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Optimization of seed rate and nutrient level for yield attributes and yield of bold seeded urdbean (*Vigna mungo*. L.)

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Abstract
An experiment was carried out during *kharif* season of 2016 at Instructional cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. The experiment was laid in Split plot design having the combination of twelve different treatments replicated thrice. Treatment combination consisting of two factors at three levels *viz.*, seed rate and recommended dose of fertilizer. In seed rate 15, 20, 25 and 30 kg ha^{-1} and recommended dose of fertilizer 100% RDF (NPK), 125% RDF (NPK) and 125% RDF (NPK + Sulphur @ 20 kg ha^{-1} + Zn @ 5 kg ha^{-1} + foliar spray urea 2% twice). In seed rate 15 kg ha^{-1} was recorded maximum yield attributing characters *viz.*, no. of pods plant^{-1}, no. of seeds pod^{-1}, no. of seed plant^{-1}, 100 seed weight and seed yield (g) plant^{-1}. In seed rate S_3 25 kg ha^{-1} was recorded maximum seed yield kg ha^{-1} and stover yield kg ha^{-1}. In case of nutrient level 125% RDF (NPK + Sulphur @ 20 kg ha^{-1} + Zn @ 5 kg ha^{-1} + foliar spray urea 2% twice), was recorded maximum yield attribute, seed yield and stover yield.

Keywords: Optimization, *Vigna mungo*. L.

Introduction
Pulses in India have long been considered as the poor man' s only source of dietary protein. Besides being a rich source of protein, they maintain soil fertility through biological nitrogen fixation in soil and thus play a vital role in furthering sustainable agriculture (Kannaiyan, 1999) [9]. Pulses occupies 25.21 m ha area and contributes 19.78 m tonnes production with an average productivity of 785 kg ha^{-1} (Anonymous, 2014-15a) [3]. As a result, per capita availability of pulses has been declined from 64 g per day in 1951-56 to less than 40 g per day as against whose recommendation of 80 g per day (Ashtana and Chaturvedi, 1999) [5]. This situation led to the severe shortage of pulses in India, which has aggravated the problem of malnutrition in large section of vegetarian population of our country.
Blackgram (*Vigna mungo.* L.) also known as urdbean or mashbean belongs to popular plant family Papillionaceae and is among the most important pulse crops of the world. The economic product of black gram is seed grain, which is a good source of dietary protein. Urdbean contains approximately 25-28% protein, 1.0-1.5% oil, 3.5 - 4.5% fibre, 4.5-5.5% ash and 62-65% carbohydrates on dry weight basis.
Chhattisgarh is divided into three agro-climatic zones *i.e.* Chhattisgarh plains, Bastar plateau and Northern hill zone. Blackgram is mainly grown by the farmers of Chhattisgarh plains during *kharif* season. Uncertain rainfall adversely affects the sowing time of blackgram under rained condition. There are number of ways to increase productivity of Urdbean out of which agronomic management *viz.* shifting of sowing time and proper weed management practices are important, one with low cost. First week of July is a normal sowing time which depends on the break of monsoon. Podding affects with rains, when mungbean is sown late. Manipulation in sowing dates and adoption of weed management practices might have reduced the loss to certain extent.

Materials and Methods
The soil of experimental field was clayey (*Vertisol*) in texture, low in nitrogen, medium in phosphorus and high in potassium contents with neutral pH and normal EC. There were 12 treatment combinations consisting of four seed rate in mainplots and three fertility levels in subplots.

