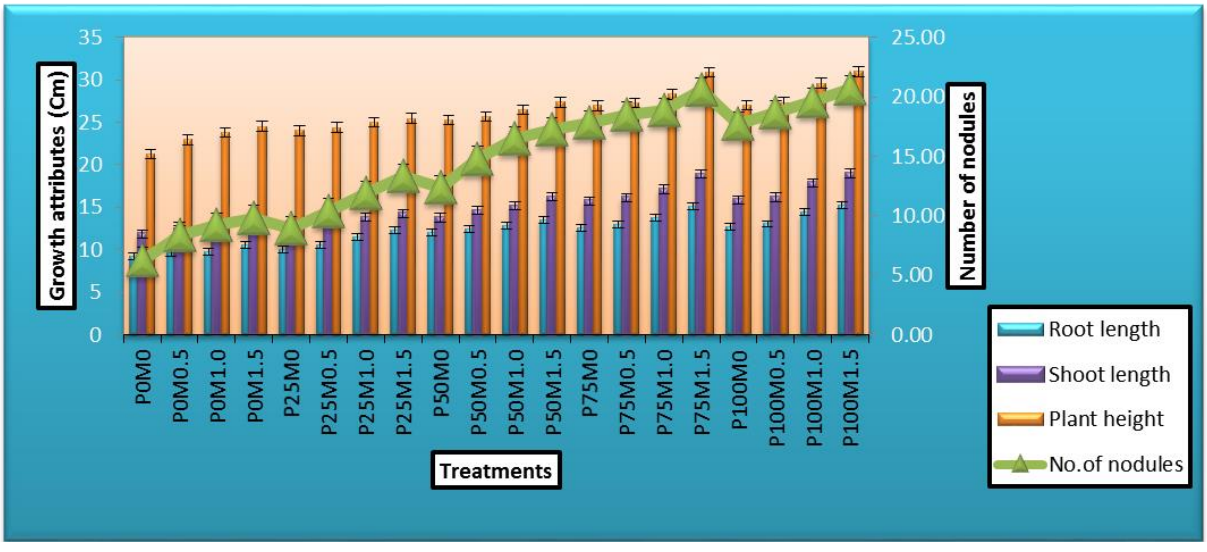
Phosphorus levels (kg ha^{-1})	Shoot length (cm)					Phosphorus Levels (kg ha^{-1})	No. of nodules plant^{-1}				
	Molybdenum levels (kg ha^{-1})						Molybdenum levels (kg ha^{-1})				
	0	0.5	1.0	1.5	Mean		0	0.5	1.0	1.5	Mean
0	11.84	12.43	12.77	13.14	12.55	0	6.30	8.40	9.21	9.82	8.43
25	12.86	13.34	13.81	14.24	13.56	25	8.92	10.41	11.89	13.34	11.14
50	13.78	14.59	15.15	16.21	14.93	50	12.39	14.80	16.43	17.23	15.21
75	15.75	16.12	17.12	18.87	16.97	75	17.80	18.50	18.88	20.55	18.93
100	15.90	16.18	17.88	18.99	17.24	100	17.73	18.63	19.65	20.70	19.18
Mean	14.03	14.53	15.35	16.29	15.05	Mean	12.63	14.15	15.21	16.33	14.58
	SEd		CD (p=0.05)				SEd		CD (p=0.05)		
P	0.16		0.33			P	0.22		0.34		
Mo	0.15		0.30			Mo	0.20		0.30		
PxMo	0.33		0.67			PxMo	0.44		0.67		

Table 3: Effect of different levels of Phosphorus and Molybdenum on No. of pods plant^{-1} and Dry matter production (kg ha^{-1}) of black gram

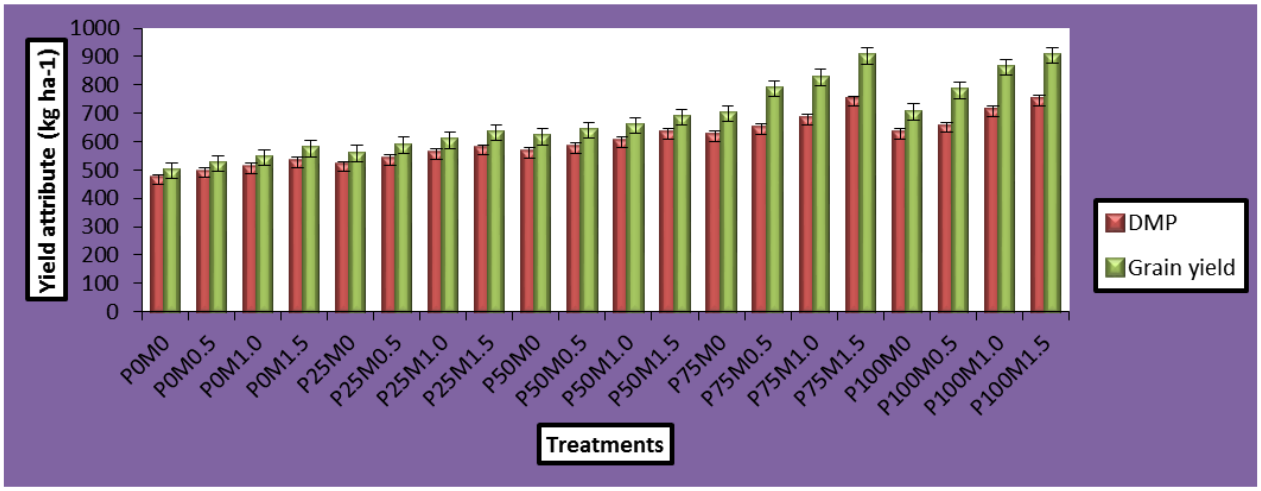
Phosphorus levels (kg ha^{-1})	No. of pods plant^{-1}					Phosphorus levels (kg ha^{-1}	DMP (kg ha^{-1})				
	Molybdenum levels (kg ha^{-1})						Molybdenum levels (kg ha^{-1})				
	0	0.5	1.0	1.5	Mean		0	0.5	1.0	1.5	Mean
0	7.61	8.23	9.74	10.21	8.95	0	466	491	507	528	498
25	9.87	10.62	11.90	12.42	11.20	25	512	535	556	571	544
50	11.66	13.10	14.21	14.98	13.49	50	561	576	597	626	590
75	17.29	19.10	19.63	21.32	19.33	75	619	644	677	743	671
100	17.34	19.21	20.42	21.42	19.60	100	626	650	707	746	682
Mean	12.75	13.28	15.18	16.07	14.51	Mean	557	579	609	643	597
	SEd		CD (p=0.05)				SEd		CD (p=0.05)		
P	0.14		0.28			P	6.94		14.04		
Mo	0.12		0.25			Mo	6.20		12.56		
PxMo	0.28		0.56			PxMo	13.88		28.09		

Table 4: Effect of different levels of Phosphorus and Molybdenum on Grain yield (kg ha^{-1}) of black gram

Phosphorus Levels (kg ha^{-1})	Grain yield (kg ha^{-1})				
	Molybdenum levels (kg ha^{-1})				
	0	0.5	1.0	1.5	Mean
0	498	524	543	575	535
25	558	589	605	631	595
50	617	641	657	687	650
75	698	787	826	902	803
100	704	781	862	903	813
Mean	615	664	698	740	679
	SEd		CD (p=0.05)		
P	7.66		15.52		
Mo	6.86		13.88		
PxMo	15.33		31.03		



Graph 1: Influence of P and Mo on growth attributes of black gram



Graph 2: Influence of P and Mo on Yield of black gram

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