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Evaluation of the use of vermicompost on the crop production of two varieties of Pak choi (*Brassica rapa* var. *chinensis*) and on the soil structure in Suriname

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Abstract. *Ramnarain YI, Ori L, Ansari AA. 2017. Evaluation of the use of vermicompost on the crop production of two varieties of Pak choi (*Brassica rapa *var.* chinensis*) and on the soil structure in Suriname. Asian J Agric 1: 73-79.* The present research was carried out from January to May 2016 at the Anton de Kom University of Suriname, Paramaribo. The investigation consisted of both field and laboratory work to evaluate the effect of vermicompost on crop production of 2 varieties *Brassica rapa var. chinensis*, white and green Pak choi, nutrient availability in the soil after the use of vermicompost and nutrient value of the crop. The experiment was carried out (Completely Randomized Block Design) in a greenhouse for six weeks. The treatments were vermicompost (V), cow manure (S), chemical fertilizer (K) and control (C). Plant growth parameters were recorded during the experiment (plant height and number of leaves) and after harvest (root and shoot biomass, leaf area). Nutrient analysis (Ca and Fe) of Pak choi was also conducted followed by pre- and post-experiment soil analysis (pH, EC, TOC, N, P, K and C/N ratio). The results were collected and analyzed using Sigma Plot 12.0 tools. In the white Pak choi, the number of leaves, root length and weight of fresh plants showed no significant differences among the four treatments using Tukey's test ($P \leq 0.05$). In the green Pak choi, the number of leaves and root length showed no significant differences among the four treatments by Tukey's test ($P \leq 0.05$). Furthermore, the soil parameters (pH, OC, N) did not indicate a significant increase or decrease of the elements in the soil. P did decrease significantly and the K increase in the treatment in the soil was not relevant. The evaluation of the use of vermicompost on the crop production of 2 varieties of Pak choi (*Brassica rapa* var. *chinensis*) proved that the plants treated with vermicompost had similar results as those treated with cow manure and chemical fertilizer.

Keywords: Bio-fertilizer, cow manure nutrients, pak choi, soil, plant-parameters, vegetables, vermicompost

INTRODUCTION

Vermicompost is a finely divided peat-like material with excellent structure, porosity, aeration, drainage, and moisture holding capacity (Edwards 1988). The input material that is used for vermicomposting decides the nutrient content of the vermicompost. It usually contains higher levels of most of the mineral elements, which are in available forms than the parent material (Edwards and Bohlen 1996). Vermicompost serves as a nutrient rich natural fertilizer, improving the physical, chemical, and biological properties of soil (Ansari and Jaikishun 2011; Nath et al. 2009; Kale 1998) and thus reducing the use of chemical fertilizers (Chanda et al. 2011; Hernandez et al. 2010). It also increases the amount of readily available water, induction of N, P and K exchange, which results in better growth of the plants (Papafotiou et al. 2005; Manivannan et al. 2009). A samba rice cultivation study revealed that the addition of vermicompost had significant positive effects on the soil physical, chemical properties, and plant growth parameters (Tharmaraj et al. 2011). According to Ali et al. (2012), the application of vermicompost increased the soil properties such as organic matter, total nitrogen, phosphorus, potassium, sulfur, zinc, and boron contents; grain and straw yields of rapeseed also increased significantly, when increasing the dose of vermicompost. Therefore, this study focuses on the effect of the application of vermicompost in the cultivation of *Brassica rapa* var. *chinensis*, white and green Pak choi and its impact on the soil structure.

MATERIALS AND METHODS

Experimental design

This research was carried out from January to May 2016 at the Anton de Kom University of Suriname, Paramaribo. The investigation consisted of a field and laboratory study to evaluate the effect of vermicompost on crop production of 2 varieties *Brassica rapa var. chinensis*, white and green Pak choi, nutrient availability in the soil after the use of vermicompost and nutrient value of the crop. The field experiment was carried out in a greenhouse for a total of 6 weeks at the Anton de Kom University of Suriname. The experiment was performed using a Completely Randomized Block Design (CRBD) with 3 repetitions for each variety and treatment of vermicompost, cow manure, chemical fertilizer, and control (Figure 1). Each block had an area of 6.0 m^2 (4.0x1.50 m^2) and each plot in a block had a length of 1 m, width of 0.75 m and height of 0.20 m. Each plot in the block consisted of 12 plants of Pak choi at 25x20 cm (Figure 2 and Figure 3), with a total of 36 plants per treatment.