The details of the treatments are presented in Table 1 and plan of layout is illustrated in Main plot - eed rate 15Kg ha^{-1}(S_1) 20Kg ha^{-1} S_2 25Kg ha^{-1} S_3 30Kg ha^{-1} S_4 and Sub plot – Fertilizer level N_1- 100 % RDF(N: P_2O_5: K_2O: 20:50: 20 kg ha^{-1}), N_2-125% RDF (NPK only) and N3-125% RDF (N: P: K + S @ 20 kg ha^{-1} + Zn @ 5 kg ha^{-1} + foliar spray urea 2% twice/TNAU pulse wonder)

Results and Discussion

Number of pods plant^{-1}

Plant growth behavior can be determined by number of pods plant^{-1}. Both remobilization of N and biological N_2 fixation during reproductive growth are important sources of N for developing pods (Neves *et al.*, 1982) [12]. Number of pods plant^{-1} depends on the number of flowering nodes plant^{-1}, branches plant^{-1} and number of flowers node^{-1} and its retention. Greater photosynthesis enhanced by more nutrient uptake helps to initiate more flowering buds, which ultimately developed as pods. The number of pods plant^{-1} influenced significantly due to seed rate and nutrient levels.

Among the number of pods plant^{-1} recorded significantly higher number of pods plant^{-1} (39.86) was obtained from lowest seeding rates *i.e.* S_1 (15 kg ha^{-1}) followed by relatively lower number of pods per plant (38.72) at a seeding rate of 20 kg ha^{-1} (S_2). Whereas, minimum number of pods plant^{-1} (36.53) which, was obtained from seeding rates of 30 kg ha^{-1} (S_4), which could be attributed to greater planting density. Similar trend of results have also been reported by Achakzai and Taran (2011) [1] in mash bean. They found that seeding rate 15 kg ha^{-1} resulted in highest number of pods plant^{-1}, while minimum number was reported with a seeding rate of 27.5 kg ha^{-1}. The decreasing trend of pods plant^{-1} with increasing seed rate could be attributed to the competition existing between the populated crops for the sake of nutrients uptake.

The nutrient requirement of a plant depends on its demand and is controlled genetically or by the nutrient status present in soil. The number of pods plant^{-1} significantly increased with increasing levels of nutrient. Plant fertilized with N_3 (125% RDF (NPK only) + 20 kg ha^{-1} S + 5 kg ha^{-1} Zn +foliar spray urea 2% twice) produced the highest number of pods plant^{-1} (40.17) and the lowest number of pods plant^{-1} (36.26) was recorded from the plants fertilized with 100% RDF (N_1). During pod development the supply of sufficient nutrient and photo assimilates are essential for increasing pod length as well as grain number in pod. The increase in number of pods plant^{-1} was probably due to balanced plant growth and better fruiting caused by optimum neutralization of NPK and S. Insufficient nutrient supply at the time of flowering and pod development stage may cause lesser number of pods plant^{-1}. Rathore *et al.*, (2007) also noted more number of pods plant^{-1} due to the application of 100% RDF over that of 50% RDF.

Number of seeds pod^{-1}

The number of seeds pod^{-1} is one of the key factors determining the final seed yield. Data on number of seeds pod^{-1} is presented in Table 1 A perusal of the results showed that seed rates and nutrient levels caused significant variations with respect to number of seeds pod^{-1}.

With regards to number of seeds pod^{-1}, urdbean showed favorable response to seed rates up to 15 kg seed ha^{-1}, but thereafter the seeds pod^{-1} reduced significantly at 30 kg seed ha^{-1}. Maximum 6.36 seeds pod^{-1} was noted from the plots sown at 15 kg seeds ha^{-1} (S_1), being significantly superior to higher seed rates. Number of seeds pod^{-1} under high seed rates might be due to lower production of assimilates to the seeds. The results are in agreement with those obtained by Singh and Singh (2010) [13, 14] at Ludhiana (Punjab).

It is evident from the data presented in Table 1 that maximum number of seeds pod^{-1} (6.24) was obtained in plants treated with N_3 (125% RDF (NPK only) + 20 kg ha^{-1} S + 5 kg ha^{-1} Zn +foliar spray urea 2% twice) which was statistically superior to that obtained in plots fertilized @ 125 and 100%RDF, while the minimum number 5.99 seeds pod^{-1} were recorded at 100% RDF. The results are in line with Singh (2008). However, these results are in contradiction with the findings of Rathore *et al.*, (2007) as they observed that pods plant^{-1} remained unaffected due to the application of nutrients in black gram.

