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Effect of Integrated Nitrogen Management on Productivity and Available Nutrient Status in Soil after Harvest of Dwarf Ricebean (*Vigna Umbellata*) under Rainfed Condition

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Abstract: Rice bean [*Vigna umbellata* (Thunb.), previously *Phaseolus calcaratus* is a non-conventional and underutilized bean. All the parameters like nodulation, yield, quality of dwarf rice bean was highest with application of 30 Kg N/ha (Urea)+ VC @5 t/ha + Neem@75Kg/ha which was statistically at par with 20 kg N/ha (Urea) + VC @ 5 t/ha + Neem@75kg/ha. Available nutrient status in soil after harvest was also highest in 30 Kg N/ha (Urea)+ VC @5 t/ha + Neem@75Kg/ha. Minimum was in VC @2.5 t/ha + Neem@50kg/ha.

Keywords: Integrated nitrogen management, Neem, Rice bean, Urea, Vermicompost.

Rice bean [*Vigna umbellata* (Thunb.) is a warm-season annual vine legume with yellow flowers and small edible beans. It belongs to the family Leguminosae, sub family Papilionaceous. Grown mainly for its beans, it is equally important as vegetable (green pod), fodder and folk medicine. A lesser-known pulse among the Asiatic *Vigna*, has long been considered as a food security crop of small and marginal farmers of Southeast Asia. Considered as a nutritionally rich food and fodder, is also a source of genes for biotic and abiotic stress tolerance including drought, soil acidity and storage pest. Despite of being a high-yielding nutritionally rich crop majority of its germplasm accessions and varieties suffers from many undesirable attributes, including asynchronous and late maturity, indeterminate growth habit, high pod dehiscence and seed shattering habit, and enhanced level of a few anti-nutritional components as compared to other major food legumes resulting underutilization of this crop.

In the year 2019-20 India produced 23.03 million tons of total pulses (Anonymous 2021). By 2050, the domestic requirements would be 26.50 million tons, necessitating stepping up production (Singh et al 2015). Efficient nutrient management is required to harness the maximum yield of the crop. Among the major nutrients, nitrogen is considered as one of the important nutrients required for optimum growth and development of the crop. The nitrogen which is supplied through inorganic fertilizers continuously will affect soil health and crop yield. Again, use of vermicompost or neem cake alone will result in poor yield of the crop as the nutrient content is less in manure. Therefore, integrated nutrient management seems an attractive option to improve soil health and crop yields (Sarwar et al 2021). Vermicompost contains nutrients in forms that are readily taken up by the plants, such as nitrates, exchangeable phosphorus and soluble potassium, calcium and magnesium. It also contains higher amount of humic acid and biologically active substances such as plant growth regulators. Integration of vermicompost with inorganic fertilization tend to increase the yield of black gram (Manivannan et al 2009). Neem Cake organic manure protects plant roots from nematodes, soil grubs and white ants probably due to its residual limoniid content. It also acts as a natural fertilizer with pesticidal properties. Neem cake also reduces alkalinity in soil, as it produces organic acids on decomposition. Being totally natural, it is compatible with soil microbes, improves the rhizosphere microflora and also enhances the fertility of the soil. Neem cake improves the organic matter of the soil, which helps to improve soil texture, water holding capacity, and soil aeration for better root development (Lalnunpui et al 2018).

Organic and inorganic fertilizers are applied in combination to fulfil the crop nutrient requirements in integrated nutrient management. Combined use of organic and inorganic resulted in better growth associated with increased availability of nutrients resulted in better development of yield attributes (De et al 2011). Integrated nutrient management exerts positive impact on biological, physical and chemical properties of soil. Limited work has been done on these aspects in dwarf rice bean. Hence, the present investigation was done in order to study the effect of integrated nitrogen management on nodulation, yield, quality and available nutrient status in soil after harvest of dwarf rice bean.

MATERIAL AND METHODS

A field experiment was conducted at the Agronomy field, College of Agriculture, Central Agricultural University, Imphal during the *kharif* season of 2021. The experimental site is located at $24^0$45' N latitude and $93^0$54' E longitude and at an altitude of 774 meters above mean sea level. This site falls under the Eastern Himalayan Region (II) and the agroclimatic zone Subtropical Zone (NEH-4) of the state of Manipur.