Plant material and cultivation

The white and green Pak choi seeds of the brand TAK II SEED from Japan were used, since this is commonly grown in Suriname. Firstly, the seeds were sown in seed trays (7x15) with potting soil of the brand "Universele potgrond van Egmond" and kept in the greenhouse. The white Pak choi had a germination rate of 94% and the green Pak choi 98%. After 2 weeks, healthy seedlings were transplanted into the field. A planting depth of approximately 3 cm was utilized and plant spacing of 25x20cm. Every day the plants were irrigated, and the harvest took place when the plants were 45 days old. The entire experimental area was managed according to standard practices for nutrient, weed and pest management. The vermicompost, cow manure and chemical fertilizer were applied to the planting hole before transplanting the seedlings into the field. The second amount of fertilizer was applied to the plants in the fourth week. The total amount of added fertilizer per plant is shown in Table 1. According to Sinha et al. (2011), an application of 1 -1.5 tons/acre of vermicompost can be used for leafy vegetables. The same applies for cow manure. For chemical fertilizers, an application of 50 g / m^2 is recommendable.

Plant observation and soil analysis

During the cultivation of Pak choi (*Brassica rapa var. chinensis*) the following growth parameters were taken weekly until harvest: number of leaves and plant height (cm). Upon maturity, the plants were harvested and preserved for analysis. The following plant growth parameters were measured: root length (cm), shoot biomass fresh (weight in grams)/ dry (at 105°C), root biomass fresh (weight in grams)/ dry (at 105°C) and leaf surface area in cm^2. After harvesting, the plants were cut into small pieces and air dried for approximately 48 hours. Afterward, the plant samples were placed in an oven at 60°C for 24 hours to dry. According to the laboratory prescription at the soil laboratory of the Anton de Kom University of Suriname, the dried plant tissue was pulverized into particles smaller than 1mm and analyzed for nutrient value of Total-Ca (%) and Total-Fe (ppm). The organic fertilizers (cow manure and vermicompost) and soil samples were subjected to various chemical analyses. Before planting and after harvesting, soil samples were taken from each plot to a depth of 10 cm. The methods described according to the laboratory prescription at the soil laboratory of the Anton de Kom University of Suriname, as mentioned before; that were used to analyze the following parameters: pH-H_2O, EC, TOC, N, C/N ratio, P and K.

Data analysis

For the statistical data analysis of the *Sigma Plot 12.0* software was used. The data was processed using an Analysis of Variance of Simple Classification and differences between means (one-way ANOVA). Treatments that were significantly different, were analyzed with Tukey's hoc test. A paired-sample t-test was conducted to compare the control (initial soil) and the experiment (final soil) treatment for different chemical parameters. Significance was set at the 0.05 level.

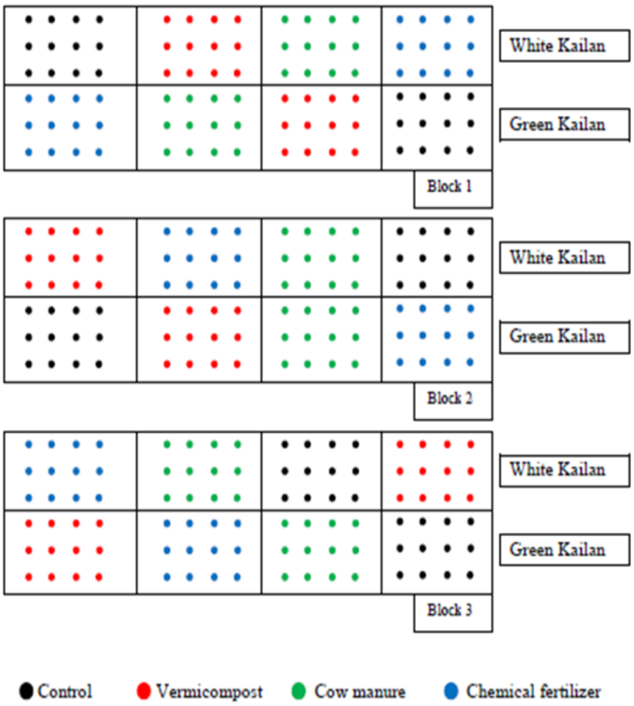

Figure 1. Randomized block design and plot 2016.