Table 1: No of pod, grain pod^{-1}, seed weight, grain yield plant^{-1} of bold seeded urdbean as influenced by seed rate and Nutrient levels.

Treatment		Yield attributes				
		No of pod plan^{-1}	**Seed pod^{-1}**	**Seed plant^{-1}**	**100 seed weight (g)**	**Seed yield (g plant^{-1})**
A. Seed rates (Kg/ha.)						
S_1	15	39.86	6.36	253.82	4.53	11.74
S_2	20	38.72	6.31	244.44	4.42	11.06
S_3	25	38.19	6.11	233.33	4.32	10.20
S_4	30	36.53	5.72	203.26	4.17	8.59
SEm±		0.37	0.03	3.18	0.02	0.18
CD (P=0.05)		1.27	0.12	11.00	0.07	0.61
B. Nutrient levels						
N_1	100 % RDF(NPK)	36.26	5.99	217.63	4.17	9.73
N_2	125% RDF(NPK)	38.54	6.14	236.84	4.30	10.19
N_3	125%RDF(N: P: K + S @ 20 kg ha-1 + Zn@ 5 kg ha-1 + foliar spray urea 2% twice)	40.17	6.24	246.67	4.60	11.27
SEm±		0.38	0.02	2.59	0.12	0.17
CD (P=0.05)		1.14	0.06	7.76	0.37	0.52
I (S X N)						
SEm±		0.76	0.04	5.18	0.25	0.35
CD (P=0.05)		NS	NS	NS	NS	NS

Number of seeds plant^{-1}

Data set out in Table 1 showed that number of seeds plant^{-1} influenced significantly due to various treatments under study. Significantly highest number of seeds (253.82) plant^{-1} were produced by the crop sown @ 15 kg seed ha^{-1} followed by sharp declined in the number of seeds (244.44) plant^{-1} at 20 kg seed ha^{-1}. The magnitudes of increase in the number of seed plant^{-1} obtained under seeding rate of 15 kg seed ha^{-1} was

5.90 and 6.20% over that of highest seeding rates. Reduced number of seeds plant^{-1} under high seed rates might be due to lower production of assimilates by lesser leaf area, which was not capable to supply available, assimilates to the seeds. This result is in agreement with that of Singh (2005) who also observed that seeds plant^{-1} decreased with increasing seed rate.

Nutrient application also exhibited significant influence on number of seeds plant^{-1} of urdbean. Maximum number of seeds (246.67) plant^{-1} were registered when crop N_3 (125% RDF (NPK only) + 20 kg ha^{-1} S + 5 kg ha^{-1} Zn +foliar spray urea 2% twice) followed by a significant reduction in the number of seeds at 125% and 100% RDF. The extent of decrease in the number of seeds plant^{-1} of urdbean was 3.98 and 11.77% due to the 125% and 100% RDF, respectively over that of full doses of recommended nutrients. Maximum number of seeds plant^{-1} under N_3 (125% RDF (NPK only) + 20 kg ha^{-1} S + 5 kg ha^{-1} Zn +foliar spray urea 2% twice) might be due to the sufficiency of essential nutrients at the time of flowering and seed setting stages of plants. Singh (2008) also observed more number of seeds plant^{-1} due to the recommended nutrient application.

100-seed weight (g)

The final seed yield is a function of combined effect of the individual yield components nourished under applied inputs and 100-seed weight is an important yield determining factor. It expresses the magnitude of seed development for deriving the seed quality and yield per hectare. Thus, seed size *i.e.*, seed weight contributes greatly to seed yield. Data presented in Table 1 showed that 100-seed weight varied significantly due to seed rate and nutrient levels.

