

Original Research Article

Effect of integrated nutrient management on soil chemical and biological properties under dolichos bean cultivation

Abstract

A field experiment to study the effect of integrated nutrient management on soil chemical and biological properties under dolichos bean cultivation was conducted during the months of June-October 2020, at the Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat-13. The experiment was laid out in Randomized Block Design with seven treatments which were replicated three times. The results revealed that the maximum available nitrogen (372 kg ha^{-1}), phosphorus (47.13 kg ha^{-1}), potassium ($184.67 \text{ kg ha}^{-1}$) were observed in T_5 (25 % RD of NPK + Enriched Vermicompost @ 2 t ha^{-1}) and organic carbon (0.98 %) also found highest in T_5 (25 % RD of NPK + Enriched Vermicompost @ 2 t ha^{-1}). The microbial population, soil enzymes activity i.e dehydrogenase activity ($122.20 \mu\text{g TPF g}^{-1} \text{ soil } 24 \text{ hr}^{-1}$), phosphomonoesterase activity ($50.90 \mu\text{g p-nitrophenol g}^{-1} \text{ soil hr}^{-1}$) and soil microbial biomass carbon (SMBC) ($240 \mu\text{g g}^{-1} 24\text{hr}^{-1}$) were observed highest in T_5 (25 % RD of NPK + Enriched Vermicompost @ 2 t ha^{-1}).

Key words: Dolichos bean, Enriched vermicompost, Microbial consortium, Soil enzyme, SMBC, Microbial population

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 [1]. Dolichos bean is a multipurpose crop mainly grown for its green pods, seeds and also for fodder purposes. Dolichos bean is a 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 [2].

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 [3]. 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 improve soil fertility and reduce the cost of production [4].

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 which enhanced the soil fertility [5]. Addition of organic matter decreases bulk density and increase porosity of the soil which improves water holding capacity of soil. This facilitates the ideal conditions for the growth of plants and activity of microorganisms. Biofertilizers like *Azotobacter*, *Rhizobium*

and *Azospirillum* fix atmospheric nitrogen which becomes readily available to crop and contribute to increased crop yield [6]. Phosphorus solubilising bacteria helps in solubilisation and mineralization of phosphorus. Consortium of bio fertilizer maintains diversity in agricultural ecosystems and also releases plant growth substances like auxins, gibberellins, cytokines, which contribute to the increase in plant growth [7, 8]. Increase in microbial population and soil enzymatic activity is the indicator of good soil condition for crop growth [9]. Addition of nitrogen doses solely and partially through chemical fertilizers resulted in accumulation of nitrate in soil, thus inhibiting the activity of enzyme through interfering in the process of electron acceptors [10]. Incorporation of bulky sources of potential beneficial microbes may provide microbial diversity and activity of microorganisms accompanied by better DH activity [11, 12]. Organic acids released by microorganisms and plant roots help in release of phosphorus from complexes to soil solution as easily available form [13]. Improvement of SMBC observed with the addition of organic manure [14].

Balanced use of organic, inorganic and bio fertilizers is essential to maintain good soil physical and chemical conditions and also serve as energy source for microbial activity [15].

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 T₁: RDF (30: 40: 20 kg ha⁻¹ NPK) + FYM @ 10t ha⁻¹, T₂: 50 % RD of NPK + Microbial consortium as seed coat + Vermicompost @ 1t ha⁻¹, T₃: 25 % RD of NPK + Microbial consortium as seed coat + Vermicompost @ 2t ha⁻¹, T₄: 50 % RD of NPK + Enriched Vermicompost @ 1t ha⁻¹, T₅: 25 % RD of NPK + Enriched Vermicompost @ 2t ha⁻¹, T₆: 50 % RD of NPK + Microbial consortium as seed coat + FYM @ 5t ha⁻¹, T₇: 25% RD of NPK + Microbial consortium as seed coat + FYM @ 10t ha⁻¹. Well rotten FYM, Vermicompost and Enriched Vermicompost were applied to different treatment plots before 10 days of sowing. Nitrogen was applied in 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 P₂O₅ and 114.00 kg ha⁻¹ K₂O 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.

For estimation of soil chemical and physical properties soil samples were collected before planting and after harvest of the crop. Soil pH was determined by glass electrode method [16]. Available N of the soil was estimated by modified Kjeldahl's method as described by [16]. Available P of the soil was estimated by Bray's method [16]. The potassium content was determined with the help of flame Photometer. Organic carbon estimated by wet digestion method. Soil microbial population was estimated by serial dilution technique. The microbial numbers were estimated as colony forming unit (cfu) g⁻¹ soil on dry weight basis.

