Effect of mixing pine needles with manures and fertilizers on soil properties and biomass production of cabbage

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ABSTRACT: Possibilities of manipulating the nutrient availability from organic and inorganic sources by the addition of pine needles were assessed. A replicated pot scale study on cabbage cv. Golden Acre was conducted in the polyhouse at College of Horticulture and Forestry, Pasighat. Arunachal Pradesh. Fertilizers NPK (150:80:80 kg ha^{-1}) and three sources of manures viz. green manure (*Sesbania aculeata*), farm yard manure (FYM) and vermicompost were applied alone or in combination with pine needles (20 t ha^{-1}). Application of pine needles showed varied response for biomass production with organic and inorganic source of the nutrients. Total biomass production of the cabbage increased significantly (12-14%) in case of inorganic fertilizers and decreased significantly (10-52%) with manures due to pine needles application. It also caused reduction in bulk density and increase in porosity and maximum water holding capacity of the soil. Pine needles reduced the 0.5 M KZSOa extractable total nitrogen from green manure, FYM and vermicompost treated soil, whereas, it increased in soil with NPK treatment. The available P content was increased by 4.0-11.8 mg kg^{-1} and decreased by 2.9 mg kg^{-1} due to pine needles application in different manure and NPK treated soils, respectively. This modifying effect of pine needles on different nutrients sources can be utilized for manipulating nutrient availability.

Key words: Extractable nitrogen, modifiers, organic sources of nutrients, quality, Soil physico-chemical properties

1. INTRODUCTION

North East region of Himalayan agro-ecosystem is endowed with a variety of natural resources including soils with different prospects and limitations. hum cultivation is extensively practiced on the steep slopes of the high hills and gentle slopes of foothills. All the states of the region grow tropical indigenous as well as exotic temperate vegetables (Yadav *et al.*, 2005). Potato, cabbage, okra, cucurbits, cauliflower and brinjal are some of the important horticultural crops being cultivated in the fragile ecosystem of the NEH Region of India. Area wise cabbage is most important cash crop of the entire region after potato (Anonymous, 2009).

Unutilized nutrients from the intensive vegetable production field are known to be an important source of diffuse pollution in agriculture particularly in relation to leaching loss of nitrogen (Neeteson, 1995). Fertilizers and manures use in intensive vegetable systems is very high, but use efficiency of nutrients from these sources are quite variable for different crops viz. nitrogen and phosphorus recovery in different vegetable crops ranges from 13.9 - 44.0 and 13.9 - 46.1 per cent, respectively (Singh, 2002). Several management practices like more number of split applications, delaying the basal application by 10 days, timing the split application with crop requirement and placements of the fertilizer has been recommended for increasing the recovery of applied nutrients. Still lots of scope exist for reducing environmental impact by increasing the use efficiency of applied nutrients through manures and fertilizer and proportionately reducing the rate of application. This can be achieved by synchronizing the mineralization immobilization turnover (MIT) of applied nutrients with crop demand. There has been some research on synchronising the MIT from crop residues with crop N demand by mixing plant residues of different qualities (Handayanto *et al.*, 1997). These organic materials could include high C:N carbonaceous materials and materials rich in polyphenols. Tannins fractions have been reported to play important role in controlling the carbon and nitrogen transformations in soil and ultimately plant nutrition and growth (Kanerva *et al.*, 2006).

Pine needles are rich in tannins (Kraus *et al.*, 2003) and it is available in abundance in Himalayan region. Tenasserim Pine (*Pinus latteri*) is the dominant species at lower elevations while Khasi Pine (*P. kesiya*) and Blue Pine (*P. wallichicrna*) are the predominant species at higher elevations (http://en.wikipedia.org/wiki/Northeast_India-Myanmar_pine _forests). Pine trees are also the integral part of the agroforestry systems at >700 m above mean sea level in north eastern hill regions of India (Bhatt *et al.*, 2005). We have studied the effect of pine needles incorporation on the biomass production of cabbage. The possibilities of manipulating the nutrient availability from organic and inorganic sources by the addition of pine needles were also studied.

