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Effect of Integrated Nutrient Management on Soil Chemical and Biological Properties under Dolichos Bean Cultivation

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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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 kg ha^{-1}) were observed in T_5 (25 % RD of NPK + Enriched Vermicompost @ 2t ha^{-1}) and organic carbon (0.98 %) also found highest in T_5 (25 % RD of NPK + Enriched Vermicompost @ 2t ha^{-1}). The microbial population, soil enzymes activity *i.e* dehydrogenase (DH) activity (122.20 µg TPF g^{-1} soil 24 hr^{-1}), phosphomonoesterase activity (50.90 µg p-nitrophenol g^{-1} soil hr^{-1}) and soil microbial biomass carbon (SMBC) (240 µg g^{-1} 24hr^{-1}) were observed highest in T_5 (25 % RD of NPK + Enriched Vermicompost @ 2t ha^{-1}).

Keywords: Dolichos bean; enriched vermicompost; microbial consortium; soil enzyme; SMBC; microbial population.

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1. 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, the productivity of dolichos bean observed around 4-5 t/ha. Cultivation of dolichos bean in this area 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].

2. 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 experimental site is located at 26°43′ N latitude and 94°12 *′ E longitude and at an elevation of 96.6 m above the mean sea level which is under Upper Brahmaputra Valley Agro climatic Zone of Assam.* The range of maximum temperature was 30.45 – 37.35°C and range of minimum temperature was 23.21- 28.77°C during the growing season. The average rainfall received was 10.10mm. 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}. 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 representative soil samples were collected from the top soil of six random spots up to the depth of 0-30 cm. 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.

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 Kjeldalh'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].

3. RESULTS AND DISCUSSION

3.1 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 T_5 (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 T_4 (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 (T_1). Increase in available nitrogen in T_5 and T_4 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 T_5 (25% RD of NPK + Enriched Vermicompost 2 t ha^{-1}) with 0.98 % per cent which was at par with T_7. 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].

3.2 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 T_5 (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].

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)

Table 2. Effect of integrated nutrient management on soil biological properties

Treatments	Bacteria (× 10^5 cfu g^{-1} soil)	Fungi (× 10^3 cfu g^{-1} soil)	SMBC (µg g^{-1} soil 24hr^{-1})	Dehydrogenase (µg TPF g^{-1} soil 24 hr^{-1})	PMEase (µg 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