Dehydrogenase activity was determined by the reduction of triphenyl tetrazolium chloride (TTC) to triphenyl formazan (TPF) as described by [17]. Phosphomonoesterase activity (PME) was estimated by method of [18]. Microbial biomass carbon was determined by chloroform fumigation extraction technique following the method of [19]. All the parameters were subjected to statistical analysis as per the standard procedure [20].

Results and Discussion

Soil chemical properties

After harvest of the crop available N, P, K of soil found significantly increased over initial values. It was observed from the data (Table 1) that the treatment T₅ (25% RD of NPK + Enriched vermicompost 2 t ha⁻¹) recorded the highest soil available nitrogen (372.00 kg ha⁻¹), available phosphorus (47.00 kg ha⁻¹), available potassium (184.10 kg ha⁻¹) followed by T₄ (50 % RD of NPK + Enriched Vermicompost @ 1t ha⁻¹). Application of full dose of chemical fertilizer with FYM did not improve the N, P, K content significantly (T₁). Increase in available nitrogen in T₅ and T₄ might be attributed to the addition of N, P, and K through enriched vermicompost which contains good amount of N, P, K as compared to the FYM and nitrogen fixation by the plants due to the application of microbial consortium either through organic manure or as seed coat. Microbial consortium increases the microbial diversity in the soil. *Rhizobium* fix atmospheric nitrogen efficiently by forming nodules in plant roots when applied to soil and *Azotobacter* which is a free living nitrogen fixer also fix nitrogen in soil. Uniform distribution of Enriched vermicompost in the plots facilitates the uniform distribution of microorganisms in the plots and contributes to increased decomposition of organic matter applied as well as already present in the soil. Similar results were obtained by [14, 21]. Organic acids released by microorganisms and plant roots interact with the Al and Fe complexes and help in release of phosphorus from these complexes to soil solution as easily available form. Similar results were observed by [22, 23]. The amount of organic carbon after harvest was found to increase in all treatments over the initial amount (0.60 %). Highest amount of organic carbon (0.98 %) was observed in T₅ (25% RD of NPK + Enriched Vermicompost 2 t ha⁻¹) with 0.98 % per cent which was at par with T₇. Organic carbon content in the soil increased significantly in the plots that had received organic manure incorporated with microbial consortium along with reduced level of chemical fertilizers than in the plots that had received RDF of chemical fertilizers and FYM alone. The decomposition of organic manure applied and organic matter already present in the soil or dead roots increase organic carbon content in the soil. These observations are in agreement with the findings of [11].

Table 1 Effect of integrated nutrient management on soil chemical properties

Treatments	Available nitrogen (kg ha ⁻¹)	Available phosphorus (kg ha ⁻¹)	Available potassium (kg ha ⁻¹)	Organic carbon (%)
T ₁ : RDF (30:40:20 kg ha ⁻¹ NPK) + FYM (10 t ha ⁻¹)	296.67	36.03	134.33	0.76
T ₂ : 50% RD of NPK + MC (Seed coat) + VC (1 t ha ⁻¹)	347.00	42.67	166.00	0.92
T ₃ : 25% RD of NPK + MC (Seed coat) + VC (2 t ha ⁻¹)	342.00	41.33	163.67	0.95
T ₄ : 50% RD of NPK + Enriched Vermicompost (1 t ha ⁻¹)	365.67	45.13	177.67	0.96
T ₅ : 25% RD of NPK + Enriched Vermicompost (2 t ha ⁻¹)	372.00	47.00	184.10	0.98
T ₆ : 50% RD of NPK + MC (Seed coat) + FYM (5 t ha ⁻¹)	328.67	38.03	148.23	0.87
T ₇ : 25% RD of NPK + MC (Seed coat) + FYM (10 t ha ⁻¹)	334.00	38.47	153.00	0.98
S.Ed (±)	6.61	1.11	4.70	0.02
CD (5%)	14.50	2.50	10.25	0.04
Initial Value	212.70	31.51	114.00	0.60

VC (vermicompost), MC(Microbial consortium)

Soil biological properties

The population of all the microbes improved due to the integrated application of inorganic fertilizers, organic manures and microbial consortium. It was observed from the data (Table 2) that the highest count of bacteria (15.59×10^5 cfu g⁻¹ soil) and fungi (6.84×10^3 cfu g⁻¹ soil) was observed in T₅ (25% RD of NPK + Enriched Vermicompost 2t ha⁻¹). Increased microbial population may be attributed to application of reduced NPK dose and inclusion of microbial consortium with enriched vermicompost. Organic matter acts as a substrate for the activities of microbes. Microorganisms facilitate the decomposition of organic matter and release of nitrogen, organic carbon and other nutrients which are utilized by microorganisms themselves as energy source for multiplication. Similar results were observed by [21, 22].

