EVALUATION OF VERMICOMPOST AND CHEMICAL FERTILIZERS ON PERFORMANCE OF PAK CHOI (*Brassica rapa* CV. Hong Tae*)* AND SOIL BIOLOGICAL PROCESS

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ABSTRACT

A field experiment was conducted to evaluate the effect of vermicompost and chemical fertilizers on the performance of *Pak choi* (*Brassica rapa* CV. Hong Tae*)* in Chitwan Nepal during November 2012 to January 2013. Four levels of vermicompost (0, 5, 10 and 15 t/ha) and four levels of NPK equivalent in the form of inorganic fertilizer (100, 50, 25 and 0% of recommended doses of 100:60:60 Kg/ha) in 16 combinations were assessed for yield, yield contributing parameters of *Pak choi* and microbial activities of soil. All levels of chemical fertilizers increased plant height, leaf number and chlorophyll content of leaves but they had no effect in increasing root length. Chemical fertilizers at 100:60:60 kg NPK/ha increased biological and economic yield of Pak choi. However, all levels of chemical fertilizers were found strongly suppressing in soil microbial activities. Vermicompost on the other hand increased root length, leaf number, biological and economic yield and more significantly increased soil microbial activities resulting in increased level of soil respiration. Chemical fertilizers were effective in increasing plant growth but suppressed microbial activities of soil. Vermicompost on the other hand was effective in long run through slow release of plant nutrients and improving soil health by increased soil microbial activities.

Key words: Chemical fertilizers, Plant Growth, Soil respiration, Vermicompost, Yield,

INTRODUCTION

Chinese cabbage is a member of the cruciferae family which also includes cabbage, cauliflower, brocauli and mustard. There are two types of Chinese cabbage available, a leafy type *Brassica rapa*-chinese group and a heading type *Brassica rapa*-pekinensis type. Chinese cabbage probably originated in china. The heading types are most often envisioned when one mentions Chinese cabbage, however the leafy type are more often called pak choi or bok choi. As a member of the *Brassicaceae*, pak choi contains significant amounts of carotenoids, polyphenols and nitrogen containing secondary metabolites, such as glucosinolates, which possess important anti-oxidative properties and exert anti-carcinogenic, anti-mutagenic, and anti-viral action (Kopsell *et al.*, 2007; Harbaum-Piayda *et al.*, 2008 ; Verkerk *et al.*, 2009).

Performance of plant growth depends on availability of soil nutrients which is related to the judicious application of chemical fertilizers and organic manure. Increased use of inorganic fertilizers in crop production deteriorates soil health, causes health hazard and cerates imbalance to environment by polluting air, water and soil. The continuous use of chemical fertilizers badly affects the texture and structure, reduces organic matter content, reduces water holding capacity and eventually decreases microbial activities of soil. Moreover, cost of inorganic fertilizers is high as well as not available in time and farmers fail to planting crop in optimum time. Hence, the use of readily available organic sources of nutrients would be ideal for soil health and productivity. Vermicompost is a good source of different macro and micronutrients. Use of vermicompost for vegetable production in large scale can solve the problem for disposal of wastes and also solve the problem lack of organic manure. On the other hand, a judicious combination of organic and inorganic sources of nutrients might be helpful to obtain a good economic return with good soil health for the

subsequent crops. Earthworms consume large quantities of organic matter, and excrete soil as cast and this cast have several enzymes and rich in plant nutrients, beneficial bacteria and mycorrhizae (Reddy and Reddi, 2002).

Recently, few researches worked to assess the performance of vermicompost in carrot (Tomar *et al*., 1998 and Alam, 2005), potato (Saikia *et al*., 1998; Upadhayay *et al*., 2003 and Bongkyoon, 2004). Application of vermicompost along with nitrogen fertilizer produced higher dry matter (16.2 g/plant) and grain yield (3.6 t/ha) in wheat (*Triticum aestvum*) and higher dry matter yield (0.66 g/ plant) in coriander (*Coriandrum sativum*) after wheat in a sequential cropping system (Desai et al., 1999). Similarly, vermicompost enhances transplant growth rate of vegetables and increases red marketable tomato with no symptoms of early blight lesions on the fruit at harvest. The yield of pea (*Pisum sativum*) was also higher at vermicompost (10 t /ha) along with recommended N, P and K than that of chemical fertilizers alone (Reddy *et al*. 1998). Application of vermicompost produced greater herbage yields of coriander comparable to those obtained with chemical fertilizers (Vadiraj et al. 1998).

