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Growth, phenology and yield of rice bean [*Vigna umbellate*] (Thunb.) Ohwi & Ohashi] genotypes under various levels of nitrogen

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Abstract
A field experiment was conducted at the instructional farm by All India Co-ordinated Research Network on Potential crops project under Odisha University of Agriculture and Technology, Bhubaneswar during kharif season of 2016 to study the response of promising rice bean (*Vigna umbellata*) (Thunb.) Ohwi & Ohashi [Fabaceae] genotypes in different levels of nitrogen in a sandy loam soil with pH 5.46, available nitrogen 230 kg/ha, available phosphorus 30.8 kg/ha (Bray's Method) and available potash 180.3 kg/ha. The treatment combination were six varieties in the main plot (RBL01, RBL06, RBL35, Phulbani Local, BRB05, BRBM102) and four levels of nitrogen (0, 20, 40 and 60 kg N.ha^{-1}**)** in the sub-plot, They were tested in a split plot design with three replications.
The variety BRBM 102 recorded highest seed yield (790.08 kg^{-1}) followed by Phulbani Local (785.4 kg.ha^{-1}). Application of successive doses of nitrogen up to 40 kg/ha produced maximum seed yield of 865.06kg.ha^{-1} and stover yield of 2231.6 kg.ha^{-1}.Seed yield increased by 20.7, 39.7 and 49.6% with application of 40 kg N.ha^{-1} over 20, 60 and 0 kg N/ha respectively. The Variety BRBM102 recorded maximum value in plant height of 111. 81cm,number of branches per plant (3.4), dry matter accumulation per plant(15.47g), root length (29.57cm), number of nodules per plant (15.33) and yield attributing characters like more number clusters per plant (17.18), pods per plant (61.38) and number of seeds per plant (8.00).Irrespective of varieties application of 40 kg Nha^{-1} favorably influenced the growth, yield and yield attributes.

Keywords: nitrogen levels, rice bean genotypes, growth, phenology and yield

Introduction
Pulses are rich in protein which form an important constituent of human diet. It provides more calcium and phosphorus than cereals along with amino acid like thiamine, niacin and riboflavin. Pulses are the main sources of protein in majority of Indian population who are vegetarian in habit. By and large 15% of the dietary protein is met from pulses in India as compared to 9% in Asia and 7% in the world
Rice bean is a fast summer-growing legume found from sea level up to altitudes of 1500 m in Assam and 2000 m in the hills of the Himalayas (Khadka *et al*., 2009) [4]. Rice bean requires a short day length to produce seeds. It is grown on a wide range of soils, including shallow, infertile or degraded soils.
India is producing 14.76 million tons of pulses from an area of 23.63 million hectare with a productivity of 650 kg/ha and is the largest pulses producing country in the world. The corresponding figures for the state of Odisha are 1.62m ha, 0.65mt and 403 kg ha^{-1}respectively (Directorate of Agricultural Statistics and Economics of Odisha, 2016-17). It is estimated that about 2-3 million tons of pulses are imported annually to meet the domestic consumption requirement. Thus, there is a great need to increase production and productivity of pulses in our country by more intensive interventions.
Variety plays an important role in enhancing the productivity of crops. The rice bean varieties that are under cultivation presently have an advantage of good yield potential. Hence an attempt was made to evaluate the recently developed high yielding superior genotypes to exploit the higher yield potential at various levels of nitrogen.

Materials and Methods
An experiment was conducted in the instructional farm by All India Co-ordinated Research Network (AICRN) on Potential Crops, Bhubaneswar under Odisha University of Agriculture

and Technology during the *Kharif* 2016 to study the response of rice bean genotype in different levels of nitrogen. The experimental design was split-plot with three replications. The experiment comprised of 24 treatment combinations with main-plot [Variety]:RBL1, RBL6, RBL35 Phulbani Local, BRB5, BRBM102] and sub-plot [Fertilizer N Kg/ha]: Control (No nitrogen), 20, 40 and 60 kg/ha of N and 40kg/ha of P and 20kg/ha of K was applied to all plots. Half of the nitrogen and full dose of phosphate (40kg/ha) and potash (20 kg/ha) were applied as basal and the rest of nitrogen was given as top dressing at 25 days after sowing followed by earthing up operations. The experiment was sown on 22.07.2016.The soil of the experimental site was sandy loam with medium levels of organic matter (0.67%), low in available nitrogen (230 Kg/ha) and medium in both available phosphorus (30.8 Kg/ha) and potassium (180.3 Kg/ha).The soil was acidic in reaction (pH 5.46). Recommended package of practices were followed for proper field management and observation on growth, yield attributes and yield were taken.

