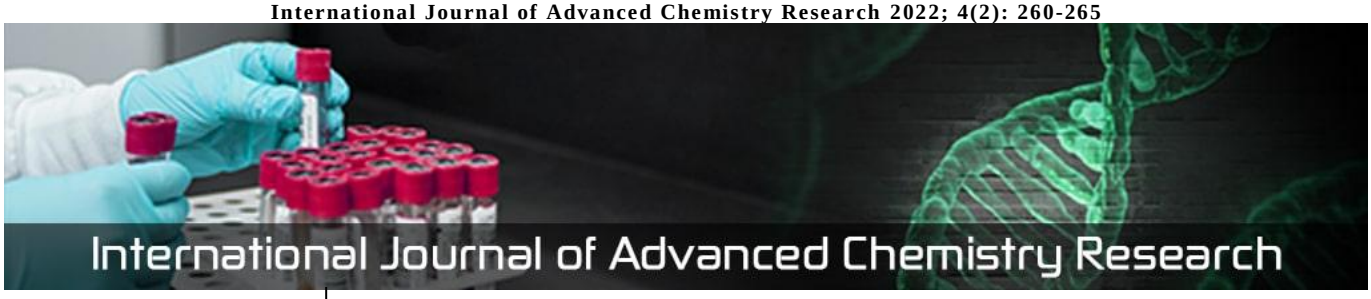

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Effect of integrated nutrient management on growth and yield of Urdbean (*Vigna mungo* L.) in Chhattisgarh plain

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Abstract
The present investigation carried out to study the ‘‘Effect of integrated nutrient management on growth and yield of urdbean (*Vigna mungo* L.) in Chhattisgarh plain ’’ at the Instructional farm, Barrister Thakur Chhedilal College of Agriculture and Research Station, Bilaspur, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh) during *kharif* season 2021. The investigation was spread out in a randomized block design where in nine treatment combinations in three replications. The size of gross plot of the experiment was 4.0 m × 3.0 m = 12.0 m² and net plot size 3.4 m × 2.4 m = 8.16 m² sowing was done in 16 July 2021. The different treatment combinations of the investigation are 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. Experimental results revealed that growth characters *viz*., plant height, number of functional leaf plant^{-1}, number of primary branches plant^{-1}, dry matter accumulation (g plant^{-1}), number of nodules plant^{-1}, dry weight of nodules (mg plant^{-1}), CGR, yield contributing characters *viz*., number of pods plant^{-1}, test weight, biological, seed as well as straw yield, were significantly more with treatment T_9 (100 % RDF + *Rhizobium* culture + PSB) which was on par with the treatments T_6 (100 % RDF + *Rhizobium* culture) and T_7 (100 % RDF + PSB).

Keywords: INM (Integrated Nutrient Management), RDF (Recommended Dose of Fertilizer), PSB (Phosphate Solubilizing Bacteria), *Rhizobium* culture, Growth, Yield, Urdbean

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.

In general, Chhattisgarh’s economy is mainly based on agriculture. The state comprising 28 districts, having 786 thousand hectare of area under pulses with 237 thousand metric tons of production during 2019-20. (Anonymous, 2020) [1]. The state is comprised with three agro-climatic zones, *viz*., Chhattisgarh plain, Bastar plateau and Northern Hill Region of Surguja.

In Chhattisgarh state the major pulse growing districts are Raigarh, Surguja, Durg, Bilaspur and Rajnandgaon. Among these, Raigarh district takes first position in area of pulses (6404 hectares) and total production (4174.7 metric tones) with an average productivity of 474.63 kg ha^{-1}. Out of the total pulses area in urdbean is important pulse crop of Raigarh district which occupies 48.39 per cent area and 46.28 per cent production of total pulse. (Anonymous, 2020) [1].

Urdbean is mainly grown during ‘*kharif*’ season by the farmers of Chhattisgarh plains. Uncertain rainfall adversely affects the sowing time of urdbean under rainfed condition. There are number of agronomic ways to increase productivity of urdbean. Out of them proper nutrient management practices is more important.

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) [18]. Inoculation of urdbean seed with bio-fertilizer enhances available P status of soil by solublizing bound phosphate into available forms (Singh and Yadav, 2008) [27]. 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) [6]. 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 fertiliser waste and improves the physical, chemical, and biological environment of the soil.

