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Effect of integrated nutrient management on growth characters and yield of urdbean (*Vigna mungo* L.)

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Abstract
The present investigation carried out to study the ‘‘Effect of integrated nutrient management on growth characters and yield of urdbean (*Vigna mungo* L.)’’ at the Instructional farm, Barrister Thakur Chhedilal College of Agriculture and Research Station, Bilaspur, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh) during *kharif* season 2021. Experimental results revealed that growth characters *viz*., plant height (54.43 cm), number of functional leaf (15.29 plant^{-1}), number of primary branches (10.40 plant^{-1}), dry matter accumulation (12.57 g plant^{-1}), number of nodules (40.34 plant^{-1}), dry weight of nodules (108.40 mg plant^{-1}), biological yield (3304 kg ha^{-1}), seed yield (1158 kg ha^{-1}) and straw yield (2146 kg ha^{-1}) as well as harvest index (35.05%), were significantly more with treatment T_9 (100% RDF + *Rhizobium* culture + PSB).

Keywords: Growth, INM integrated nutrient management, PSB phosphate solubilizing bacteria), RDF recommended dose of fertilizer, *Rhizobium* culture, urdbean, yield

Introduction
Urdbean (*Vigna mungo* L. Hepper) is an ancient and well known leguminous crop and popular because of its nutritional quality (protein). Urdbean is one of the most important cultivated pulse crops of the ‘Vigna’ group. It is cultivated since prehistoric period in India and considered to be originated from *Vigna silvestris*. Urdbean is also known as black gram. Based on seed colour and other characteristics, urdbean has been grouped under two main type’s *viz*. var. *niger* (Large black seeded and early maturing) and var. *viridis* (small greenish seeded and late maturing). Major portion of urdbean is utilized in making dal, curry, soup, sweet and snack. In South India, the most popular idli and dosa are prepared using mixed proportions of rice and urdbean. The food values of urdbean lie in its high and easily digestible protein. Urdbean seeds are known to contain high protein (23.5%), fat (1.6%) and carbohydrates (63.4%) on dry weight basis.

Nitrogen an essential element to all life, although abundant and composes nearly 80 per cent of the atmosphere, yet nitrogen is one of the major constraints that limit the growth and productivity of plant in many ecosystems. This is a result of the inability of plant to directly utilize atmospheric nitrogen to meet their biological requirement for this element.

Application of bio-fertilizer recorded the highest value of growth and yield attributes and yield of urdbean. It was observed that the plants treated with experimental bio-fertilizer *Rhizobium* showed excellent result in the morphological and bio-chemical parameters (Nalawde and Bhalerao, 2015) [5]. Inoculation of urdbean seed with bio-fertilizer enhances available P status of soil by solublizing bound phosphate into available forms (Singh and Yadav, 2008)[17]. Dual inoculation of *Rhizobium* and phosphate solubilizing bacteria (PSB) may help the plant to acquire both N and P Co-inoculation of PSB with ‘*Rhizobium*’ have been found to improve the nodulation and nitrogen fixation in urdbean (Gaur and Algawadi, 1989) [5]. Integrated nutrient management contributes to the restoration and maintenance of soil fertility and crop productivity. It may help to prevent the emergence of nutrient deficiencies other than NPK. It reduces fertilizer waste and improves the physical, chemical, and biological environment of the soil.

Materials and Methods
The present experiment was conducted at Instructional Farm of Barrister Thakur Chhedilal College of Agriculture and Research Station, Sarkanda, Bilaspur Chhattisgarh during *kharif*

season of 2021 (16 July to 03 October).

The general climatic condition of Bilaspur is sub-humid region and dry-moist with mean annual rainfall of 1200-1400 mm (based on 80 year mean), mostly during the period between June to September. The weekly maximum temperature raises up to 37 ^{0}C during summer and minimum temperature drop down as 8.5 ^{0}C during winter season. May and December are the hottest and coolest months, respectively.

The weather data were recorded from meteorological observatory, Department of Agro-Meteorology, BTC College of Agriculture and Research Station, Bilaspur, Chhattisgarh.

