The Pharma Innovation Journal 2022; 11(11): 959-962

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(11): 959-962

www.thepharmajournal.com
Received: 06-07-2022
Accepted: 04-10-2022

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Effect of integrated nutrient management on growth and yield of dolichos bean (*Lablab purpureus*)

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Abstract
An experiment entitled "Integrated nutrient management in dolichos bean (*Lablab purpureus*)" was conducted during the months of June-October 2020, at the Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat-13 with the objective to study the effect of integrated nutrient management on growth and yield of dolichos bean. The experiment was laid out in Randomized Block Design with seven treatments which were replicated three times. The treatments were T_1: RDF (30: 40: 20 kg ha^{-1} NPK) + FYM @ 10t ha^{-1}, T_2: 50 % RD of NPK + Microbial consortium as seed coat + Vermicompost @ 1t ha^{-1}, T_3: 25% RD of NPK + Microbial consortium as seed coat + Vermicompost @ 2t ha^{-1}, T_4: 50 % RD of NPK + Enriched Vermicompost @ 1t ha^{-1}, T_5: 25 % RD of NPK + Enriched Vermicompost @ 2t ha^{-1}, T_6: 50 % RD of NPK + Microbial consortium as seed coat + FYM @ 5t ha^{-1}, T_7: 25 % RD of NPK + Microbial consortium as seed coat + FYM @ 10t ha^{-1}. Among the different treatments, significantly superior results in terms of growth and yield attributes of dolichos bean were obtained in treatment T_2 (50 % RD of NPK + Microbial consortium as seed coat + Vermicompost @ 1t ha^{-1}) which was followed by treatment T_4 (50 % RD of NPK + Enriched Vermicompost @ 1t ha^{-1}).

Keywords: Dolichos bean, enriched Vermicompost, microbial consortium, NPK, Vermicompost

Introduction
The dolichos bean (*Lablab purpureus* L.) belongs to the family Fabaceae. It occupies a unique position as vegetable among the legume crops due to its high nutritive value (Basu *et al.*, 2002) [3]. Dolichos bean is a multipurpose crop grown for its green pods as vegetable, seeds as pulse and also for fodder purposes. Dolichos bean is nutrient rich crop and also have various medicinal properties. The fresh green pods are good source of digestible vegetable protein (20-25%) required for human health, it is considered as a poor man's bean (Joshi and Rahevar, 2015) [8].

India ranks fourth among major beans producing countries in the world and which are grown over 0.23 million hectares area and production was around 2.34 million metric tonnes (NHB, 2017-2018) [13]. Within India, this crop is mostly cultivated in Karnataka and some districts of Tamil Nadu and Maharashtra. In Assam, cultivation of dolichos bean is limited, mainly utilized for subsistence use. Low productivity of this crop is mainly attributed to inadequate nutrient management practices. If the crop is managed properly, green pods can be produced continuously for several months. Long term use of chemical fertilizers deteriorates soil health and reduces the crop productivity. Use of chemical, organic and bio fertilizers inputs may increase the productivity of dolichos bean, improve soil fertility and reduce the cost of production (Gandhi and Sivakumar, 2010) [6].

Application of organic manures like farm yard manure and vermicompost significantly increase the availability of nitrogen, phosphorus and potassium to the plants and also add other macro and micro nutrients like Ca, Mg, Fe, S, Mn to the soil and increase the soil fertility (Ullasa *et al.*, 2018) [18]. Addition of organic matter decreases bulk density and increase the porosity of soil which increases water holding capacity of soil. This facilitates the ideal conditions for the growth of plants and activity of microorganisms. Bio fertilizers like *Azotobacter*, *Rhizobium* and *Azospirillum* fix atmospheric nitrogen which becomes readily available to crop and contribute to increased crop yield (Neha *et al.*, 2021) [12]. Phosphorus solubilising bacteria helps in solubilisation and mineralization of phosphorus in the soil. Microorganisms release plant growth substances like auxins, gibberellins, cytokines, which contribute to the increase in plant growth (Lal and Kumar, 2016; Ananth and Kumar, 2018) [11, 2]. Further, consortium of bio fertilizer maintains diversity in agricultural ecosystems (Akram *et al.*, 2014) [1].

Integrated nutrient management system has become an advanced approach over conventional way of cultivation to increase the growth and yield of vegetable crops. With the above view, an experiment was conducted to study the effect of integrated application of inorganic, organic and bio-fertilizers on growth and yield of dolichos bean.