2. MATERIALS AND METHODS

Experiment was conducted in polyhouse during 2004-2005 and 2005-2006 at College of

Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh (28.07°N, 95.33°E and 153 m elevation). The surface soil (0-15 cm) used in the present study was a sandy loam collected from fallow virgin land. Initial properties of the soil are given in Table 1. Three organic sources of nutrient were selected to represent the wide spectrum of manure quality viz. green manure of Sesbania aculeata (1.05% N, 0.42% P, 0.48% K), farm yard manure (FYM) (0.50% N, 0.48% P, 0.29% K) and vermicompost (0.60% N, 0.45% P, 0.16% K). FYM and vermicompost were obtained from the vermicompost unit of the college. The green manure plants were collected from small pure stand plots grown on farm as a green manure. Pine needles (1.36% N, 0.16% P, 0.22% K) were collected from the pine trees present in Pasighat. The green manure plants and pine needles were manually shredded to pieces < 2.0 cm,

Table 1. Properties of the soil used in the experiment

Available P (mg kg^{-1})	33.6
Available K (mg kg^{-1})	125.5
EC (1:2 soil:water)	0.05
pH (1:2 soil:water)	6.7
Maximum water holding capacity (%)	58.53
Particle density (Mg m^{-3})	2.81
Soil BD (Mg m-3)	1.55
Sand (%),	66.5
Silt (%)	15.0
Clay (%)	19.5
Texture	Sandy loam

Air dried soil was sieved (less than 2 mm) and placed in plastic pots (30 cm dia) @ 10 kg per pot. Replicate pots were set up by mixing the manures each @ 10, 20, 30, 40 and 50 t ha^{-1} (considering one ha furrow slice contain $2.2x10^6$ kg soil). Another set of pots receiving manures @ 50 t ha^{-1} and recommended NPK were supplemented with pine needles @ 20 t ha^{-1} (fresh weight basis). Pots without manures and with recommended dose of NPK (150: 80: 80) were also maintained. Two seedlings of the 35 days old cabbage (cv. Golden Acre) were transplanted in each pot. After one week, plants were thinned to one plant per pot. The experiment was laid out in Completely Randomized Design with four replications.

Plants grown were watered on three days interval to maintain at field capacity. Pots were harvested at crop maturity. At harvesting, the plants from each treatment were cut at the ground level and mean weight was recorded and expressed as yield of the biomass (g $plant^{-1}$). Plants were washed with distilled water and oven dried for further analysis. Vitamin C was measured in fresh leaves by estimating the ascorbic acid content following the colourimetric method given in Sadasivam and Manickam (1992). Crude fiber of the cabbage was determined in the oven-dried sample following the method given by Maynard (1970). Ash content was determined by igniting 2.0 g finely grounded oven-dried sample in muffle furnace (AOAC 1965).

After harvesting, three cores of sample were drawn from each pot. Collected moist samples were thoroughly mixed, air-dried and sieved (<2 mm) for subsequent analysis. The soil reaction (pH of 1:2.5 soil: water suspensions) was determined by glass electrode pH meter. The electrical conductivity of 1: 2.5 soils: water extract was determined using conductivity bridge. Organic C was analysed by the Walkley and Black dichromate oxidation method. Available potassium were extracted with 1 N ammonium acetate (1: 5 soil: solution ratio for 5 min.) and K in the extracts were analysed by flame photometer. Available P was extracted with 0.5 M $NaHCO_3$ by the Olsen method. Total extractable nitrogen in the 0.5 M K_2SO_4 extract (2.5 K_2SO_4: 1 soil) were determined by Mg0 and Devardas alloy distillation.

The particle size analysis was carried out by the international pipette method using sod ium-hexa-meta-phosphate as a dispersing agent. The textural class was determined using USDA textural triangle. The bulk density was determined by the core method at two randomly chosen points from each pot. Particle density was measured by measuring the change in volume of water by soil solids using 100 ml graduated cylinder. The per cent pore space was calculated using bulk density and particle density data [pore space (%) = 100 {1-(BD/PD)}]. Maximum water holding capacity was determined by using keen Rackzowski box.