The crop received 780.20 mm of rainfall during the entire growth period. The maximum temperature during this period varied between 28.37 ^{0}C in third week of July to 33.43 ^{0}C in the first week of July, 2021 whereas, minimum temperature varied between 22.29 ^{0}C in the third week of July to 24.43 ^{0}C in first week of July, 2021. Relative humidity throughout the crop season varied between 91.86 to 96.29 per cent at morning and 77.43 to 88.43 per cent in evening hour. The open pan evaporation mean values ranged from 1.83 to 3.43 mm day^{-1}, whereas the bright sunshine varied from 0.31 to 7.01 hours day^{-1}. The wind velocity ranged between 0.37 to 2.51 km hour^{-1}. The experimental field was sandy soil. The soil was neutral in reaction, medium in available nitrogen, phosphorus and potash contents. Further, the organic carbon content showed medium status.

Table 1: Experimental details

Crop	- Urdbean
Spacing	- 30 cm (row to row) - 10 cm (plant to plant)
Variety & Date of sowing	Indira urdpratham & 16-07-2021
Date of harvesting	- 03-10-2021
Design	- RBD
Replications	- 3
Gross plot size	- 12 m^2
Net plot size	- 8.16 m^2
Seed rate	- 18 kg ha^{-1}

Table 2: Treatment Combinations of the experiment

TreatmentNo.	Treatment details
T_1	Control
T_2	100% RDF
T_3	125% RDF
T_4	*Rhizobium* culture
T_5	PSB
T_6	100% RDF+ *Rhizobium* culture
T_7	100% RDF+ PSB
T_8	*Rhizobium* culture + PSB
T_9	100% RDF + *Rhizobium* culture + PSB

Note: PSB – Phosphate solubilizing bacteria, RDF- Recommended Dose of fertilizer (20:40:20 kg N, P_2O_5, K_2O ha^{-1})

Urdbean variety Indira urd pratham (RU 03-14) is released by AICRP on MULLaRP, Indira Gandhi Krishi Vishwa Vidyalaya, Raipur Chhattisgarh. Crop takes 75-80 days to maturity and the potentiality of seed yield is 12-14 q ha^{-1}. It is resistant to powdery mildew up to the podding stage and has been recommended in Chhattisgarh state for *kharif* as well as summer irrigated condition.

The data recorded from the various observations were tabulated and then subjected to their statistical analysis by using the method of analysis of variance (ANOVA) as described by Panse and Sukhatme (1967). The treatment was tested by F shown critical difference (CD) at 5% level of significance. It was determined for each character to compare the differences among treatment means.

Results and Discussion

Growth characters

Plant height

Among different treatments, effect of integrated nutrient management on plant height at various growth stage of urdbean was found to be significant under study (Table 3).The highest plant height at 20, 40, 60 DAS and at harvest was recorded 14.43, 38.11, 53.46 and 54.43 cm in treatment T_9 (100% RDF + *Rhizobium* culture + PSB) which was at par with treatment T_6 (100% RDF + *Rhizobium* culture) and T_7 (100% RDF + PSB) while lowest plant height was recorded with treatment T_1 (control). Similar result was also reported by Rathore *et al.* (2010) [12] and Goud *et al.* (2010) [7].

Functional leaf plant^{-1} (No.)

Effect of integrated nutrient management on number of functional leaf plant^{-1} at various growth stage of urdbean was found to be significant under study (Table 3). The maximum number of functional leaf plant^{-1} at 20, 40, 60 DAS and at harvest was recorded 3.11, 8.89, 15.29 and 9.69 plant^{-1} in treatment T_9 (100% RDF + *Rhizobium* culture + PSB) which was at par with treatment T_6 (100% RDF + *Rhizobium* culture) and T_7 (100% RDF + PSB) while minimum number of functional leaf plant^{-1} was recorded with treatment T_1 (control). Similar finding was also reported by Vadgave (2010) [20].

Primary branches plant^{-1} (No.)