Materials & Methods

The present experiment entitled ''Effect of integrated nutrient management on growth and yield of urdbean (*Vigna mungo* L.) in Chhattisgarh plain'' 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 field experiment was carried out during *Kharif* season of 2021 at the Instructional Farm of Barrister Thakur Chhedilal College of Agriculture and Research Station, Sarkanda, Bilaspur, Chhattisgarh. The state is classified into three agro-climatic zones, *viz.*, Chhattisgarh plain, Bastar plateau and Northern Hill Region of Surguja, of which Bilaspur comes under the Chhattisgarh plains zone and situated at $22^{0}09'$ North latitude, $82^{0}15'$ East longitude and at an altitude of 298.0 meters above mean sea level.

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 weather data recorded during the period of investigation are given in Appendix-I and depicted through Fig.3.1.

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 clay soil (Vertisols). The soil was neutral in reaction, medium in available nitrogen, phosphorus and potash contents. Further, the organic carbon content showed medium status.

The investigation was spread out in a randomized block design where in nine treatment combinations in three replications. The size of gross plot of the experiment was 4.0 m × 3.0 m = 12.0 m² and net plot size 3.4 m × 2.4 m = 8.16 m² sowing was done in 16 July 2021. The different treatment combinations of the investigation are 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.

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 attributes.

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 1). 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) [21] and Goud *et al.* (2010) [8].

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 1). 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) [31].

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 2). 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) [11], Gilani and Bharose (2004) [7] and Singh *et al.* (2004) [25].

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 2). 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) [4].

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 3). 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) [15], Singh and Gupta (2006) [26] and Jain *et al.* (2006) [12].

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 3). 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 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 [4] also reported similar results.

Crop growth rate (g day^{-1} plant^{-1})

Crop growth rate of urdbean increased progressively up to 40 DAS. A quantum jump in CGR has been observed during the period of 20-40 days interval. It is more likely that new and actively photo-synthesizing tissues of increasing dry matter might be responsible for the increase in CGR during this phase (20-40 DAS) and after that continuously decreased to harvest stage (Fig 1). At various interval highest crop growth rate recorded with treatment T_9 (100 % RDF + *Rhizobium* culture + PSB) and lower value of crop growth rate was found in treatment T_1 (control).

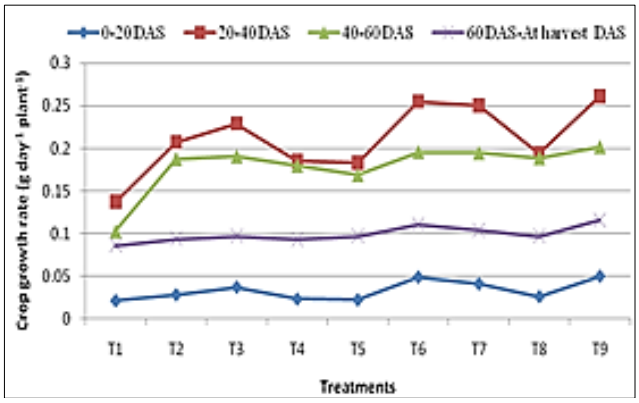

Fig 1: Effect of integrated nutrient management on crop growth rate (g day^{-1} plant^{-1}) at 0-20, 20-40, 40-60 DAS and at 60 DAS-harvest of urdbean

Yield attributes

Pods plant^{-1} (No.)

Effect of integrated nutrient management on number of pods plant^{-1} of urdbean was significant under study (Table 4). All INM methods found significantly better than T_1 (control) treatment. Treatment T_9 (100% RDF + *Rhizobium* culture + PSB) recorded the maximum pods (42.92) plant^{-1} than all other treatments but it was significantly on par with T_6 (100% RDF+ *Rhizobium* culture) which noted 41.38 pods plant^{-1}. Further treatment T_7 (100% RDF+ PSB) recorded 41.27 pods plant^{-1} and stood in third position under study. The result was in conformity with Neenu *et al.* (2014) [19] and Meena *et al.* (2018) [16].

Seeds pod^{-1} (No.)

Effect of integrated nutrient management on number of seeds pod^{-1} of urdbean was significant under study (Table 4). All INM methods found significantly better than T_1 treatment. Treatment T_9 (100% RDF + *Rhizobium* culture + PSB) recorded the highest seeds (7.62) pod^{-1} than all other treatments, but it was significantly at par with T_6 (100% RDF + *Rhizobium* culture) which showed 7.51 seeds pod^{-1}. Further treatment T_7 (100% RDF+ PSB) recorded 7.32 seeds pod^{-1} and stood in third position under study. This type of results are also recorded by Rashid *et al.* (2013) [20].