Figure 2. Site view of one plot (white Pak choi) at the greenhouse 2016.

Table 1. Fertilization treatments per plant.

Symbol	Treatments	Total amount added per plant (g)
C	Control (soil)	0
S	Cow manure	100
V	Vermicompost	100
K	Fertilizer (12-12-17)	2

RESULTS AND DISCUSSION

The research conducted on the use of vermicompost on the productivity of two varieties of Pak choi is highlighted by the impact in terms of plant growth and soil parameters. In Figure 3 the weekly average number of leaves is given and in Figure 4 the weekly average plant height (cm). It can be observed that the number of leaves and plant height did increase weekly until harvesting. There was progressively a greater number of leaves in treatment green Pak choi [K] followed by white Pak choi [C] and green Pak choi [S] (Figure 3). There was also a progressively greater plant height in treatment white Pak choi [S] followed by white Pak choi [K] and green Pak choi [V] (Figure 4).

The average values of the plant parameters of both varieties were taken on the 45th day at harvesting, which are shown in Table 2. With reference to cultivation of white Pak choi (Table 2), highest plant height was obtained by WS. The highest weight of fresh root was obtained by WS followed by WK and WV. For leaf area, there was a significant difference between WS and WC, WS and WV, WS and WK ($P \leq 0.05$). The highest leaf area was obtained by WS followed by WK and WV. With reference to cultivation of green Pak choi (Table 2), the highest plant height was obtained by GV followed by GC and GS. The highest weight of fresh plant was obtained by GC followed by GV and GK. The highest weight of fresh root was obtained by GS followed by GV and GC. The highest leaf area was obtained by GV followed by GC and GS. The results correlate with the works of Pant et al. 2011 and Archana et al. 2012.

According to Amiri Pour et al. (2013), the application of vermicompost to cabbage seedlings indicated that the effects of vermicompost on plant growth and development (leaf area, number of leaves, fresh and dry mass) not only were nutritional, but also hormonal and biochemical (Zn and auxin contents). Other studies revealed that the application of vermicompost increased leaf area and biomass in various plants such as radish, marigold, upland cress, Chinese cabbage, strawberry, and tomato (Bachman and Metzger 2008; Singh et al. 2008; Singh et al. 2010; Wang et al. 2010; Warman and Anglopez 2010). As reported by Vennila et al. (2012) vermicompost contains some plant growth stimulating substances, promotes better root growth and nutrient absorption.

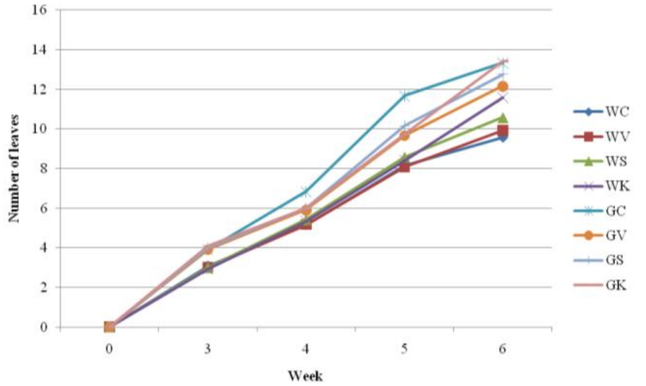

Figure 3. Growth of number of leaves.

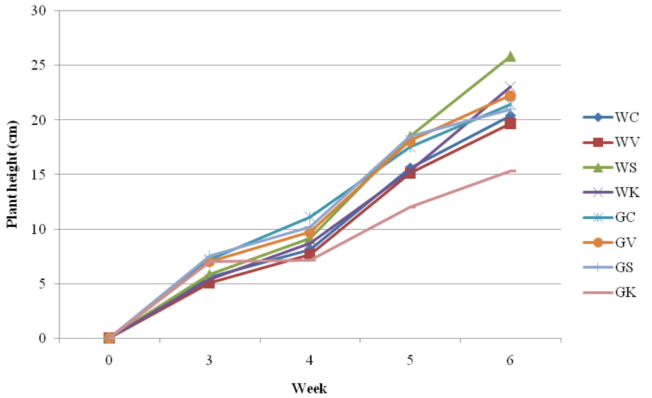

Figure 4. Growth of plant height (cm).