The chemical analysis of soil showed that the soil is clay in texture and medium in available N (260.51 Kg/ha), Available P_2O_5 (26.10 Kg/ha) and available K_2O (232.31 Kg/ha). The experiment was conducted laid out in a Randomized Block Design consisting of eight treatments replicated thrice. The treatments were T_1: 10 kg N/ha (Urea) + VC @ 2.5 t/ha + Neem @ 50kg/ha, T_2: 10 kg N/ha (Urea) + VC @ 5 t/ha + Neem @ 75kg/ha, T_3: 20 kg N/ha (Urea) + VC @2.5 t/ha + Neem @ 50 kg/ha, T_4: 20 kg N/ha (Urea) + VC @ 5 t/ha + Neem @ 75kg/ha, T_5: 30 kg N/ha (Urea) + VC @ 2.5 t/ha + Neem @ 50kg/ha, T_6: 30 Kg N/ha (Urea)+ VC @ 5 t/ha + Neem @ 75Kg/ha, T_7: VC @ 2.5 t/ha + Neem @ 50kg/ha and T_8: VC @ 5 t/ha + Neem @ 75kg/ha. Rice bean (Local Variety) was sown in line, with the recommended spacing of 60 cm line to line and 20 cm plant to plant on 13 th July, 2021 with seed rate of 15 Kg/ha. The gross experimental area was 223.2 m^2. All of the plots received the recommended dose of fertilizer 60:20 kg PK/ha, applied uniformly in the form of single super phosphate and muriate of potash respectively. In addition to that nitrogen through urea, vermicompost and neem were also applied as per treatments. Just before application, the necessary amount of organic manures and fertilizers were individually weighed. After this all the fertilizers and organic manures of each plot were applied in the form of a continuous band in furrows and were mixed with soil. Data recorded were on nodulation like number of nodules, fresh and dry weight of nodules, yield attributes like number of pods per plant, number of seed per pod, number of seeds per plant and test weight, yield parameters like grain yield (q/ha), stover yield (q/ha) and harvest index (%), quality parameters like crude protein content in seed (%), crude protein yield (Kg/ha) and post-harvest nutrient status. Nodulation recorded 3 times at 60, 90 DAS and at harvest. Whereas, yield, yield attributes, quality and post-harvest nutrient status were recorded at harvest. Data obtained on various variables were analyzed by analysis of variance technique. The level of significance of the different sources of variation was tested by use of F test at 5% critical difference (CD) value.

RESULTS AND DISCUSSION

Nodulation: The number of root nodules per plant, fresh weight of root nodules, and dry weight of root nodules increased up to 90 DAS and thereafter declining till harvest (Table 1 and 2). This might be due to autoregulation of nodulation (AON), which causes disintegration of root nodules post-flowering stage (Downie, 2014). T_6 treatment, followed by T_4, recorded the highest number of root nodules per plant, fresh weight of root nodules, and dry weight of root nodules at all stages of sampling and T_7 recorded the least. This may be attributed to the higher level of inorganic fertilization in T_6, which may have stimulated nodule formation. The carbon and nitrogen in organic manure could be easily used as energy and nutrient sources for soil microorganisms, and this might increase the number of nodules too (Basu et al 2008). These results are supported by the findings of Meena et al (2014), Devi et al (2016), Raj et al (2019) and Pratap et al (2020).

Table 1. Number of nodules and Fresh weight of nodules of dwarf rice bean as influenced by integrated nitrogen management

Treatments	Number of nodules			Fresh weight of nodules (g)		
	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest
T_1	174.67	304.97	52.67	1.09	2.66	0.60
T_2	180.33*	310.90*	55.33	1.33	2.91*	0.90
T_3	176.23	306.67	53.33	1.18	2.70	0.70
T_4	182.67*	312.33*	56.60*	1.42*	3.00*	1.05*
T_5	178.80*	308.67	54.77	1.23	2.84*	0.80
T_6	184.33	314.67	57.40	1.55	3.12	1.13
T_7	167.33	297.33	48.73	0.60	2.20	0.27
T_8	173.33	303.67	51.33	0.91	2.53	0.50
CD (p=0.05)	6.46	5.46	1.81	0.18	0.36	0.22

*On par with highest treatment

Yield and yield attributes: Yield attributes like pods per plant, number of seeds per pod, and number of seeds per plant were significantly influenced by different treatments. T_6 recorded the highest, followed by T_4 and T_7 recorded the least. Profuse nodulation might lead to increased nitrogen fixation, which might in turn have a beneficial effect on the photosynthetic activity of plants. This might be attributed to the larger availability of stored photo assimilates that are translocated towards the development of reproductive organs. The 100 seed weight was maximum in T_6 followed by T_4, T_2, and T_5. This may be due to the greater accumulation and translocation of photosynthates from source to sink, which might have resulted in slightly bolder seeds. These results are in consonance with the findings of Kamal et al (2021) and Biswash et al (2014). Similar pattern was also observed in the grain yield, straw yield, and harvest index. This might be due to the cumulative effect of yield attributes on account of increased growth, which was due to higher biomass accumulation during the vegetative phase leading to increased bearing capacity, which ultimately increased yield parameters. Similar findings were also reported by Khan et al (2013) and Banotra et al (2021) . Similarly, harvest index also recorded the highest in T_6, and did not differ significantly from other treatments. T_7 significantly recorded the lowest harvest index. These results were in conformity with the findings of and Dhakal et al (2015) and Kamal et al (2021)

Biochemical analysis: The crude protein content of dwarf rice bean seed was highest by T_6, which was statistically at par with T_4 (Table 3). This could be due to increased nitrogen fixation by the bacteria, which in turn improved the absorption and utilization of nitrogen and enhanced the activity of nitrate reductase, which plays a very significant role in the synthesis of proteins in seeds. The findings of Dhakal et al (2015), Chauhan et al (2016), and Banotra et al (2021) support these conclusions. Due to the accumulation of greater crude protein content in seeds along with a higher seed yield, crude protein yield followed similar trend. Devi et al 2021 also found a similar result.