As regards to seeding rate, 100-seed weight differed significantly due to varying seed rates. A maximum 100-seed weight (4.53 g) was obtained with a seeding rate of 15 kg ha^{-1} followed by 20 kg ha^{-1}. Whereas, higher seeding rate at 30 kg ha^{-1} gave the minimum value (4.17 g) of 100-seed weight. Reduced 100-seed weight at higher seed rate might be due to lower amount of assimilate translocation from leaf to grain (Gupta and Lal, 1988) [7]. Turk and Tawaha (2002) [15] also stated that 100-seed weight in fababean were negatively related to seeding rate and found that there was trend for seed rate to decrease with increasing seeding rate. While contradicted with the findings, Achakzai and Taran (2011) [1] reported that 100-seed weight did not influenced by varying seed rates.

Seed size varies with the variation in nutrient levels. Among the various nutrient levels tested, significant variation in 100-seed weight was observed (Table 1) and it varied from (4.17) g to (4.60) g. The highest 100-seed weight (4.60 g) was observed at N_3 (125% RDF (NPK only) + 20 kg ha^{-1} S + 5 kg ha^{-1} Zn +foliar spray urea 2% twice) that was statistically superior over lower levels of nutrients *i.e.* (100% RDF). The quality of seed of a crop depends on the translocation of photosynthates from photosynthesizing organ to seed during the period from pod setting to pod maturity. Seed weight depends on protein synthesis in it and seed protein increases by nitrogen fertilization. Similarly, Ali (1993) [2] also expressed the beneficial effects of N and P fertilization on yield attributes in black gram. Increase in 100-seed weight associated with increasing nutrient levels confirmed the findings of Singh (2008).

Seed yield (g plant^{-1})

Seed yield plant^{-1} of urdbean Table 1 significantly affected by seed rates and fertility levels. Different seed rates had significantly affected on seed yield plant^{-1} of urdbean. Seed yield plant^{-1} was negatively related to increasing seeding rates. The seed yield plant^{-1} increased with decreasing rate producing the highest yield (11.74 g) plant^{-1} at 15 kg seed ha^{-1}, which was statistically superior over rest of the seeding rate and lowest yield (8.59 g) per plant was obtained at 30 kg seed ha^{-1}. The highest seed rate resulted in reduction in yield plant^{-1} because of performance of individual plant as judged by various yield attributes, which were significantly of lower order where high seed rates was used. Seed due to better performance of individual plant under lower seed rate (15 kg ha^{-1}) did not seem to be promising to compensate the overall advantage accrued due to higher number of plants per unit area under higher seed rate (30 kg ha^{-1}). Similar results were also reported by Singh and Singh (2010) [13, 14].

Nutrient levels significantly improved the seed yield plant^{-1}. Marked improvement in seed yield plant^{-1} was found with N_3 (125% RDF (NPK only) + 20 kg ha^{-1} S + 5 kg ha^{-1} Zn +foliar spray urea 2% twice) over those of 125% and 100% reduction in RDF. Significantly higher seed yield (11.27 g plant^{-1}) were recorded by the plant treated with N_3 (125% RDF (NPK only) + 20 kg ha^{-1} S + 5 kg ha^{-1} Zn +foliar spray urea 2% twice), being 45.75% greater than that found in 100% RDF (N_1). More availability of major nutrients (N, P, K and S) in optimum quantity at (125% RDF (NPK only) + 20 kg ha^{-1} S + 5 kg ha^{-1} Zn +foliar spray urea 2% twice) might have increased the seed yield plant^{-1} due to enhanced photosynthesis activity followed by efficient transfer of these metabolites in the seed with the resultant increase in the size and weight of individual seed (Goud and Kale, 2010) [6]. These results corroborated the findings of Singh (2008).

Yield

Seed yield (kg ha^{-1})

Increase in seed rate in an increase in seed yield (810.89 kg ha^{-1}) up to 25 kg seed ha^{-1} (S_3). No advantageous effect of increasing seed rate beyond 25 kg ha^{-1} in relation to seed yield ha^{-1} might be owing to severe plant competition to the extent that its adverse effect on seed yield plant^{-1} could not be proportionally counteracted by an increase in plant population. Therefore, sowing @ 25 kg seed ha^{-1} seems optimum which could be due to the most desirable planting density or population in the existing environmental conditions of Raipur. Similar results have also been reported by Singh (2008).