It is evident from the data that the soil microbial biomass carbon differed significantly amongst the treatments. The highest amount of SMBC ($241.59 \mu\text{g g}^{-1}$ soil 24hr⁻¹) was found in T₅ (25% RD of NPK + Enriched Vermicompost 2t ha⁻¹). This might be due to the less inorganic inputs and more organic inputs in T₅ have provided a steady source of organic carbon to support the microbial community. Application of biofertilizers, besides showing their primary effect are also known to produce diverse growth promoting substances that might contribute intense proliferation of microbial growth and increased microbial biomass carbon. Similar improvement in microbial biomass was observed by [9, 11]. The activity of

dehydrogenase enzyme considers as most reliable criteria that signifies the microbial activity in the soil. The highest activity of dehydrogenase enzyme ($122.53 \mu\text{g TPF g}^{-1} \text{ soil } 24\text{hr}^{-1}$) was observed under T_5 . Dehydrogenase (DH) involved in oxidation of organic matter and is an important indicator of microbial activity in the soil. Incorporation of organic sources with biofertilizers may provide microbial diversity and activity of microorganisms accompanied by better DH activity [9, 12].

It was observed from the study that the highest phosphomonoesterase activity ($50.58 \mu\text{g p-nitrophenol g}^{-1} \text{ soil hr}^{-1}$) was found in T_5 . Phosphomonoesterase (PMEase) is an enzyme of agronomic value because it hydrolyses compounds of organic phosphorus (P) and transforms them into inorganic phosphorus. Addition of Enriched vermicompost along with reduced dose of inorganic fertilizer recorded to increase PMEase activity. Similar observation was recorded by [9, 14].

CONCLUSION

The evaluation of the results from the present investigation revealed that integrated application of inorganic, organic and biofertilizers significantly improved the soil health by increasing available NPK, organic carbon and soil microbial activity. Among the different treatments, the treatment T_5 (25% RD of NPK + Enriched Vermicompost 2t ha^{-1}) found to be superior over other treatments.

Table 2 Effect of integrated nutrient management on soil biological properties

Treatments	Bacteria ($\times 10^5$ cfu g ⁻¹ soil)	Fungi ($\times 10^3$ cfu g ⁻¹ soil)	SMBC ($\mu\text{g g}^{-1}$ soil 24hr ⁻¹)	Dehydrogenase ($\mu\text{g TPF g}^{-1}$ soil 24 hr ⁻¹)	PMEase ($\mu\text{g p-}$ nitrophenol g ⁻¹ soil hr ⁻¹)
T ₁ : RDF (30:40:20 kg ha ⁻¹ NPK) + FYM (10 t ha ⁻¹)	9.63	4.16	186.15	94.07	36.37
T ₂ : 50% RD of NPK + MC (Seed coat) + VC (1 t ha ⁻¹)	11.50	5.72	227.67	118.80	44.72
T ₃ : 25% RD of NPK + MC (Seed coat) + VC (2 t ha ⁻¹)	11.58	5.74	233.33	113.60	44.08
T ₄ : 50% RD of NPK + Enriched Vermicompost (1 t ha ⁻¹)	12.60	6.80	237.00	119.84	46.99
T ₅ : 25% RD of NPK + Enriched Vermicompost (2 t ha ⁻¹)	15.59	6.84	241.59	122.53	50.58
T ₆ : 50% RD of NPK + MC (Seed coat) + FYM (5 t ha ⁻¹)	10.36	5.60	222.67	110.70	43.30
T ₇ : 25% RD of NPK + MC (Seed coat) + FYM (10 t ha ⁻¹)	10.62	5.63	223.44	112.92	43.63
S.Ed (±)	0.07	0.08	4.86	2.77	1.50
CD (5%)	0.16	0.17	10.60	6.04	3.27
Initial Value	5.10	2.92	145.40	65.51	31.20