Materials and Methods

The experiment was conducted during the months of June-October 2020, at the Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat-13. The representative soil samples were collected from the top soil of six random spots up to the depth of 0-30 cm. The experiment was laid out in Randomized Block Design with seven treatments which were replicated three times. The treatments were T_1: RDF (30:40: 20 kg ha^{-1} NPK) + FYM @ 10 t ha^{-1}, T_2: 50 % RD of NPK + Microbial consortium as seed coat + Vermicompost @ 1t ha^{-1}, T_3: 25 % RD of NPK + Microbial consortium as seed coat + Vermicompost @ 2 t ha^{-1}, T_4: 50 % RD of NPK + Enriched Vermicompost @ 1 t ha^{-1}, T_5: 25 % RD of NPK + Enriched Vermicompost @ 2 t ha^{-1}, T_6: 50 % RD of NPK + Microbial consortium as seed coat + FYM @ 5t ha^{-1}, T_7: 25 % RD of NPK + Microbial consortium as seed coat + FYM @ 10 t ha^{-1}. Well rotten FYM, Vermicompost and Enriched Vermicompost were applied to different treatment plots before 10 days of sowing. Nitrogen was applied in the form of two equal splits *viz*. first dose at the time of sowing and second dose as top dressing at 30 days after sowing. Phosphorus and potassium were applied as basal dose through SSP and MOP respectively. Microbial consortium was applied by soaking the seeds in microbial consortium slurry for one hour which form coating on seeds when dried in shade. The soil of experimental site was sandy loam soil, acidic in nature with a pH of 5.40 and low in available nitrogen, phosphorus and potassium (212.70 kg ha^{-1} N, 31.51 kg ha^{-1} P_2O_5 and 114.00 kg ha^{-1} K_2O respectively). Seeds of Arka Jay variety of dolichos bean were sown on 20th June 2020. A plant spacing of 60 cm x 30 cm was followed in a plot of 2.5 m x 1.4 m dimension.

The growth parameters *viz*. plant height, number of leaves per plant, number of branches per plant, leaf area index, total chlorophyll in fresh leaf tissue and yield parameter like days to first flowering and fruiting, pods per plant, pod length, pod width, pod weight, pod yield per plant, pod yield per hectare and harvest index were recorded and the data were statistically analysed by adopting the standard procedure of Panse and Sukhatme (1985) [14] and using OPSTAT software. Wherever, the results were found significant, critical differences (CD) were computed at 5 per cent level of significance to draw statistical conclusions.

Results and Discussion

Plant Height: As presented in the Table 1, it is apparent that the measured plant height of dolichos bean plants has significantly responded to the applied treatments. The highest plant height of 85.20 cm was found in T_2 (50 % RD of NPK + Microbial consortium as seed coat + Vermicompost 1t ha^{-1}). The increased plant height may be attributed to the effect of integrated use of organic, inorganic and bio fertilizer which created nutrient rich environment in soil and facilitate the availability of nutrients to the plants. The inoculation of microbial consortium to seeds enhances early formation of nodules in the plants which contributed to the fixation of atmospheric nitrogen (Akram *et al*., 2014) [1]. The results were in accordance with Ananth and Kumar (2018) [2] who observed enhancement in plant height due to the application of Vermicompost along with inorganic and bio fertilizers.

Branches per plant: Results revealed that the highest number of branches (8.27) was found in T_2 (50 % RD of NPK + Microbial consortium as seed coat + Vermicompost 1t ha^{-1}) followed by T_4 (7.67) and T_6 (7.00). It may be concluded that the significant increase in number of branches may be due to the integrated use of various fertilizer sources which supply the nutrients in available form (Gandhi and Sivakumar, 2010) [6].

Number of leaves per plant: The maximum number of leaves with mean value of (60.67) was found in T_2 (50 % RD of NPK + Microbial consortium as seed coat + Vermicompost 1 t ha^{-1}) followed by T_4 (56.73) Vermicompost treatments compensated the reduced level of recommended dose of inorganic fertilizers. Additional supply of nutrients like Ca, Mg, Fe in adequate amount in available form from organic manures like Vermicompost, enriched Vermicompost increase plant growth, proliferation of root system and absorption of nutrients which contribute to the growth of the plants. These results were in harmony with those obtained by Ananth and Kumar (2018) [2].

Leaf area index: It is evident from the data presented in the Table 1, the highest leaf area index of 7.60 was observed in the T_2 (50 % RD of NPK + Microbial consortium as seed coat + Vermicompost 1 t ha^{-1}). The increase in leaf area index attributed to increased availability of nutrients over long periods from diverse sources of nutrients which have positive effect on growth of the plant. Nitrogen, being a constituent of protoplasm would increase cell division and multiplication while, potassium improves the photosynthetic activity and translocation of carbohydrates. The results were in accordance with the findings of Ananth and Kumar (2018); Tyagi and Singh (2019) [2, 17].