Results and Discussion

Variety RBL 01 recorded significantly the highest plant height (114.95 cm) among all the varieties at harvest. The increase in plant height of RBL 01 at harvest was higher than the varieties RBL 06, RBL 35, Phulbani local, BRB 05, BRBM 102 respectively. The initial rate of increase in plant height was rapid (64.39%), (30 – 45 DAS) and moderate between 45 – 60 days after sowing (DAS) and decreased thereafter. The maximum plant height of RBL 01 could be attributed to its genetic potentiality. The wide variation in plant height in different varieties of rice bean has been reported by Baishak (1992) [2] and OUAT, AICRN on UU crops (2003) [1]. The increase in height with increased level of nitrogen might be due to adequate nutrient supply at higher levels of nitrogen application. Similar results are also reported by NBPGR (2003) [1].

The no. of branches per plant increased rapidly up to 60 DAS and slowly thereafter. The variety BRB 05 and Variety BRBM 102 recorded the highest number of branches during different stages of growth. It produced the maximum (3.40) number of branches while the variety RBL01 recorded the lowest number of branches (2.99) at harvest. Increasing the N level increased the branch number at all the stages of growth. The maximum number of branches per plant was recorded at 75DAS with 60kg N ha^{-1}(3.58) while the lowest was recorded at 45 DAS in control (1.36).

Root length increased progressively from 30DAS to harvest. The variety BRB 05 recorded significantly the highest root length at all stages of crop growth followed by BRBM 102.The longest root was observed at harvest (32.11cm) with variety BRB05. RBL06 recorded the lowest root length of 25.22cm at harvest. Application of nitrogen increased the root length irrespective of crop growth stages up to harvest. The highest root length of 29.67cm was recorded with 40 kg $N.ha^{-1}$ where as increasing the nitrogen to 60 kg N ha^{-1} reduced the root length significantly. Root length was lowest in control treatment (no Nitrogen).Similar trend was observed in all stages of crop growth.

Maximum number of nodules per plant increased progressively up to 60 DAS and decreased thereafter. It was observed that variety RBL35 produced significantly the maximum number of nodules per plant (28.6) at 45 DAS. This was closely followed by the variety BRBM102.The variety RBL06 recorded the lowest number of nodules per plant (23.3). Increase in levels of nitrogen from 40 to 60 $kgha^{-1}$ decreased the number of nodules per plant. The highest number of nodules per plant (32.72) was recorded at 45 DAS with 40 $kgN.ha^{-1}$ but at 60 kg Nha^{-1} the nodule number per plant was decreased (28.1).A similar trend was observed with the later stages of crop growth. This might be due to the fact that the bacteria rhizobium species could not have tolerated high concentration of nitrogen resulting in lower nodulation (Raggio and Raggio, 1962) [13].

Dry matter accumulation increased progressively up to 75 DAS and slowly from 75 DAS to harvest. The variety RBL 35 also recorded the maximum dry weight per plant (16.12) among the varieties tested. The variety BRBM 102 recorded highest grain yield of 790.0 kg ha^{-1} with a corresponding highest harvest index of 29.50%. Wide variation in dry matter production among different genotypes were also reported by Dwivedi (1997) [6], Mandal and Mukherjee (1999) [11].

Daily accumulation of dry matter of unit area is an indicator of crop growth. It was revealed that the crop growth rate (CGR) increased up to 60 - 75 days in all the varieties and thereafter declined. The variety RBL35 recorded higher CGR (15.69) than other varieties followed by variety Phulbani Local (15.68) during 60 - 75 DAS. Variety RBL06 recorded the lowest CGR (15.55) at all stages of crop growth. The maximum CGR (21.55) was registered with 60 kg N ha^{-1} at 60 DAS followed by 40 kg N ha^{-1} (17.52).