Test Weight (g)

Effect of integrated nutrient management on test weight of urdbean was to be significant under study (Table 4). The maximum weight (42.89 g) of 1000 seeds were found in T_9

(100% RDF + *Rhizobium* culture + PSB) which was at par with T_6 (100% RDF + *Rhizobium* culture) and T_7 (100% RDF+ PSB) while lowest test weight was (36.59 g) observed under T_1 (control). The findings are supported by Meena *et al.* (2002) [17] and Hakeem *et al.* (2008) [9].

Biological yield (kg ha^{-1})

The biological yield of urdbean is significantly affected due to different integrated nutrient management treatments (Table 4). 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) [13], Tanwar *et al.* (2002) [29], Bhat *et al.* (2005) [3], Band *et al.* (2007) [2] and Rathore *et al.* (2007) [22].

Seed yield (kg ha^{-1})

The seed yield of urdbean is significantly affected due to different integrated nutrient management treatments (Table 4). 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) [21] and Shete *et al.* (2011) [24].

Straw yield (kg ha^{-1})

The straw yield of urdbean is significantly affected due to different integrated nutrient management treatments (Table 4). 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) [5] and Tomar *et al.* (2001) [30].

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

Treatment	Plant height (cm)				Functional leaf plant^{-1} (No.)			
	20 DAS	40 DAS	60 DAS	At harvest	20 DAS	40 DAS	60 DAS	At harvest
T_1	10.45	32.76	44.89	45.59	1.74	5.77	10.96	6.28
T_2	12.31	34.71	50.13	51.20	2.50	7.47	12.34	8.75
T_3	12.71	35.59	51.16	52.01	2.57	7.92	13.55	8.84
T_4	12.26	33.90	48.71	49.12	2.32	6.73	11.78	7.87
T_5	11.47	33.72	47.30	47.69	1.96	6.59	11.25	7.69
T_6	14.31	38.03	53.38	54.17	2.98	8.48	14.95	9.29
T_7	13.99	36.71	52.71	53.79	2.76	8.42	14.14	9.25
T_8	12.28	34.19	49.30	49.94	2.41	6.82	12.16	7.96
T_9	14.43	38.11	53.46	54.43	3.11	8.89	15.29	9.69
SEm ±	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 2: Effect of integrated nutrient management on number of primary branches plant^{-1} and dry matter accumulation (g plant^{-1}) at various growth stages of uredbean

Treatment	Primary branches plant^{-1} (No.)				Dry matter accumulation (g plant^{-1})			
	20 DAS	40 DAS	60 DAS	At harvest	20 DAS	40 DAS	60 DAS	At harvest
T_1	1.7	3.67	5.53	5.67	0.41	3.14	5.19	6.91
T_2	2.3	5.33	7.60	7.97	0.55	4.68	8.43	10.30
T_3	2.3	5.67	7.73	7.83	0.73	5.31	9.13	11.00
T_4	2.0	4.63	6.93	6.97	0.45	4.12	7.71	9.57
T_5	2.0	4.33	6.77	6.80	0.43	4.10	7.49	9.43
T_6	2.7	6.67	9.07	9.39	0.97	6.06	9.98	12.20
T_7	2.6	6.47	8.93	9.37	0.82	5.82	9.72	11.80
T_8	2.3	5.10	7.37	7.61	0.52	4.39	8.16	10.14
T_9	3.0	7.50	10.10	10.40	0.99	6.21	10.25	12.57
SEm ±	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 3: Effect of integrated nutrient management on number of nodules plant^{-1} and nodule dry weight at 40 and at 60 DAS of uredbean

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

Table 4: Effect of integrated nutrient management on yield attributing characters and yield of uredbean

Treatment	Yield attributing character					
	Number of pods plant^{-1}	Number of seed pod^{-1}	Test weight (g)	Biological yield (kg ha^{-1})	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1	25.22	5.16	36.59	2576	704	1872
T_2	37.60	6.45	40.71	2975	950	2025
T_3	38.69	6.71	39.82	3013	982	2031
T_4	32.55	6.36	37.89	2884	878	2006
T_5	31.21	6.33	39.49	2845	833	2012
T_6	41.38	7.51	42.72	3212	1092	2120
T_7	41.27	7.32	42.15	3198	1084	2114
T_8	33.60	6.38	40.42	2906	909	1997
T_9	42.92	7.62	42.89	3304	1158	2146
SEm ±	0.62	0.24	0.69	55.15	35.13	37.79
CD (P=0.05)	1.85	0.72	2.07	165.35	105.32	113.30

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