Total chlorophyll content: As represented in the Table 1, maximum amount of chlorophyll (2.30 mg g^{-1} leaf tissue) obtained in the treatment T_2 (50 % RD of NPK + Microbial consortium as seed coat + Vermicompost 1 t ha^{-1}) which was followed by T_4 (2.28 mg g^{-1} leaf tissue). High chlorophyll content may be attributed to the supply of Mg in adequate amount from the Vermicompost as Magnesium is the central element in chlorophyll structure. Organic manures also increase the antioxidant activity within plants which slow down the breakdown of chlorophyll. Higher doses of inorganic fertilizers decrease antioxidant activity. Adequate supply of nutrients found to increase the growth and chlorophyll content of leaves. These results are in close conformity with the findings of Ananth and Kumar (2018); Jaishankar and Manivannan (2018) [2, 7].

Days to first flowering and fruiting: It is apparent from the Table 2, maximum number of days for first flowering (47.07) and first fruiting (51.07) were taken in T_7 (25 % RD of NPK + Microbial consortium as seed coat + 10 t ha^{-1} FYM) from the date of sowing. The early flowering and fruiting was observed in T_2 (50 % RD of NPK + Microbial consortium as seed coat + Vermicompost 1 t ha^{-1}) which has taken 40.13 and 44.13

days to produce first flowering and fruiting on the plant from the date of sowing. It may be attributed to the early growth of plants which was obtained with the supply of nutrients by integrated approach. For flowering, plant should exhibit high C:N ratio which can be achieved when all the macro and micro nutrients are available to the plants. Initial supply of nutrients from inorganic fertilizers which are readily available to the plants and slow release of essential nutrients from organic manures *i.e*. Vermicompost, enriched Vermicompost and plant growth promoting substances from bio fertilizers enhance C:N ratio, early vegetative growth, early flowering and fruiting. The results obtained were in harmony with Esakkiammal *et al*. (2015); Kumar *et al.* (2017) and Ananth and Kumar (2018) [5, 9, 2].

Number of pods per plant: As evident from the Table 2, the number of pods per plant was significantly affected by different treatment. T_2 (50 % RD of NPK + Microbial consortium as seed coat + Vermicompost 1 t ha^{-1}) gave the highest number of pods (45.47). Availability of nutrient helps the plant to bear a greater number of flowers and reduce the chance of flower and fruit drop which results in high number of pods per plant. The results were in confirmation with Singh and Chauhan (2009); Desai *et al*. (2020); Kumar *et al*. (2021) and Sindhuja *et al*. (2021) [16, 4, 10, 15].

Table 1: Growth attributing characters of dolichos bean

Treatments	Plant height (cm)	Branches per plant	Leaves per plant	Leaf area index	Total chlorophyll Content (mg g^{-1} leaf tissue)
T_1: RDF (30:40:20 kg ha^{-1} NPK) + FYM (10t ha^{-1})	77.87	6.87	55.67	6.30	2.21
T_2: 50 % RD of NPK + MC (as seed coat) + VC (1t ha^{-1})	85.20	8.27	60.67	7.60	2.30
T_3: 25 % RD of NPK + MC (as seed coat) + VC (2t ha^{-1})	74.67	6.70	53.47	6.03	2.24
T_4: 50 % RD of NPK + Enriched Vermicompost (1t ha^{-1})	82.17	7.67	56.73	7.30	2.28
T_5: 25 % RD of NPK + Enriched Vermicompost (2t ha^{-1})	75.30	6.63	52.40	5.77	2.25
T_6: 50 % RD of NPK + MC (as seed coat) + FYM (5t ha^{-1})	78.03	7.00	56.30	6.31	2.27
T_7: 25 % RD of NPK + MC (as seed coat) + FYM (10t ha^{-1})	71.27	6.50	51.40	5.57	2.22
S.E.D (±)	1.47	0.42	1.13	0.28	0.07
CD (5 %)	3.22	0.91	2.47	0.63	0.15

RDF (Recommended dose of fertilizer), MC (Microbial consortium), VC (Vermicompost), FYM (Farm yard manure)

Pod length: As represented in the Table 2, length of the pods was significantly influenced by different treatments. Maximum length of the pod of 8.11 cm was observed in T_2 (50 % RD of NPK + Microbial consortium as seed coat + Vermicompost 1t ha^{-1}) which was followed by T_6 (7.65 cm). The higher length of the pods might be due to the synergistic effect of inorganic fertilizer and Vermicompost and incorporation of bio fertilizers in making available more of plant nutrients by improving the soil physical health and solubilizing the nutrients in soil. The increased vegetative growth, balance C: N ratio and increased accumulation of carbohydrates, in turn increased pod size. The results are in confirmation with Ananth and Kumar (2018); Jaishankar and Manivannan (2018) and Kumar *et al.* (2021) [2, 7, 10].