Relative growth rate (RGR) was affected by variety and N and a progressive decreases in RGR value with respect to time. It was higher at initial stage, which decreased towards harvest. It was observed that the highest RGR was recorded during 30-45 DAS irrespective of varieties. Between 30-45 DAS, the variety RBL-06 recorded the highest RGR (89.79). Increasing the N levels increased the RGR value. It was highest with application of 60 kg N ha^{-1} at all stages of crop growth. Lowest RGR was observed in control treatment (81.38).

Variety BRBM102 recorded highest number of clusters per plant (18.46) followed by variety Phulbani Local (18.10).Variety RBL06 recorded significantly lowest number of clusters per plant (17.07). There was significant increase in no. of clusters with increase in levels of N up to 40 kg Nha^{-1} 21.85. Increase in level of N up to 60 N ha^{-1} decreased the number of clusters per plant. The minimum number of clusters per plant 12.79 was recorded in control.

Number of pods per cluster increased significantly by application of nitrogen and also differ among the varieties. Variety BRB 05 recorded significantly the maximum number of pods per cluster (3.63) followed by variety BRBM102. Variety RBL01 recorded the lowest number of pods per cluster (3.40). Application of nitrogen had a positive influence on number of pods per cluster. The highest number of pods per cluster was produced with application of 40 kg N ha^{-1} 3.98, which was significantly superior to the other levels of nitrogen tested.

The number of pods per plant were affected by variety and nitrogen. It is evident from the data that the varieties differed significantly among themselves with respect to number of pods per plant. The variety BRB05 recorded significantly the maximum no. of pods per plant (67.29) followed by Phulbani Local (66.27). Application of nitrogen increased the number of pods per plant as compared to control. The maximum pods per plant (86.40) was recorded with 40 kg N/ha which decreased by 5.8 per cent with application of 60 kg N/ha.

Number of seeds per pod were affected by different varieties and nitrogen levels. Among the varieties BRBM102 recorded maximum number of seeds per pod (8.00) followed by variety

BRB05 (7.74). The lowest no. of seeds per pod was obtained with the variety RBL01. (7.74) Application of nitrogen increased the number of seeds per pod. The maximum number of seeds per pod was found with 40 kg N/ha (8.19) followed by 20 kg N / ha (7.44).

Application of 40 kg N/ha recorded significantly the highest seed yield (865.06 kg/ha) followed by 60 kg N/ha (808.83 kg/ha). Yield advantage of 40 kg N/ha was to the tune of 49.6 per cent were recorded as compared to control. Higher seed yield of 40 kg N/ha could be due to better utilization of nitrogen at this level. Application of 40 kg N/ha resulted in higher number of cluster per plant, pods per plant and seeds per pod. Similar results have also been reported by Mohapatra *et al.* (1996) [12], Behera and Mishra (1997) [3], Malick *et al.* (1999) [9] and NBPGR (2003) [10]. Application of 60 kg N/ha decreased seed yield by 6.9 per cent than that of the yield obtained at 40 kg N/ha. Decreased in seed yield with 60 kg N/ha was also reported by Mishra *et al.* (1996) [8].

The variety BRBM 102 at 40 kg N/ha recorded the highest seed yield of 865.06 kg/ha which might be due to its yield potential of the variety to record higher yield under this level of nitrogen. Maximum stover yield of 2231.6 kg/ha was recorded with 40 kg N/ha which remained at par with the stover yield of 2226.6 kg/ha recorded at 60 kg N/ha. The increase in stover yield at 40 and 60 kg N/ha could be due to more vegetative growth as nitrogen accelerates the process of cell division and cell enlargement resulting in higher biomass production. It was in confirmation with the findings of Behera and Mishra (1997) [3], Khanda *et al*. (1999) [7]. Application of 40 kg N/ha increased the harvest index than 20 kg and 60 kg N/ha. These results are infirmity with the earlier findings of Khanda *et al.* (1999) [7].

The yield attributes such as number of pods per cluster, pods per plant and seeds per pod were increased significantly up to 40 kg N/ha. Further increase in nitrogen level decreased the value of these yield attributing characters. These results are in conformity with the findings of Mohapatra *et al.* (1996) [12].