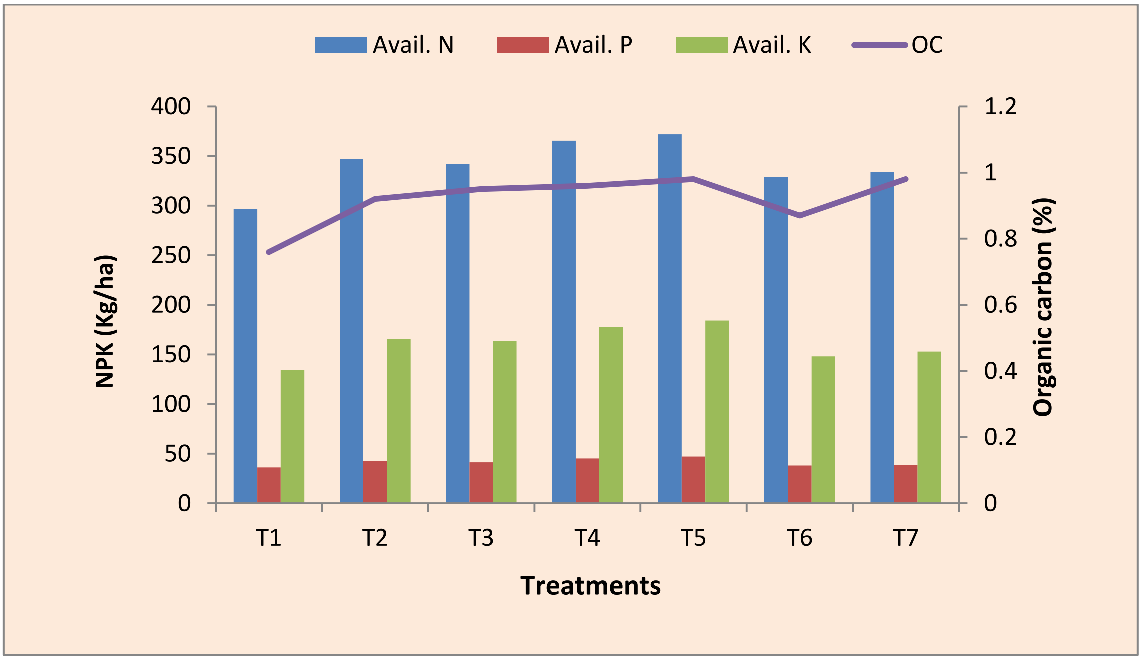

Fig. 1. Soil available NPK (kg/ha) and organic carbon (%)

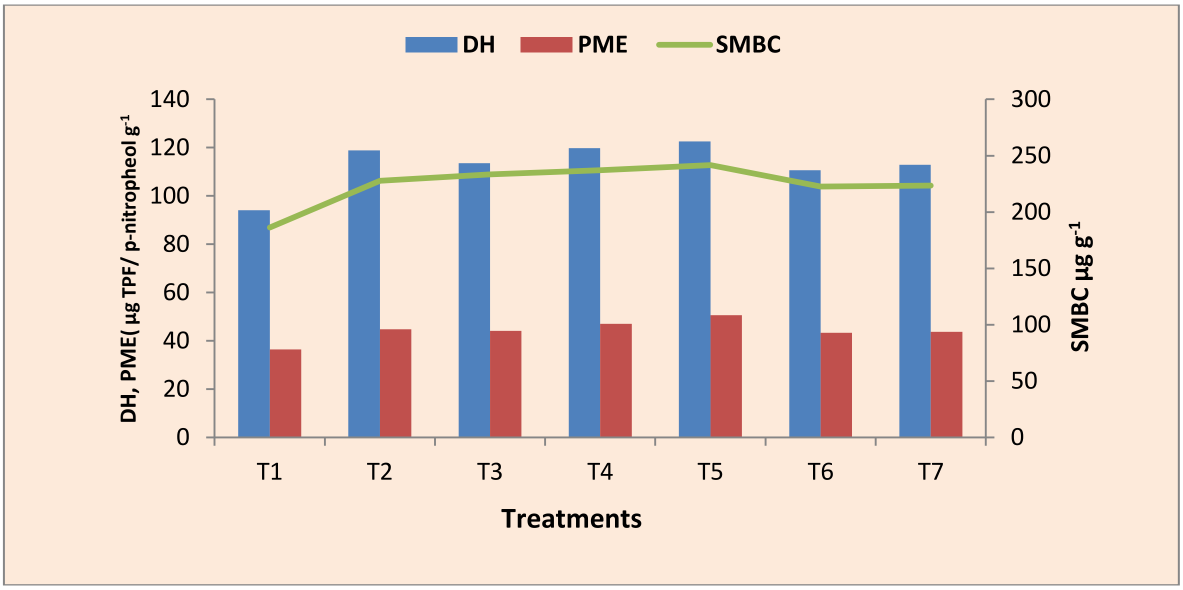

Fig. 2. Soil DH, PMEase Activity and soil microbial biomass carbon (µg g^{-1} soil)

It is evident from the data that the soil microbial biomass carbon differed significantly amongst the treatments. The highest amount of SMBC (241.59 µg g^{-1} soil 24hr^{-1}) was found in T_5 (25% RD of NPK + Enriched Vermicompost 2t ha^{-1}). This might be due to the less inorganic inputs and more organic inputs in T_5 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 µg TPF g^{-1} soil 24hr^{-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 µg p-nitrophenol g^{-1} 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].

4. CONCLUSION

Results of the study indicated that the application of organic matter along with biofertilizers and reduced dose of inorganic fertilizers improved the soil health by increasing available NPK, organic carbon, soil enzymes and soil microbial biomass. It can be concluded that the enhanced soil chemical and biological properties can be achieved with the application of 25% (7.5: 10: 5 kg ha^{-1}) RD of NPK + Enriched Vermicompost 2t ha^{-1}.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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