References

1. Basu AK, Samantha SK, Sasmala AC. Genetic analysis for some seed parameters in *Lablab purpureus*. Veg. Sci 2002; 32(2): 129-132.
2. Joshi SK, Rahevar H. Effect of dates of sowing, row spacing and varieties on growth and yield attributes of Rabi Indian bean (*Dolichos lablab* L.). Indian J. Agric.Res 2015; 49(1): 59-64.
3. N.H.B. 2017-18. *National Horticulture Board database*, Gurgoan, Haryana, India. [http://nhb.gov.in/statistics/State_Level/2017-18-\(Final\).pdf](http://nhb.gov.in/statistics/State_Level/2017-18-(Final).pdf).
4. Gandhi A, Sivakumar K. Impact of vermicompost carrier based bioinoculants on the growth, yield and quality of rice (*Oryza sativa*) cv. nlr 145. The Ecoscan 2010; 4(1): 83-88.
5. Ullasa MY, Pradeep S, Naik AK. Long-term effect of different organic nutrient management practices on growth, yield of field bean (*Dolichos lablab* L.) and soil properties. Int. J. Curr. Microbiol. App. Sci 2018; 7(10): 51-62.
6. Neha, Chandra R, Pareek N, Raverkar KP. Enhancing mungbean (*Vigna radiata* L.) productivity, soil health and profitability through conjoint use of *Rhizobium* and PGPR. Legum. Res. Int. J 2021; 1: 6.
7. Lal M, Kumar S. Effect of chemical and organic fertilizers on growth, flowering and yield of okra (*Abelmoschus esculentus* L.) cv. Arka Anamica. Agriways 2016; 4(1): 69-72.
8. Akram JF, Nejada TS, Mojadam M. Effect of different methods of *Rhizobium* bacteria inoculation on biological nitrogen fixation in broad bean. Int. J. Plant Anim. Environ. Sci 2014; 4(2): 346-352.
9. Kumar V, Kumar A, Singh MK, Kumar M, Kumar U. Growth and yield of pea (*Pisum sativum* L.) cv. Azad P-1 as influenced by NADEP Composts prepared by using different raw materials. Int. J. Curr. Microbiol. App. Sci 2017; 6(11): 2260-2267.
10. Goyal, S.; Mishra, M.M.; Hooda, I.S. and Singh, R. (1992). Organic matter-microbial biomass relationships in field experiments under tropical conditions: effects of inorganic fertilization and organic amendments. *Soil Bio. Biochem.*, **24**(11): 1081-1084.
11. Gupta, R.; Swami, S. and Rai, A.P. (2019). Impact of integrated application of vermicompost, farmyard manure and chemical fertilizers on okra (*Abelmoschus esculentus* L.) performance and soil biochemical properties. *Int. J. Chem. Stud.*, **7**: 1714-1718.
12. Nayak, D.R.; Babu, Y.J. and Adhya, T.K. (2007). Long-term application of compost influences microbial biomass and enzyme activities in a tropical Aeris Endoaquept planted to rice under flooded condition. *Soil Bio. Biochem.*, **39**(8): 1897-1906.
13. Mallikarjun, M. and Maity, S. K. (2018). Effect of integrated nutrient management on soil biological properties in Kharif rice. *Int. J. Curr. Microbio. Appl. Sci.*, **7**(11): 1531-1537.
14. Nath, D.J.; Ozah, B.; Baruah, R.; Barooah, R.C. and Borah, D.K. (2011). Effect of integrated nutrient management on soil enzymes, microbial biomass carbon and bacterial populations under rice (*Oryza sativa*)-wheat (*Triticum aestivum*) sequence. *Indian J. Agric.Sci.*, **81**(12): 1143.

15. Gopalasundaram, P.; Bhaskaran, A. and Rakkiyappan, P. (2012). Integrated nutrient management in sugarcane. *Sugar Tech.*, **14**(1): 3-20.
16. Jackson, M. L. (1973). Soil chemical analysis, pentice hall of India Pvt. Ltd., New Delhi, India, **498**: 151-154.
17. Casida, J.L.E.; Klein, D.A. and Santoro, T. (1964). Soil dehydrogenase activity. *Soil Sci.*, **98**(6): 371-376.
18. Tabatabai, M.A. and Bremner, J.M. (1969). Use of p-nitrophenyl phosphate for assay of soil phosphatase activity. *Soil Boil. Biochem.*, **1**(4): 301-307.
19. Vance, E.D.; Brookes, P.C. and Jenkinson, D.S. (1987). An extraction method for measuring soil microbial biomass C. *Soil Bio. Biochem.*, **19**(6): 703-707.
20. Panse VG, Sukhtame PU. Statistical methods for Agric.workers. Indian Council of Agricultural Research New Delhi 1985; pp. 145-152.
21. Laishram, N.; Dhiman, S.R.; Gupta, Y.C.; Bhardwaj, S.K. and Singh, A. (2013). Microbial dynamics and physico-chemical properties of soil in the rhizosphere of chrysanthemum (*Dendranthema grandiflora*) as influenced by integrated nutrient management. *Indian J. Agric. Sci.*, **83**: 447-455.
22. Datt, N.; Dubey, Y.P.; and Chaudhary, R. (2013). Studies on impact of organic, inorganic and integrated use of nutrients on symbiotic parameters, yield, quality of French-bean (*Phaseolus vulgaris* L.) and soil properties of an acid alfisol. *African J. Agric. Res.*, **8**(22): 2645-2654.
23. Jaisankar, P. and Manivannan, K. (2018). Effect of integrated nutrient management on growth, yield attributes and yield of dolichos bean (*Lablab purpureus* L.). *Ann. Pl. Soil Res.*, **20**(4): 391-395.