Table 2. Plant parameters of white and green Pak choi (Mean ± SEM).

	Number of leaves	Plant height (cm)	Root length (cm)	Weight fresh plant (g)	Weight fresh root (g)	Leaf area (cm^2)
White Pak choi						
WC	10±0.9 a	20.40±1.8 ab	15±0.8 a	109.80±26.3 a	8.30±1.5 b	181.80±17.9 b
WS	11±0.3 a	25.80±1.2 a	12.90±1.0 a	169.80±22.6 a	16.70±2.0 a	300.40±23.7 a
WV	10±0.3 a	19.70±1.5 b	12.80±1.0 a	108.40±20.0 a	9.70±1.4 b	205.30±18.6 b
WK	12±0.8 a	23±1.1 ab	13.80±1.1 a	115.30±14.9 a	10.20±1.2 b	207.10±17.0 b
Green Pak choi						
GC	13±0.7 a	21.40±0.8 a	13.50±0.7 a	117.10±13.6 a	6.70±0.6 a	141.80±11.9 a
GS	13±0.9 a	21.00±1.1 a	11.40±0.8 a	93.30±14.7 ab	9.30±2.0 a	111.60±10.0 ab
GV	12±0.7 a	22.30±1.2 a	14.00±0.9 a	110.60±18.2 a	8.40±1.1 a	156.00±15.8 a
GK	13±0.8 a	15.30±1.2 b	11.00±0.9 a	46.40±9.0 b	3.10±0.8 b	71.10±6.3 b

Note: WC: White Control; WS: White Cow manure; WV: White Vermicompost; WK: White Chemical Fertilizer; GC: Green Control; GS: Green Cow manure; GV: Green Vermicompost; GK: Green Chemical Fertilizer. *Values followed by different letters are significantly different at $P \leq 0.05$ according to Tukey's multiple range test (Tukey's test)

Earlier studies have reported a positive effect of vermicompost application on growth and productivity of cereals and legumes (Hameeda et al. 2007; Ansari and Jaikishun 2011; Fritz et al. 2012), ornamental and flowering plants (Atiyeh et al.2002; Marfá et al. 2002; Arancon et al. 2008; Chamani 2008; Lazcano and Dominguez 2010), vegetables (Atiyeh et al. 2000; Ansari 2008b; Peyvast et al. 2008; Suthar 2009; Ansari and Sukhraj 2010). Vadiraj et al. (1998) reported that application of vermicompost produced herbage yields of coriander cultivars were comparable to those obtained with chemical fertilizers, which agree with the findings of this current study, indicating that the usage of any artificial chemical input is not needed.

Nutrients in plants are an essential component for the nutritive value in diet and are indication of good plant productivity. Table 3 illustrates an overview of the nutrient value in white and green Pak choi. With reference to cultivation of white Pak choi, the nutrient analysis indicated that the highest T-Ca was observed in WK followed by WS and WC. With reference to cultivation of green Pak choi, the nutrient analysis indicated that the highest T-Fe was observed in GC followed by GK and GV.

The concentrations of total Ca in both varieties of Pak choi were in range of sufficient or normal concentrations (Table 4) of macroelements that should occur in mature leaf tissue, which is between 1 – 4 %. The concentrations of total Fe in both varieties of Pak choi were in range of sufficient or normal concentrations of microelements that should occur in mature leaf tissue, which is between 100 – 500 ppm (Munson 1998).