Post-harvest nutrient status: The T_6 recorded the highest

Table 2. Dry weight of nodules per plant and yield attributes of dwarf rice bean as influenced by integrated nitrogen management

Treatments	Dry weight of nodules per plant (g)			Yield attributes			
	60 DAS	90 DAS	At harvest	Pods/plant	Seeds/pod	Seeds/plant	100 seed weight (g)
T_1	0.36 (0.93)	1.68	0.09 (0.77)	58.90	6.77	398.56	19.60
T_2	0.68 (1.08)*	1.90*	0.39 (0.94)	64.10	7.30	468.48	20.24*
T_3	0.40 (0.95)	1.73	0.18 (0.83)	60.89	6.97	424.20	19.87
T_4	0.73 (1.11)*	2.00*	0.44 (0.97)*	66.90*	7.57*	506.21*	20.43*
T_5	0.59 (1.04)*	1.80	0.25 (0.87)	62.80	7.17	449.79	20.02*
T_6	0.80 (1.14)	2.10	0.52 (1.01)	68.27	7.78	531.17	20.64
T_7	0.08 (0.76)	1.28	0.05 (0.74)	51.00	6.00	306.03	18.90
T_8	0.25 (0.86)	1.51	0.08 (0.76)	57.53	6.57	377.57	19.50
CD (p=0.05)	0.10	0.26	0.06	4.12	0.41	43.32	0.70

*On par with highest treatment

Table 3. Yield, quality parameters and post-harvest nutrient status of dwarf rice bean as influenced by integrated nitrogen management

Treatments	Yield (q/ha)			Quality parameters		Post-harvest nutrient status (Kg/ha)		
	Grain yield	Stover yield	Harvest Index	Crude protein content (%)	Crude protein yield (kg/ha)	N	P_2O_5	K_2O
T_1	16.27	33.93	32.41	19.53	317.77	279.52	28.77*	266.20
T_2	18.5	36.60*	33.57	21.00	388.51	309.42	33.90*	277.98*
T_3	17.37	34.63	33.40	20.07	348.48	292.69	29.73*	267.50
T_4	19.43*	37.77*	33.98	21.50*	417.74*	317.60	34.53*	278.80*
T_5	18.00	35.33	33.83	20.50	368.94	326.14*	30.90*	268.13
T_6	20.10	38.27	34.45	22.03	443.22	342.87	35.83	279.52
T_7	12.27	29.87	29.23	17.57	215.48	240.75	27.37	267.37
T_8	14.5	32.57	30.80	19.07	276.26	253.24	32.64*	276.71*
CD (p=0.05)	1.05	2.80	2.47	0.66	26.01	22.56	0.96	3.86

*On par with highest treatment

Available Nitrogen which was found to be statistically at par with T_5 (Table 3). The lowest Available Nitrogen (kg/ha) was recorded in T_7. Similarly, the highest Available Phosphorus was recorded in T_6 and it was followed by T_4, T_2, T_8, T_5, T_3, T_1 and the lowest Available Phosphorus was recorded in T_7. Likewise, highest Available Potassium was recorded in T_6 and it was at par with T_4, T_2 and T_8 and the lowest Available potassium was recorded in T_7. Vermicompost contains appreciable amount of nutrients with in deal pH range, which may have contributed to their elevated status in the soil following harvest. Additionally, formation of organic acids by vermicompost had a beneficial influence on the characteristics of the soil and the mineralization of phosphorus, potassium, and nitrogen through leaf fall and rhizodeposition, legume crops contribute a significant quantity of organic residues to the soil. The intermediate acids created during the decomposition of organic residues also solubilize fixed forms of phosphorus and nitrogen, increasing the amounts of these nutrients. The findings of Meena et al (2015), Kanwar et al (2017) and Jat et al (2008) confirm these conclusions.

CONCLUSION

The application of 30 Kg N/ha (Urea)+ VC @5 t/ha + Neem @ 75 Kg/ha performed better in all parameters like nodulation, yield and yield attributes, quality and post-harvest nutrient status after harvest when compared to other treatments, but 20 kg N/ha (Urea) + VC @ 5 t/ha + Neem @ 75 kg/ha was statistically on par. Application of 20 kg N/ha (Urea) + VC @ 5 t/ha + Neem @ 75 kg/ha is recommended for farmers because of its potential to achieve equivalent benefits compared to highest treatment in addition to this, can reduce quantity of inputs applied which in turn decreases cost of production.

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