The number of primary branches plant^{-1} increased progressively at successive observations with advancement of crop age at various growth stages of urdbean was significantly affected by different integrated nutrient management practices under study (Table 4). The maximum number of primary branches plant^{-1} at 20, 40, 60 DAS and at harvest was recorded 3.00, 7.50, 10.10 and 10.40 plant^{-1} in treatment T_9 (100% RDF + *Rhizobium* culture + PSB) which was at with treatment T_6 (100% RDF + *Rhizobium* culture) and T_7 (100% RDF + PSB) while minimum number of primary branches plant^{-1} was recorded with treatment T_1 (control). The result is supported by Jain and Singh (2003)[8], Gilani and Bharose (2004) [6] and Singh *et al.* (2004)[15].

Dry matter accumulation (g plant^{-1})

The effect of integrated nutrient management on dry matter accumulation at various growth stages of urdbean was found to be significant under study (Table 4). The highest dry matter accumulation at 20, 40, 60 DAS and at harvest was recorded 0.99, 6.21, 10.25 and 12.57 g plant^{-1} in treatment T_9 (100% RDF + *Rhizobium* culture + PSB) which was at par with treatment T_6 (100% RDF + *Rhizobium* culture) and T_7 (100% RDF + PSB) while minimum dry matter accumulation g plant^{-1} was recorded with treatment T_1 (control). The findings are in accordance with those of Bhattacharya *et al.* (2004)[3].

Nodule plant $^{-1}$ (No.)

Effect of integrated nutrient management on number of nodules plant^{-1} at 40 and 60 DAS of urdbean was found to be significant under study (Table 5). At 40 and 60 DAS, all INM

methods found significantly better than T_1 control treatment. The treatment T_9 (100% RDF + *Rhizobium* culture + PSB) recorded the maximum number of nodule plant^{-1} (40.34 and 29.90) at 40 and 60 DAS, respectively, than all other treatments, but it was significantly on par with treatment T_6 (100% RDF + *Rhizobium* culture) which recorded (38.41 and 28.19) nodules plant^{-1} at respective dates of observation. Similarly treatment T_7 (100% RDF + PSB) recorded 38.35 and 27.54 nodule plant^{-1} at 40 and 60 DAS, respectively. Further treatments T_3 (125% RDF), T_2 (100% RDF) and T_8 (*Rhizobium* culture + PSB) being at par and better than treatments T_4 (*Rhizobium* culture) and T_5 (PSB) under 40 and 60 days observations. The result are supported by Khatkar *et al.* (2007) [10], Singh and Gupta (2006)[16] and Jain *et al.* (2006) [9].

Dry weight of nodule (mg plant^{-1})

Effect of integrated nutrient management on dry weight of nodule plant^{-1} at 40 and 60 DAS of urdbean was found to be significant under study (Table 5). At 40 and 60 DAS, all INM methods found significantly better than T_1control treatment. The treatment T_9 (100% RDF + *Rhizobium* culture + PSB) recorded the maximum dry weight of nodule (108.40 and 80.79 mg plant^{-1}) at 40 and 60 DAS, respectively, but it was significantly at par with treatment T_6 (100% RDF + *Rhizobium* culture) which showed respectively nodules dry weight of 104.90 and 78.85 mg plant^{-1}.Similarly treatment T_7 (100% RDF + PSB) recorded 104.60 and 78.20 mg plant^{-1} dry weight of nodule at 40 and 60 DAS, respectively and stood in third position under study. Further treatments T_3 (125% RDF), T_2 (100% RDF) and T_8 (*Rhizobium* culture + PSB) being on par and better than treatments T_4 (*Rhizobium* culture) and T_5 (PSB) on both the days of observations. Bhattacharya *et al.* 2004[3] also reported similar results.

Yield

Biological yield (kg ha^{-1})

The biological yield of urdbean is significantly affected due to different integrated nutrient management treatments(Table 6). Treatment T_9 (100% RDF + *Rhizobium* culture + PSB) produced significantly the highest biological yield (3304 kg ha^{-1}) as compare to all other treatments under study. Further, treatment T_6 (100% RDF + *Rhizobium* culture) and T_7 (100% RDF+ PSB) produced significantly at par biological yield 3212 and 3198 kg ha^{-1}, respectively and both stood in second order after T_9. The treatment T_3 (125% RDF), T_2 (100% RDF), T_8 (*Rhizobium* culture + PSB), T_4 (*Rhizobium* culture) and T_5 (PSB) were also shows their superiority over T_1 treatment. The control (T_1) treatment recorded significantly the lowest biological yield of 2576 kg ha^{-1} under study. The result is supported by Jain *et al.* (1999), Tanwar *et al.* (2002)[18], Bhat *et al.* (2005)[2], Band *et al.* (2007)[1] and Rathore*et al.* (2007) [13].