3. RESULTS AND DISCUSSION

3.1 Biomass production

Manure application showed consistent increase in the biomass production with increase in the rate of the manure application (Table 2). The manurial treatment showed significant (P<0.05) increase in the biomass production with every 10 t ha^{-1} increase in the manure applied. The correlation coefficients between amount of manures application and biomass production were 0.84, 0.81 and 0.75 (P < 0.001) for green manure, FYM and vermicompost, respectively. Green manure @ 50 t ha I recorded highest biomass (438.3 g $plant^{-1}$), significantly higher than the NPK recommended. Other manures showed significantly lower biomass than the NPK recommended. Biomass production was highest in green manure, followed by vermicompost and FYM at all the level of manure application. At 50 t ha^{-1} the green manure showed

Table 2. Effect of treatments on yield of cabbage (cv. Golden Acre)

Treatments	Rate of application ($t\ ha^{-1}$)	Fresh biomass ($g\ plant^{-1}$)
Green manure	10	168.2
	20	236.4
	30	265.7
	40	298.2
	50	438.3
Farm yard manure	10	173.7
	20	181.2
	30	192.4
	40	232.8
	50	271.5
Vermicompost	10	172.7
	20	199.7
	30	219
	40	257.6
	50	280.7
NPK recommended*	150:80:80	385.9
Control		148.5
LSD (P<0.05)		13.2

* NPK in kg ha^{-1}

61.4 and 56.1 per cent more biomass production than the FYM and vermicompost, respectively. Rembialkowska and Vollebregt (2003) and Eggert and Kahrmann (1984) reported significantly higher yield of various vegetables like tomato, potato, carrot, beans, soybeans, etc. under organic system than the conventional. Willumsen and Thorup-Kristensen (2001) also reported that green manure was self sufficient in nutrient supply to the subsequent vegetable crops.

Application of pine needles showed varied response for biomass production with organic and inorganic source of the nutrients (Fig. 1). With inorganic fertilizers it registered a significant increase, while manures caused significant reduction in the total biomass production. Pine leaves + NPK registered 434.4 g/plant biomass, showing 12.6 per cent increase over NPK alone.

Similar trend was observed in second year repeated with selected treatment of first year in theyear 2006 (Figure 1). Anonymous (2005) also reported the increased production of kharif rice by application of chopped pine litter with rock phosphates and urea in comparison to NPK recommended. Conversely, the biomass production in green manure + Pine, FYM + Pine and vermicompost + Pine were 39.7, 54.5 and 55.5 per cent less than the green manure, FYM and vennicompost alone applied @ 50 t ha^{-1}, respectively. In traditional agroforestry systems of the Meghalaya, Pinu.s ke.siya has been reported to cause 39% reduction in the paddy yield in comparison to Lagerstroemia speciosa based systems (Bhatt *et al.*, 2005).

3.2 Soil physico-chemical properties

The pH of the soil used in the study was in the neutral range (Table 1). Different manurial and fertilizer treatments caused minor decrease in soil pH. Application of pine leaves with manures and fertilizers caused further reduction in soil pH by 0.05-0.45 unit. In FYM + pine treated soil reduction in soil pH was significant. This lowering exudates from the pine needles (Tangjang *el al.*, 2005) and also after decomposition of organic matter present in the manures. increase in the EC of the soil determined after 90 days of incorporation (Table 3). The EC of the treatments receiving vermicompost were highest, followed by green manure and FYM in pH may be due to acidic release of some organic acid Different treatments showed

Vermicompost and vermicompost + pine leaves registered significantly less bulk density than the control and NPK treatment (Table 3). Other treatments were statistically at par. Green increase in the MWHC but differences were not perceptible for manures. In NPK treated soil, application of pine leaves caused significant increase and MWHC was 9.04 and 9.62 per cent more than the NPK and control, respectively. This increase in MWHC also corroborates with increase in soil porosity and possible reason may be the improved soil aggregation due to organics application.

Different treatments showed significant increase in organic carbon content of the soil in comparison to control and NPK (Table 4). At the similar rate of manuring, organic carbon content was maximum in vermicompost followed by FYM and green manure. This variation in the effect of various manures on OC is mainly because of difference in the nature of the manures. Vermicompost and FYM are well decomposed before application hence it contributes more towards stabilized organic carbon pool of the soil. Green manures containing easily decomposable materials contribute to a lesser extent towards the organic carbon pool. Pine leaves application further increased the OC of the soil but effect of pine leaves was more visible in NPK treatment. NPK+ pine showed significant increase and registered 77.8 per cent more OC than NPK alone.