Pod Width: It was observed from the data Table 2 that the width of the pods was significantly affected by the different treatments. Maximum width of (1.54 cm) was observed in T_4 (50 % RD NPK + Enriched Vermicompost 1 t ha^{-1}) which were followed by T_2 (1.52 cm). The adequate supply of nutrients from the diverse nutrient sources may contribute to the increased pod size.

Pod weight: Weight of the pod was significantly influenced by different treatments as seen in Table 2. The treatment T_4 (50 % RD of NPK + Enriched Vermicompost 1t ha^{-1}) resulted in highest weight of the pod (4.22 g). Increased pod yield may be attributed to the availability and uptake of more plant nutrients which increased the plant growth, photosynthetic area and translocation of photosynthates resulting in increased pod weight. These results were in harmony with Jaishankar and Manivannan (2018) [8].

Pod yield per plant and pod yield per hectare: Pod yield was significantly affected by different treatments (Table 2). The treatment T_2 (50 % RD of NPK + Microbial consortium as seed coat + Vermicompost 1 t ha^{-1}), resulted in a significant increase in pod yield than other treatments for both per plant and per hectare basis (187.08 g $plant^{-1}$ and 10.33 t ha^{-1} respectively), which was followed by T_4 (183.33 g $plant^{-1}$ and 10.18 t ha^{-1}). Application of Vermicompost attributed to better growth of plant and yield by slow release of N, P, K for absorption and also supply additional essential nutrients like Ca, Mg, Fe, Mn and incorporation of bio fertilizers with Vermicompost supply plant growth regulators like gibberellins, cytokine's and auxins. Soil microbial biomass and enzyme activity improved as a result of Vermicompost addition, which favoured the total increase in plant produce as reported by Lal and Kumar (2016); Ananth and Kumar (2018) [11, 2]. Enhanced yield recorded in T_2 (50% RDF of NPK + Microbial consortium as seed coat + Vermicompost 1t ha^{-1}) might be due to better assimilation of nutrients by formation of photosynthetic elements and better partitioning into different parts of the plant which may have contributed to improved yield attributing characters like flowering, fruiting, number of pods, pod length and pod weight.

Harvest index: As evident from the Table 2, the maximum harvest index (37.26) was observed in T_2 (50 % RD of NPK + Microbial consortium as seed coat + Vermicompost 1t ha^{-1}) which was followed by T_4 (36.33), T_6 (35.54). With the increase in number of pods and weight of pods, harvest index also found to increase as harvest index represents the economic yield over total biological yield.

Table 2: Effect of integrated nutrient management on yield attributing characters and pod yield of dolichos bean

Treatments	Days to first flowering	Days to first fruiting	Pods Plant^{-1}	Pod Length (cm)	Pod Width (cm)	Pod weight (g)	Pod yield (g plant^{-1})	Pod yield (t ha^{-1})	Harvest Index
T_1: RDF (30:40:20 kg ha^{-1} NPK) + FYM (10t ha^{-1})	43.50	47.50	40.10	7.60	1.40	4.02	161.29	8.90	35.36
T_2: 50 % RD of NPK + MC (as seed coat) + VC (1t ha^{-1})	40.13	44.13	45.47	8.11	1.53	4.18	187.08	10.33	37.26
T_3: 25 % RD of NPK + MC (as seed coat) + VC (2t ha^{-1})	45.00	49.00	38.33	7.40	1.35	3.87	148.67	8.25	33.17
T_4: 50 % RD of NPK + Enriched Vermicompost (1t ha^{-1})	42.40	46.40	43.53	7.63	1.54	4.22	183.33	10.18	36.33
T_5: 25 % RD of NPK + Enriched Vermicompost (2t ha^{-1})	45.47	49.47	39.60	7.16	1.36	4.06	159.26	8.84	33.72
T_6: 50 % RD of NPK + MC (as seed coat) + FYM (5t ha^{-1})	43.40	47.40	40.50	7.65	1.41	4.10	165.67	9.20	35.54
T_7: 25 % RD of NPK + MC (as seed coat) + FYM (10t ha^{-1})	47.07	51.07	37.47	7.10	1.34	3.85	145.77	8.08	32.77
S.E.D (±)	1.25	1.24	0.91	0.07	0.03	0.11	3.62	0.20	2.53
CD (5%)	2.7	2.72	1.98	0.15	0.08	0.27	7.89	0.44	5.53

RDF (Recommended dose of fertilizer), MC (Microbial consortium), VC (Vermicompost), FYM (Farm yard manure)

Conclusion

The evaluation of the results from the present investigation revealed that integrated application of inorganic, organic and biofertilizers significantly increased the growth and yield of dolichos bean. Among the different treatments, the treatment T_2 [50 % RD of NPK (15:20:10 kg ha^{-1}) + Microbial consortium as seed coat + Vermicompost @ 1 t ha^{-1}] was found best in terms of growth and yield of dolichos bean.

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