Seed yield (kg ha^{-1})

The seed yield of urdbean is significantly affected due to different integrated nutrient management treatments (Table 6). Treatment T_9 (100% RDF + *Rhizobium* culture + PSB) recorded significantly the highest seed yield (1158 kg ha^{-1}) as compare to all other treatments under study. Further, treatment T_6 (100% RDF + *Rhizobium* culture) and T_7 (100% RDF+ PSB) recorded significantly at par seed yield of 1092 and 1084 kg ha^{-1}, respectively and both stood in second order after T_9. The treatment T_3 (125% RDF), T_2 (100% RDF), T_8 (*Rhizobium* culture + PSB), T_4 (*Rhizobium* culture) and T_5 (PSB) were also shows their superiority over T_1 treatment. The control (T_1) treatment recorded significantly the lowest seed yield of 704 kg ha^{-1} under study. The finding are in accordance with the findings of Rathore *et al.* (2010) [12] and Shete *et al.* (2011).

Straw yield (kg ha^{-1})

The straw yield of urdbean is significantly affected due to different integrated nutrient management treatments (Table 6). Treatment T_9 (100% RDF + *Rhizobium* culture + PSB) produced significantly the highest straw yield (2146 kg ha^{-1}) as compare to all other treatments under study. Further, treatment T_6 (100% RDF + *Rhizobium* culture) and T_7 (100% RDF+ PSB) produced significantly at par straw yield 2120 and 2114 kg ha^{-1}, respectively and both stood in second order after T_9. The treatment T_3, T_2, T_5, T_4 and T_8 (*Rhizobium* culture + PSB) were also shows their superiority over T_1 treatment. The control (T_1) treatment recorded significantly the lowest straw yield of 1872 kg ha^{-1} under study. These results are in close conformity with the findings of Biswas and Patra (2007) and Tomar *et al.* (2001).

Harvest index (%): Harvest index is a measure of physiological productivity potential of crop. It is the ability of a plant to convert the dry matter into economic yield.

The harvest index of urdbean was significantly affected due to integrated nutrient management practices.(Table 6)

The treatment T_9 (100% RDF + *Rhizobium* culture+ PSB) recorded highest harvest index (35.05%) as compare to all other treatments under study. Further, T_6 (100% RDF + *Rhizobium* culture) and T_7 (100% RDF + PSB) recorded significantly at par harvest index of 34.00 and 33.90 per cent, respectively and both stood in second order after T_9. The lowest harvest index 27.33 per cent was recorded in T_1 (control).

Table 3: Effect of integrated nutrient management on plant height (cm) and number of functional leaf plant^{-1}at various growth stages of urdbean

Treatment		Plant height (cm)				Functional leaf plant^{-1} (No.)			
		20 DAS	40DAS	60DAS	At harvest	20 DAS	40DAS	60DAS	At harvest
T_1	Control	10.45	32.76	44.89	45.59	1.74	5.77	10.96	6.28
T_2	100% RDF	12.31	34.71	50.13	51.20	2.50	7.47	12.34	8.75
T_3	125% RDF	12.71	35.59	51.16	52.01	2.57	7.92	13.55	8.84
T_4	*Rhizobium* culture	12.26	33.90	48.71	49.12	2.32	6.73	11.78	7.87
T_5	PSB	11.47	33.72	47.30	47.69	1.96	6.59	11.25	7.69
T_6	100% RDF+ *Rhizobium* culture	14.31	38.03	53.38	54.17	2.98	8.48	14.95	9.29
T_7	100% RDF+ PSB	13.99	36.71	52.71	53.79	2.76	8.42	14.14	9.25
T_8	*Rhizobium* culture + PSB	12.28	34.19	49.30	49.94	2.41	6.82	12.16	7.96
T_9	100% RDF + *Rhizobium* culture + PSB	14.43	38.11	53.46	54.43	3.11	8.89	15.29	9.69
S.Em ±		0.51	0.82	0.70	0.77	0.12	0.28	0.44	0.26
CD (P=0.05)		1.52	2.47	2.09	2.32	0.35	0.83	1.32	0.78