Table 5 provides an overview of the cow manure, vermicompost and soil measured parameters before and after harvesting of the field experiment "cultivation of white and green Pak choi”. The results of the chemical analysis of cow manure and vermicompost are also shown. For each analysis, 3 samples were taken to determine the nutrient value. The pH-H_2O in the vermicompost was 6.60±0.00 and in the cow manure 6.03±0.03. The soluble salt concentrations (measured as Electric conductivity) in the resulting vermicompost and cow manure were respectively 7200±180µS/cm and 8367±300µS/cm, indicating a lower salinity in the vermicompost compared to the cow manure. The total organic carbon was 23.20±0.59% in the vermicompost and 17.69±0.72% in the cow manure. The total nitrogen was 1.60±0.04% in the vermicompost and 1.48±0.05% in the cow manure. The C/N ratio in the vermicompost and cow manure was as followed 15:1 and 12:1. Total phosphorus was 8745±604.26 ppm in the vermicompost and 9818±195.73 ppm in the cow manure. The total potassium was 7030±186.48 ppm in the vermicompost and 8255±473.30 ppm in cow manure. Vermicompost contains essential nutrients, which were within the limits as reported by earlier researchers (Ismail 1997; Ansari and Sukhraj 2010; Ansari et al. 2016).

Soil pH did not have a notable increase or decrease for all the treatments (Table 6). Soil pH is one of the most important soil properties that affect the availability of nutrients. Macronutrients tend to be less available in soils with low pH and micronutrients tend to be less available in soils with high pH (Ansari and Jaikishun 2011). According to Krogh (2005), worm cast and composts are considered to have a positive effect on soil by helping to balance the pH, retain moisture, improve drainage, and control pathogens. Vermicompost improves the pH of soil and makes the nutrient available for the crop yield (Srikanth et al. 2000).

Soil EC did increase in all the samples though not significantly, except for WS which indicated a relevant increase (Table 7). According to Atiyeh *et al.* (2002), the electrical conductivity of vermicompost depends on the raw materials used for vermicomposting and their ion concentration.

Organic carbon did not increase or decrease significantly in the soil (Table 8). According to Ansari and Jaikishun (2011), vermicompost are rich in organic carbon content and can release these into the soil very slowly and steadily, enabling the plants to absorb the available nutrients (Lalitha et al. 2000; Ansari 2008a; b).

Nitrogen did not increase or decrease notably in the soil (Table 9). The presence of nitrogen fixing bacteria in the vermicompost plays a great role in increasing the nitrogen content of the soil and mineralization (Lalitha et al. 2000; Debosz et al. 2002; Arancon et al. 2006; Ansari 2008a; b).

Phosphorous did decrease notably in the treatments WV, GC, and GS (Table 10). According to Erich *et al.* (2002), the application of vermicompost increases the bioavailability of phosphorus in the soil affecting plant growth in potato cropping.

Table 3. Nutrient value in Pak choi varieties after harvesting (Mean ± SEM).

Parameter	T-Ca (%)	T-Fe (ppm)
White Pak choi		
WC: White Control	1.94 ± 0.08 a	114 ± 6.85 a
WS: White Cow manure	1.94 ± 0.04 a	122 ± 5.36 a
WV: White Vermicompost	1.67 ± 0.03 b	123 ± 4.07 a
WK: White Chemical Fertilizer	2.00 ± 0.02 a	112 ± 6.42 a
Green Pak choi		
GC: Green Control	2.22 ± 0.06 a	146 ± 8.71 a
GS: Green Cow manure	2.12 ± 0.05 a	107 ± 6.32 b
GV: Green Vermicompost	2.14 ± 0.06 a	107 ± 2.83 b
GK: Green Chemical Fertilizer	2.27 ± 0.04 a	108 ± 4.54 b

Note: *Values followed by different letters are significantly different at P≤0.05 according to Tukey’s multiple range test (Tukey’s test).

Table 4. Concentration or ranges of the major elements and micronutrients in mature leaf tissue generalized as deficient, sufficient, or excessive for various plant species (Munson 1998) .

Essential elements	% Deficient	% Sufficient or normal	% Excessive or toxic
Major elements			
Calcium (Ca)	<0.50	1.00 - 4.00	>5.00
Micronutrients	**ppm**	**ppm**	**ppm**
Iron (Fe)	<50	100 - 500	>500

Table 5. Cow manure, vermicompost and soil parameters (Mean ± SEM).