Application of manures caused increase in the K_2SO_4 extractable nitrogen content of the soil (Table 4). The extractable nitrogen content of the vermicompost treated pots was higher than the

Table 3. Effect of different treatments on physico-chemical and physical properties of soil after harvesting of cabbage

Treatments*	Soil pH (1:2: soil: water)	EC (1:2: soil: water)	Bulk density (Mg m^{-3})	Porosity (%)	MWHC (%)
Green manure	6.55	0.14	1.498	46.69	68.89
Green manure+ Pine	6.50	0.15	1.487	47.09	69.49
Farm yard manure	6.60	0.11	1.490	46.97	68.97
Farm yard manure + Pine	6.25	0.13	1.481	47.29	69.86
Vermicompost	6.60	0.16	1.453	48.15	70.01
Vermicompost+ Pine	6.45	0.19	1.452	48.27	72.57
NPK	6.70	0.06	1.555	44.66	58.87
NPK + Pine	6.65	0.08	1.539	45.24	67.91
Control	6.70	0.05	1.556	44.64	58.29
LSD (P< 0.05)	0.38	0.20	0.087	3.09	4.20

*Green manure, vermicompost and Farm yard manure - 50 t ha^{-1}; pine leaves -20 t ha^{-1}; NPK-150:80:80 kg ha^{-1}

Table 4. Effect of different treatments on soil chemical properties after harvesting of cabbage

Treatments	Organic carbon (%)	0.5 M K_2SO_4 extractable nitrogen (mg kg^{-1} soil)	Available phosphorus (mg kg^{-1} soil)	Available potassium (mg kg^{-1} soil)
Green manure	0.57	7.03	47.86	158.81
Green manure + Pine	0.59	6.13	59.7	168.62
Farm yard manure	0.59	8.74	58.2	157.17
Farm yard manure + Pine	0.61	5.82	62.19	187.41
Vermicompost	0.61	12.02	62.58	178.62
Vermicompost + Pine	0.67	6.72	61.99	170.75
NPK	0.27	5.03	40.5	131.02
NPK + Pine	0.48	5.99	37.61	130.65
Control	0.29	4.74	33.13	124.37
LSD (P< 0.05)	0.09	0.9	10.4	31.43

*Green manure, vermicompost and Farm yard manure - 50 t ha^{-1} ; pine leaves -20 t ha^{-1}; NPK-150:80:80 kg ha^{-1}

green manure and FYM. Application of pine leaves reduced the K_2SO_4 extractable nitrogen from the manure treated soil, but it conversely increased it in NPK treated soils. These findings are in conformity with those of Neve *et al.* (2004) who reported the manipulation of nitrogen mineralization to increase the efficiency and reduce nitrate leaching from high nitrogen crop residues by simultaneous incorporation of crop residues and other organic materials which either inhibit mineralization of the crop residue nitrogen or immobilize the mineralized nitrogen. Handayanto *et al.* (1997) also reported the synchronization of the mineralization immobilization turnover from crop residues with crop N demand by mixing plant residues of different qualities.

The Olson's P increased in the soil due to application of manures (Table 4). The available P was the highest in the vermicompost treated soils followed by FYM and green manure. In green manure available P was almost similar to the NPK recommended, while FYM and vermicompost treatments had significantly more available P than NPK recommended. The faster rate of mineralization of the green manure in the initial 10-15 weeks liberated most of the plant nutrients for crop uptake and showed lower estimates of OC, N, P and K in comparison to relatively recalcitrant materials like FYM and vermicompost. This hypothesis is supported from the fact that the biomass productions in green manure treated pots were more than the FYM and vermicompost treated pots (Fig. 1). Lupwayi and Haque (1999) reported the rapid decomposition of Leucaena prunings in comparison to cattle manure. The