Conclusion

Ricebean genotype BRBM102 produced the highest seed yield (790.08 $kgha^{-1}$).It was followed by the variety Phulbani Local (785.42 $kgha^{-1}$). It also recorded recorded maximum value in plant height, number of branches per plant, dry matter accumulation per plant, root length, number of nodules per plant and yield attributing characters like more number of clusters per plant, pods per plant and number seeds per pod. Irrespective of varieties, application of 40 kg N ha^{-1} favorably influenced the growth, yield and yield attributes.

Table 1: Mean plant height, LAI, number of nodules, dry matter accumulation, root length, CGR & RGR of ric ebean as influenced by variety and nitrogen during different stages of growth.

Genotypes	Plant height in cm at harvest	No. of branches per plant at harvest	No. of Nodules plant^{-1} at 75DAS	Dry Matter accumulation (gm/plant) at harvest	Root length in cm	CGR(gm^{-2}/day) at 60 DAS	RGR(gm$^{-2/}$day) at 30 DAS
V1(RBL01)	114.95	2.99	13.00	15.57	28.18	15.62	89.07
V2(RBL06)	111.20	3.14	10.58	15.67	25.22	15.55	89.79
V3(RBL35)	114.55	3.39	13.67	16.12	29.34	15.69	86.48
V4(PHUBANI.L)	112.45	3.17	12.67	14.34	26.06	15.68	89.57
V5(BRB05)	112.53	3.40	16.75	15.59	32.11	15.61	87.55
V6(BRBM102)	111.81	3.40	15.33	15.47	29.57	15.64	89.02
SE m ±	0.009	0.004	0.60	0.07	4.326	0.004	0.009
CD(P=0.05)	0.020	0.009	1.88	0.23	9.428	0.010	0.021
Nitrogen(kg/ha)							
No(Control)	109.16	2.77	10.00	9.69	27.41	9.68	81.38
N1(20Kg/ha)	112.34	3.14	13.22	14.57	27.62	13.78	87.57
N2(40Kg/ha)	114.76	3.50	15.78	17.62	29.67	17.52	91.53
N3(60Kg/ha)	115.39	3.58	15.67	20.33	28.96	21.55	93.83
SE m ±	0.008	0.003	0.77	0.06	0.004	0.005	0.011
CD(P=0.05)	0.024	0.006	2.22	0.16	0.007	0.009	0.023

Table 2: Mean no. of clusters/plant, pods/cluster, pods/plant & seed per pod at harvest of rice bean as influenced by variety and nitrogen

Genotypes	Cluster/plant	Pods/cluster	Pods/plant	Seeds/pod
V1(RBL01)	17.56	3.40	61.40	7.44
V2(RBL06)	17.07	3.56	61.10	7.60
V3(RBL35)	17.76	3.43	61.64	7.72
V4(PHUBANI.L)	18.30	3.56	66.27	7.56
V5(BRB05)	17.18	3.63	67.29	7.74
V6(BRBM102)	18.46	3.61	61.38	8.00
SE m ±	0.041	0.023	0.061	0.013
CD(P=0.05)	0.092	0.052	0.136	0.028
No(Control)	12.79	2.81	35.20	6.90
N1(20Kg/ha)	15.75	3.58	54.58	7.74
N2(40Kg/ha)	21.85	3.98	86.40	8.19
N3(60Kg/ha)	20.50	3.76	76.53	7.88
SE m ±	0.025	0.030	0.039	0.043
CD(P=0.05)	0.050	0.062	0.079	0.087

Table 3: Seed yield, Stover yield and Harvest index of rice bean as influenced by variety and nitrogen

Genotypes	Seed yield(kg/ha)	Stover yield (kg/ha)	Harvest Index (%)
V1(RBL01)	702.08	1941.42	26.56
V2(RBL06)	717.00	1882.25	27.59
V3(RBL35)	715.92	1940.92	26.94
V4(PHUBANI.L)	785.42	1853.58	29.76
V5(BRB05)	715.00	1926.83	27.06
V6(BRBM102)	790.08	1887.92	29.50
SE m ±	2.501	1.170	0.040
CD(P=0.05)	5.572	2.607	0.089
Nitrogen(kg/ha)			
No(Control)	578.22	1620.17	26.30
N1(20Kg/ha)	698.22	1943.56	26.42
N2(40Kg/ha)	865.06	2231.61	27.93
N3(60Kg/ha)	808.83	2226.61	26.46
SE m ±	3.731	5.485	0.056
CD(P=0.05)	7.566	11.124	0.115

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