Using of vermicompost is now a global movement for the second green revolution that emphasizes on composting. This mixture is made by earthworm's activities which are necessary for soil improvement and farm production, raw materials and various microorganisms which decompose organic wastes and convert them into suitable nutritional elements particularly NPK.

Pak choi (*Brassica rapa)* has been emerging as an important leafy vegetable with ever increasing tourist influx in the country. Growth, yield and quality of Pak choi depend on nutrient availability in soil, which is directly related to the judicious application of manures and fertilizers. Therefore, the present investigation was undertaken to study the effect of vermicompost and NPK fertilizers on growth, and yield of Pak choi and biological properties of soil in sub-tropical condition of Chitwan, Nepal.

METHODOLOGY

The experiment was conducted at Horticulture Research Farm, of an NGO namely MADE - NEPAL, Bharatpur, during December 2012 to February 2013. The the site is situated about 27°31' North latitude and 84°25' East longitude at altitude of about 256m above mean sea level. Four levels of vermicompost (0, 5, 10 1nd 15 t/ha) and four levels of NPK (100, 50, 25 and 0% of recommended doses (100:60:60 Kg/ha) in 16 combinations were applied for Pak choi production. The full dose of vermicompost, TSP, MP and half dose of urea were applied at the time of land preparation before transplanting Pak choi seedlings. The rest of urea was applied at 15 days after transplanting. The net plot size was 1.5m x 1.3m. The Pak choi seedlings of 28 day old were transplanted on 10 December 2012 The seedlings were spaced at 25 x 30cm with 25 seedlings per plot.. Plant height, leaf number, root length, chlorophyll content, yield and soil respiration were recorded. The parameters were analyzed by using the ANOVA procedure as described by Gomez and Gomez (1984). When the F-test indicated statistical significance at the P = 0.01 and P = 0.05 level, the Duncan's Multiple Range Test was used to compare the difference of the means.

RESULTS AND DISCUSSION

Plant height

The different levels of NPK fertilizer were significantly effective in increasing plant height of Pak choi. The effects became more pronounced with time or growth period. The NPK at 100:60:60 Kg/ha was effective only at 30 DAT. But change with time at 45 DAT all the doses of NPK showed significant effects. However, the increasing level of NPK increased the plant height of Pak choi at 45 DAT (Table 1).

Leaf number

All NPK levels significantly increased the leaf number over control but effects of different levels were at par at 30 and 45 DAT. There was no effect on leaf number at 15 DAT. Unlike NPK levels vermicompost had no effect on plant height of Pak choi but it had significantly increased the leaf number. Vermicompost at 15 t/ha produced highest number of leaf but not significantly different from other levels of vermicompost. But at 45 DAT vermicompost had significantly increase the leaf number per plant (Table 1).

It is noted that chemical fertilizers release nutrients rapidly and plant utilizes them quickly resulting in significant change in growth and development of a plant. Hence they are more efficient than vermicompost in short run. But in long run or after one month the effects of vermicompost are more favorable than chemical fertilizers. Chemical fertilizers (NPK) were efficient than the organic manures in the short run (Asiegbu and Oikeh, 1995). In other leafy crops such as cabbage maximum number of loose leaf was found when organic and chemical fertilizers were applied in combination (Kabir, 1998 and Azad, 2000).

Table 1. Effect of chemical fertilizer and vermicompost on plant height and number of leaf per plant of Pak choi at different dates of transplantation (DAT), Chitwan Nepal, 2013.