Seed yield of urdbean differed significantly due to different nutrient levels. The highest grain yield (775.00 kg ha^{-1}) was observed at application of 125% RDF (NPK only) + 20 kg ha^{-1} S + 5 kg ha^{-1} Zn +foliar spray urea 2% twice (N3), being significant over F_1 and F_2 levels of fertilization. Minimum seed yield was registered by the crop treated with only 100% recommended doses of nutrients (N_1). There were 22.12 and 9.97% reduction in seed yield due to N_1 and N_2 treatments over that of N_3 treatment. The increase in the seed yield ha^{-1} of black gram owing to increase in the fertility level was due to the fact that application of adequate of nutrients in the balanced proportion enhanced the growth of the crop and made better utilization of soil moisture and other resources led to better development of the yield attributes. Moreover the improvement in yield attributes and consequent to higher yield by N_3 (125% RDF (NPK only) + 20 kg ha^{-1} S + 5 kg ha^{-1} Zn +foliar spray urea 2% twice) might possibly be due to the enhanced synthesis of carbohydrates and proteins and their transport to the sink through efficient physiological activities in plants, as evident from improved physiological parameters like LAI and CGR. The results of Singh *et al.*, (2005) revealed that the higher grain yield of black gram was mainly owing to significantly superior yield attributes like effective number of pods plant^{-1} and 100-seed weight. Our result enlightened with the findings of Rathore *et al.*, (2007).

Interactive effects of S x N was found to be significant on seed yield of urdbean (Table 2). Crop sown with seed rate of 25 kg ha^{-1} (S_3) and provided with (125% RDF (NPK only) + 20 kg ha^{-1} S + 5 kg ha^{-1} Zn +foliar spray urea 2% twice)N_3 recorded significantly higher seed yield (990 kg ha^{-1}) compared to any other treatment combinations. The higher seed yield of urdbean with a seeding rate of 25 kg ha^{-1} could be attributed to the increase in total productivity than the individual plant performance. The advantage of recording higher seed yield with 125% RDF (NPK only) + 20 kg ha^{-1} S + 5 kg ha^{-1} Zn +foliar spray urea 2% twice could be justified with better growth and yield attributes. In earlier study also linear increase in seed yield was recorded with increase in the levels of nutrient application. Similar significant interaction was reported by Kumar *et al.*, (2014) [10].

Table 2: Seed yield, Stover yield, harvest index of bold seeded urdbean as influenced by seed rate and Nutrient levels

Treatment		seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
A. Seed rates (Kg/ha.)				
S_1	15	587.44	866.41	40.41
S_2	20	700.00	1153.44	38.09
S_3	25	810.89	1330.99	37.95
S_4	30	669.89	1065.32	38.65
SEm±		21.45	33.66	0.13
CD (P=0.05)		74.23	116.49	0.45
B. Nutrient levels				
N_1	100 % RDF(NPK)	603.50	899.09	40.23
N_2	125% RDF(NPK)	697.67	1155.91	37.87
N_3	125% RDF(N: P: K + S @ 20 kg ha^{-1} + Zn @ 5 kg ha^{-1} + foliar spray urea 2% twice)	775.00	1257.13	38.22
SEm±		18.65	31.07	0.12
CD (P=0.05)		55.91	93.16	0.36
I (S X N)				
SEm±		37.30	62.14	0.24
CD (P=0.05)		108.86	181.39	0.69

Stover yield (kg ha^{-1})

Biological or stover yield is a measure of total dry matter production of crop during its life span. The data on stover yield of urdbean (Table 2) indicated that different treatments had significant effects on the stover yield.

The varying seed rate had significant impact on stover production as it increased with increase in the seeding rate. Significantly maximum stover yield (1330.99 kg ha^{-1}) were obtained at highest seeding rate (25 kg ha^{-1}) followed by 20, 30 and 15 kg seed ha^{-1}, respectively. All these treatments differed significantly from each another. These results are in line with those of Rathore *et al.*, (2007) who also reported an increased stover yield with increased seed rates.