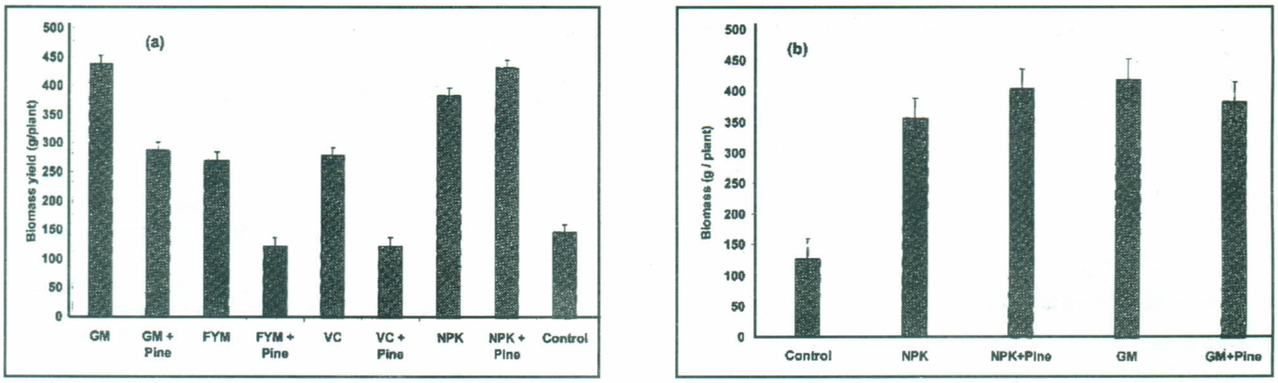

Figure 1. Effect of pine needles on the biomass production in year 2005 (a) and 2006 (b). Soils were treated with 50 t ha^{-1} of Sesbania aculeata green manure (GM), farm yard manure (FYM) vermicompost (VC) and 15:80:80 kg ha^{-1}1 of N:P:K. Whiskers on the bars shows LSD (P<0.05).

release of N, P and K was more from the tree prunings than from manures. Rai *et al.* (1999) also reported the peak of nutrients mineralization from green manure crops within 10 days of incorporation in soil. Application of pine leaves with green manure, FYM and vermicompost registered further increase in the available P content at harvesting. This finding indicates that pine leaves reduces the rates of mineralization of the organic materials and maintain higher Olson's extractable P in the soil even after 90 days of incorporation. In contrast to manures, pine leaves with NPK reduced the available P content in comparison to NPK estimated at harvesting, probably due to increased inimobilization. The residual soil fertility has also been reported to be more in chopped pine litter treated soils of Meghalaya (Anonymous, 2005).

Among the organic sources of nutrients, available K was also maximum in vermicompost followed by green manure and FYM treatments and these sources showed significantly higher available K than the control. Like other nutrients, availability of potassium was also affected by application of pine leaves. Its availability was reduced in the NPK treated soil but increased in organic treated soil (Table 4).

3.3 Quality of the biomass

Quality parameters of the cabbage harvested were estimated by determining vitamin C, ash content (total minerals) and crude fibre (Table 5). Green manure treated plants recorded higher vitamin C content than the FYM and vermicompost. In comparison to NPK all the treatments recorded significantly higher vitamin C content. Ash content of the cabbage leaves was more in green manure treated plants followed by vermicompost and FYM. The crude fibre content of the manure and fertilizer treatments was almost same.

Thus it may be concluded that green manure through Sesbania aculeata (50 t ha^{-1}) resulted in higher biomass production and it was self sufficient in supply of nutrients to the cabbage. Application of pine leaves showed varied response for biomass production and available nutrient contents in the

Table 5. Effect of different treatments on the quality of cabbage

Treatments	Vitamin C content (mg g^{-1} fresh weight)	Ash content (%)	Crude fibre (%)
Green manure	0.45	11.81	57.09
Green manure + Pine	0.43	9.73	75.08
Farm yard manure	0.37	9.39	74.78
Farm yard manure + Pine	0.28	11.32	88.89
Vermicompost	0.30	9.8	71.22
Vermicompost + Pine	0.36	11.32	66.45
NPK	0.20	10.41	69.56
NPK + Pine	0.24	9.38	69.25
Control	0.36	10.70	71.66
LSD (P<0.05)	0.035		0.797

*Green manure, vermicompost and Farm yard manure - 50 t ha^{-1}, pine leaves -20 t ha^{-1}; NPK-150:80:80 kg ha^{-1}

soil treated with organic and inorganic source of the nutrients. Total biomass production of the cabbage was increased significantly in case of inorganic fertilizers and decreased significantly with manures due to pine leaf application. This shows that pine leaves have some modifying effect on the nutrients availability from inorganic and organic sources. It needs further investigation to establish the mechanisms involved.

ACKNOWLEDGEMENT

Authors are thankful to Vice-chancellor CAU and Dean(s) College of Horticulture and Forestry, CAU, Pasighat, Arunachal Pradesh for providing facilities required for conducting the research work presented in this article.

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