Treatments	Plant height (cm)			Leaf number per plant		
	15 DAT	30 DAT	45 DAT	15 DAT	30 DAT	45 DAT
Chemical Fertilizer						
100:60:60 Kg N_2:P_2O_5:K_20 per ha	12.23	17.23$^{a}_{b}$	22.69^{a}	10.56	11.74^{a}	16.09^{a}
50:30:30 Kg N_2:P_2O_5:K_20 per ha	11.95	14.46$_{b}$	21.00^{b}	10.33	11.73^{a}	15.78^{a}
25:15:15 Kg N_2:P_2O_5:K_20 per ha	12.11	14.92$_{b}$	19.78^{c}	10.41	11.89^{a}	15.75^{a}
Control	12.19	13.94	17.83^{d}	10.36	10.97^{b}	14.78^{b}
SEM(±)	0.207	0.29	0.357	0.18	0.24	0.31
F-test)	0.52	17.79**	32.80**	0.31	2.94*	3.28*
LSD (0.05)	Ns	0.838	1.031	ns	0.698	0.90
Vermicompost						
Control	11.74	15.33	20.17	10.09	11.23	14.90^{b}
5 ton/ha	11.97	15.59	19.69	10.33	11.56	15.51^{ab}
10 ton/ha	12.29	15.48	20.57	10.56	11.88	15.71^{ab}
15 ton/ha	12.19	15.93	20.85	10.70	11.66	16.29^{a}
SEM(±)	0.207	0.29	0.357	0.18	0.24	0.31
LSD (0.05)	Ns	Ns	Ns	Ns	Ns	0.90
P value (F-test)	1.39	0.77	1.97	2.15	1.31	3.37*
CV (%)	5.97	6.45	6.08	6.05	7.23	6.94
Interaction effect						
Chemical fertilizer x vermicompost	Ns	Ns	Ns	Ns	Ns	Ns

Leaf chlorophyll content

The relative concentration of chlorophyll content of leaves due to various dose of chemical fertilizer was significant at 25 DAT and 45 DAT (Table 2). At 25 DAT and 45 DAT maximum SPAD value 49.28% was found at full doses of chemical fertilizers (100:60:60 kg NPK/ha). Unlike, chemical fertilizers, vermicomost did not show any increment in chlorophyll content of pak choi leaf.

Root length

Root length was not affected by Chemical fertilizers (Table 2). But vermicompost significantly increased the root length of Pak choi. Maximum root length was obtained in vermicompost at 15 t/ha. However, vermicompost at 10 t/ha and 5 t/ha was at par with control. The humic acids in humus stimulate root growth. In a similar study, Tomati *et al.* 1985) and Canellas *et al*. (2002) found that humic acids isolated from vermicompost enhanced root elongation and formation of lateral roots in maize roots.

Table 2. Effect of chemical fertilizer and vermicompost on root length (cm) and SPAD value of Pak choi, Chitwan Nepal, 2013.

Treatments	Root length (cm)	SPAD value	
		25DAT	45DAT
Chemical Fertilizer			
100:60:60 Kg N_2:P_2O_5:K_20 per ha	11.637	49.28[a]	49.23[a]
50:30:30 Kg N_2:P_2O_5:K_20 per ha	11.353	46.84[ab]	47.60[ab]
25:15:15 Kg N_2:P_2O_5:K_20 per ha	11.773	46.10[b]	45.17[b]
Control	11.607	42.89[c]	44.99[b]
SEM(±)	NS	0.92	0.89
P Value (F-test)		8.03	5.17
LSD (0.05)		2.68**	2.58**
Vermicompost			
Control	10.59[b]	44.761	45.94
5 ton/ha	11.23[b]	46.259	46.47
10 ton/ha	11.23[b]	45.936	46.87
15 ton/ha	12.61[a]	48.153	47.69
SEM(±)	0.23	0.92	0.89
LSD (0.05)	0.6686	2.68*	Ns
P value (F-test)	14.22*	4.50	0.68
CV (%)	6.92	6.97	6.64
Interaction			
Chemical fertilizer vermicompost	Ns	Ns	Ns

Biological yield

Vermi compost and chemical fertilizers alone and their combinations significantly influenced the fresh yield of Pak choi. Maximum biological yield (0.2358 kg) was obtained from chemical fertilizer at 100:60:60 Kg NPK/ha followed by 0.1975 Kg at 50:30:30 Kg/ha (Table 3). Biological yield obtained from chemical fertilizer at 50:30:30 and 25:15:15 Kg N2:P2O5:K2O per ha was at par with control. In contrast, all levels of vermicompost application produced significantly higher biological yield compared to control. However, the biological yield of Pak choi was at par at all levels of vermicompost.