Similarly, the nutrient levels also significantly affected the stover yield, maximum (1257.13 kg ha^{-1}) being recorded in the treatments receiving 125% RDF (NPK only) + 20 kg ha^{-1} S + 5 kg ha^{-1} Zn + foliar spray urea 2% twice, while minimum stover yield (899.09 kg ha^{-1}) was obtained with 100% RDF. The increase in stover yield is due to increase in plant height and dry matter production at higher nutrient levels. The presence of adequate amount of major nutrients in the soil might have enabled the plant to fix nitrogen from the atmosphere in nodules which improved the plants growth and its development, which is the probably responsible for increased stover yield. Similar findings were also reported by Mishra and Mishra (1995). Furthermore, higher stover yield obtained with application of 125% RDF (NPK only) + 20 kg ha^{-1} S + 5 kg ha^{-1} Zn +foliar spray urea 2% twice (N_3) could be due to pronounced vegetative growth which resulted in higher plant height and more number of branches plant^{-1}.

Stover yield was significantly influenced by the interaction effect of seed rate and nutrient levels (Table 2). Seed rate and nutrient level interaction showed that significantly highest stover yield (1573.33 kg ha^{-1}) was obtained with a seeding rate of 25 kg ha^{-1}coupled with nutrient level 125% RDF (NPK only) + 20 kg ha^{-1} S + 5 kg ha^{-1} Zn +foliar spray urea 2% twice (S_3 F_1). At the same or different levels of nutrient application, highest seed rate produced the maximum stover yield of black gram. Higher stover yield obtained under 125% RDF (NPK only) + 20 kg ha^{-1} S + 5 kg ha^{-1} Zn +foliar spray urea 2% twice could be due pronounced vegetative growth which resulted in higher plant height and more number of branches plant^{-1} and higher amount of dry matter accumulation. Present findings are in conformity with those of Singh (2008).

Harvest Index (HI)

Harvest index is a measure of the productive efficiency of crop. Data of the harvest index (Table 2) also depicted significant response in relation to various treatments under study.

With respect to effect of various seed rates, the study revealed that among the 4 seed rates tried, crop sown with 15 kg seed ha^{-1} recorded the maximum HI values (40.41), which proved to be significantly superior over higher seed rates. Low harvest index in other seed rates may also be due to inefficient partitioning of assimilates between vegetative growths (source) to grains (sink). Singh and Singh (2010) [13, 14] also observed significant variation in HI due to varying seed rates. On the other hand Achakzai and Taran (2011) [1] noted insignificant response of HI in relation to various seed rates.

As regard nutrient levels the crop supplied with lower nutrient levels produced higher harvest index and their values in a linear response when nutrient rates (N_1) were increased. The higher values of HI (40.23) were realized with 100% RDF followed by 125% RDF (NPK only) + 20 kg ha^{-1} S + 5 kg ha^{-1} Zn + foliar spray urea 2% twice (N_3). Poor and inefficient partitioning of assimilates between vegetative parts and grains, might be the probable reason behind low HI under lower levels of nutrient. The results are in line with the observations made by Hussain *et al.*, (2011) [8] who opined that application of nitrogen and phosphorus proved beneficial for boosting harvest index in urdbean.

Harvest index was significantly influenced by the interaction effect of S x N (Table 3). Seed rate and nutrient level interaction showed that significantly highest Harvest index (40.14 kg ha^{-1}) was obtained with a seeding rate of 15 kg ha^{-1} coupled with nutrient level of 125% RDF (NPK only) + 20 kg ha^{-1} S + 5 kg ha^{-1} Zn +foliar spray urea 2% twice (S_1N3). At the same or different levels of nutrient application, lowest seed rate produced the maximum Harvest index of urdbean. The maximum Harvest index with lower seeding rate could be attributed to the decrease in the plant density coupled with smaller plants than those found at higher seed rates. Present findings are in conformity with those of Singh (2008).

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