Table 4: Effect of integrated nutrient management on number of primary branches plant^{-1} and dry matter accumulation (g plant^{-1}) at various growth stages of urdbean

Treatment		Primary branches plant^{-1} (No.)				Dry matter accumulation (g plant^{-1})			
		20DAS	40DAS	60DAS	At harvest	20 DAS	40DAS	60DAS	At harvest
T_1	Control	1.7	3.67	5.53	5.67	0.41	3.14	5.19	6.91
T_2	100% RDF	2.3	5.33	7.60	7.97	0.55	4.68	8.43	10.30
T_3	125% RDF	2.3	5.67	7.73	7.83	0.73	5.31	9.13	11.00
T_4	*Rhizobium* culture	2.0	4.63	6.93	6.97	0.45	4.12	7.71	9.57
T_5	PSB	2.0	4.33	6.77	6.80	0.43	4.10	7.49	9.43
T_6	100% RDF+ *Rhizobium* culture	2.7	6.67	9.07	9.39	0.97	6.06	9.98	12.20
T_7	100% RDF+ PSB	2.6	6.47	8.93	9.37	0.82	5.82	9.72	11.80
T_8	*Rhizobium* culture + PSB	2.3	5.10	7.37	7.61	0.52	4.39	8.16	10.14
T_9	100% RDF + *Rhizobium* culture + PSB	3.0	7.50	10.10	10.40	0.99	6.21	10.25	12.57
S.Em ±		0.17	0.36	0.39	0.42	0.08	0.28	0.39	0.34
CD (P=0.05)		0.51	1.07	1.18	1.25	0.25	0.85	1.16	1.01

Table 5: Effect of integrated nutrient management on number of nodules plant^{-1} and nodule dry weight at 40 and at 60 DAS of urdbean

Treatment		Nodule plant^{-1} (No.)		Dry weight of nodule (mg plant^{-1})	
		40DAS	60DAS	40DAS	60DAS
T_1	Control	25.32	17.32	68.44	46.88
T_2	100% RDF	34.10	24.84	92.27	67.26
T_3	125% RDF	35.37	25.60	95.08	69.35
T_4	*Rhizobium* culture	32.50	22.49	87.88	60.48
T_5	PSB	29.76	21.19	80.37	57.36
T_6	100% RDF+ *Rhizobium* culture	38.41	28.91	104.90	78.85
T_7	100% RDF+ PSB	38.35	27.54	104.60	78.20
T_8	*Rhizobium* culture + PSB	33.74	23.66	90.24	64.27
T_9	100% RDF + *Rhizobium* culture + PSB	40.34	29.90	108.40	80.79
S.Em ±		0.69	0.84	1.29	0.99
CD (P=0.05)		2.07	2.51	3.88	2.98

Table 6: Effect of integrated nutrient management on biological, seed and straw yield as well as harvest index of urdbean

Treatment		Biological yield (kg ha^{-1})	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
T_1	Control	2576	704	1872	27.33
T_2	100% RDF	2975	950	2025	31.93
T_3	125% RDF	3013	982	2031	32.59
T_4	*Rhizobium* culture	2884	878	2006	30.44
T_5	PSB	2845	833	2012	29.28
T_6	100% RDF+ *Rhizobium* culture	3212	1092	2120	34.00
T_7	100% RDF+ PSB	3198	1084	2114	33.90
T_8	*Rhizobium* culture + PSB	2906	909	1997	31.28
T_9	100% RDF + *Rhizobium* culture + PSB	3304	1158	2146	35.05
S.Em ±		55.15	35.13	37.79	0.39
CD (P=0.05)		165.35	105.32	113.30	1.17

Conclusion

T_9 (100% RDF + *Rhizobium* culture + PSB) produced significantly highest seed yield (1158 kg ha^{-1}) as compared to all other treatment.

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