Economical yield

Economic yield of Pak choi was influenced by different doses of chemical fertilizers and vermicompost (Table 3). Maximum economical yield (0.1448 kg) was found in application of chemical fertilizer at 100:60:60 kg/ha followed by 50:30:30 kg. However, the economic yield was

not significantly different between control (0.09525 kg) and chemical fertilizers at 25:15:15 Kg NPK/ha. Similar to chemical fertilizers, vermicompost application showed significantly higher economical yield over control. Vermicompost applied at 15 ton/ha showed significantly higher economical yield (0.1333 kg) but it was statistically similar to the yield obtained at 10 and 5 t/ha. Both chemical fertilizers and vermicompost did not influence crop harvest index of Pak choi.

Table 3. Effect of chemical fertilizers and vermicompost on biological, economic yield and harvest index of Pak choi in Chitwan Nepal, 2013.

Treatments	Biological yield (kg per plant)	Economic yield (kg per plant)	Harvest Index
Chemical Fertilizer			
100:60:60 Kg N_2:P_2O_5:$K_2$0 per ha	0.2358[a]	0.1448[a]	0.631
50:30:30 Kg N_2:P_2O_5:$K_2$0 per ha	0.1975[b]	0.1289[ab]	0.679
25:15:15 Kg N_2:P_2O_5:$K_2$0 per ha	0.1722[b]	0.1140[bc]	0.681
Control	0.1593[b]	0.09525[c]	0.602
SEM(±)	0.0129	0.0091	0.0394
F-value	6.8415*	10.28***	0.953
LSD (0.05)	0.037	0.026	Ns
Vermicompost			
Control	0.1530[b]	0.1001[b]	0.666
5 ton/ha	0.1965[a]	0.1262[ab]	0.670
10 ton/ha	0.2029[a]	0.1233[ab]	0.624
15 ton/ha	0.2124[a]	0.1333[a]	0.632
SEM(±)	0.0129	0.0091	0.0394
LSD (0.05)	0.037	0.026	Ns
F value	4.1631*	4.76**	0.355
CV (%)	23.35	18.92	21.08

Soil respiration rate

Application of different doses of chemical fertilizer and vermicompost significantly influenced the soil respiration rate before harvest (Table 4). The respiration rate of soil before harvest of the crop significantly decreased under all levels of chemical fertilizers. The respiration rate in control was 4.814 gm $CO_2/m^2/hr$ which decreased with increasing level of chemical fertilizers. The lowest respiration rate (3.762 gm $CO_2/m^2/hr$) was found at full dose of chemical fertilizers (100:60:60 NPK/ha). The maximum rate was found under control which was free from chemical fertilizers. In contrast, the respiration rate increased with increasing level of vermicompost. The respiration rate was significantly high (5.1 mg $CO_2/m^2//hr$) at 15 t/ha and minimum at the control.

After harvesting of the crops, the rate of respiration reduced under both chemical fertilizer and vermicompost application indicating decreased activities of soil microorganism. However 15t/ha vermicompost treated plot showed the higher respiration rate as compared to chemical fertilizers.

Table 4. Effect of chemical fertilizer and vermicompost on soil respiration rate before and after harvest of Pak choi, chitwan Nepal 2013.

Treatments	Soil respiration rate (gm CO_2/m^2/hour)	
	Before harvest	After harvest
Dose of chemical Fertilizer		
100:60:60 Kg N_2:P_2O_5:K_20 per ha	3.762[b]	0.99
50:30:30 Kg N_2:P_2O_5:K_20 per ha	3.774[b]	0.92
25:15:15 Kg N_2:P_2O_5:K_20 per ha	3.893[b]	0.86
Control	4.814[a]	0.94
SEM(±)	0.28	0.13
P-value (F-test)	3.97	0.18
LSD (0.05)	0.81*	ns
Vermicompost		
Control	3.726[b]	0.96
5 ton/ha	4.238[b]	0.86
10 ton/ha	4.137[b]	0.84
15 ton/ha	5.142[a]	1.05
SEM(±)	0.28	0.13
LSD (0.05)	0.81**	ns
P value (F- test)	4.51	0.54
CV (%)	22.60	48.29
Interaction effect		
Chemical fertilizer × vermicompost	Ns	Ns

It is very obvious that chemical fertilizer application suppressed the microbial growth and activities in the soil resulting in low CO_2 accumulation in the soil. In contrast to chemical fertilization, vermicompost promoted microbial activities in the soil. Respiration or carbon dioxide accumulation in soil was higher before harvest in standing crops which may be attributed to additional release of CO_2 by respiration of roots.

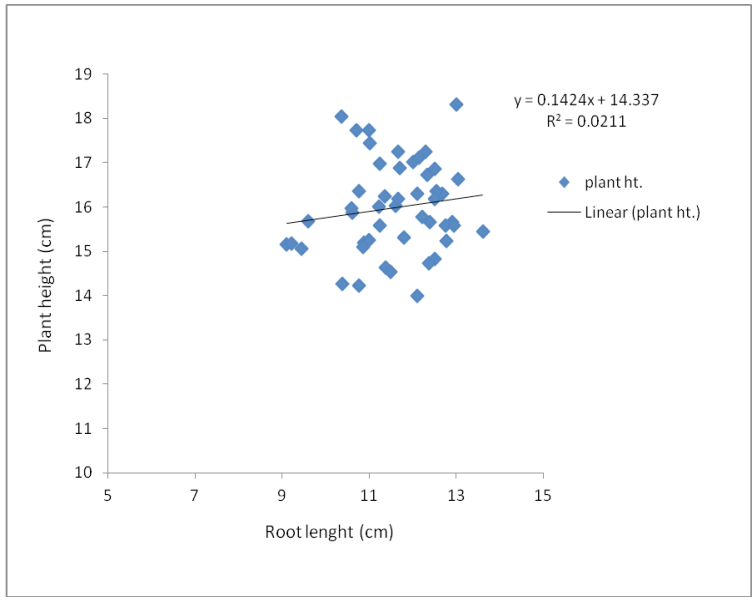

Figure 2. Correlation between root length (cm) and average plant height (cm) of *Pak choi*

Root length and plant height were found positively related (Slope=0.142). The increment in plant height by 2.1% is contributed by root length. Increased root length absorbed more nutrients and water. Similar relationship between root length and yields was reported in red amaranth (Alam et al. 2007).

Other researchers also reported similar results in several other crops. Application of recommended dose of fertilizers and vermicompost indicated maximum yield in Potato (Patil, 1995), rice (Jeyabal and Kuppusamy, 2001) and significantly influenced various growth parameters in Cabbage plant (Canellas *et al*., 2002). Combination of Vermicompost at 10 t/ha + NPK at 25:60:50 kg/ha increased nodulation, plant height and yield in Pea (Chauhan *et al*., 2010). Similarly, 150 kg N/ha and 12 t/ha vermicompost increased the leaf number in Potato (Yourtchi, Haj, Hadi, & Taghi, 2013) and vermicompost at 15 t/ha significantly increase the growth and yield of Okra (Azarmi *et al*., 2008). Chemical fertilizer was most effective within a month of application in influencing growth performance in amaranths whereas vermicompost was more favorable than chemical fertilizer after a month (Alam, 2007).

Chemical fertilizers were effective in increasing plant growth in short run but suppressed significantly the microbial activities of soil. Vermicompost on the other hand was effective in long run through slow release of plant nutrients and improving soil health by increased soil microbial activities

CONCLUSION

It is concluded that chemical fertilizers release nutrients rapidly and plant utilizes them quickly resulting in significant change in growth and development of a plant. Hence they are more efficient than vermicompost for short run. After one month or in long run, the effects of vermicompost are more pronounced than chemical fertilizers. Besides, vermicompost enhances the soil fertility by promoting beneficial microbial growth and activities in soils and releases the humic and other organic substances beneficial to growth and development of crops in sustainable ways.

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