Parameter	pH-H_2O	EC (µS/cm)	TOC (%)	TN (%)	C/N ratio	TP (ppm)	TK (ppm)
Cow manure	6.03±0.03	8367±300	17.69±0.72	1.48±0.05	12: 1	9818±195.73	8255±473.30
Vermicompost	6.60±0.00	7200±180	23.20±0.59	1.60±0.04	15: 1	8745±604.26	7030±186.48
Before							
Soil	7.65±0.35	369±36.50	3.87±0.76	0.25 ± 0.04	16: 1	2050±127.75	792±34.26
After							
WC	7.85±0.05	1612±498	4.52±1.44	0.25±0.12	18: 1	2813±2717	1011±410
WS	7.55±0.05	1465±114	4.41±0.40	0.31±0.06	14: 1	648±10	853±35
WV	7.60±0.00	1525±318	3.82±0.59	0.25±0.0	15: 1	276±77	725±25
WK	7.95±0.15	1202±350	2.95±0.09	0.17±0.0	17: 1	851±623	834±296
GC	7.65±0.35	1314±465	4.52±1.62	0.29±0.11	16: 1	490±186	685±15
GS	7.60±0.10	1509±711	4.35±0.11	0.32±0.04	14: 1	1049±154	996±64
GV	7.60±0.00	1164±379	5.99±0.42	0.37±0.03	16: 1	3228±2733	1103±408
GK	7.65±0.05	2045±246	4.89±0.96	0.30±0.09	16: 1	2972±2675	1046±481

Note: WC: White Control; WS: White Cow manure; WV: White Vermicompost; WK: White Chemical Fertilizer; GC: Green Control; GS: Green Cow manure; GV: Green Vermicompost; GK: Green Chemical Fertilizer; TOC: Total Organic Carbon; TN: Total-N; TP: Total-P; TK: Total-K

Table 6. Soil pH (Mean ± SEM).

Treatment	Initial soil	Final soil	Increase in pH
WC	7.65±0.35	7.85±0.05	0.20
WS	7.65±0.35	7.55±0.05	-0.10
WV	7.65±0.35	7.60±0.00	-0.05
WK	7.65±0.35	7.95±0.15	0.30
GC	7.65±0.35	7.65±0.35	0.00
GS	7.65±0.35	7.60±0.10	-0.05
GV	7.65±0.35	7.60±0.00	-0.05
GK	7.65±0.35	7.65±0.05	0.00

Note: Confidence level 95%; - indicates decrease

Table 7. Soil EC (µS/cm) (Mean ± SEM).

Treatment	Initial soil	Final soil	Increase in EC (µS/cm)
WC	369±36.50	1612±498	1243
WS	369±36.50	1465±114	1096
WV	369±36.50	1525±318	1156
WK	369±36.50	1202±350	833
GC	369±36.50	1314±465	945
GS	369±36.50	1509±711	1140
GV	369±36.50	1164±379	795
GK	369±36.50	2045±246	1676

Note: Confidence level 95%; - indicates decrease

Table 8. Total Organic carbon (%) (Mean ± SEM).

Treatment	Initial soil	Final soil	Increase in OC (%)
WC	3.87±0.76	4.52±1.44	0.65
WS	3.87±0.76	4.41±0.40	0.53
WV	3.87±0.76	3.82±0.59	-0.05
WK	3.87±0.76	2.95±0.09	-0.93
GC	3.87±0.76	4.52±1.62	0.65
GS	3.87±0.76	4.35±0.11	0.47
GV	3.87±0.76	5.99±0.42	2.11
GK	3.87±0.76	4.89±0.96	1.01

Confidence level 95%; - indicates decrease

Table 9. Total Nitrogen (%) (Mean ± SEM).

Treatment	Initial soil	Final soil	Increase in N (%)
WC	0.25 ± 0.04	0.25±0.12	0.00
WS	0.25 ± 0.04	0.31±0.06	0.06
WV	0.25 ± 0.04	0.25±0.00	0.00
WK	0.25 ± 0.04	0.17±0.0	-0.08
GC	0.25 ± 0.04	0.29±0.11	0.04
GS	0.25 ± 0.04	0.32±0.04	0.07
GV	0.25 ± 0.04	0.37±0.03	0.12
GK	0.25 ± 0.04	0.30±0.09	0.05

Note: Confidence level 95%; - indicates decrease

Table 10. Total phosphorous (ppm) (Mean ± SEM).

Treatment	Initial soil	Final soil	Increase in P (ppm)	t-test
WC	2050±127.75	2813±2717	763	NS
WS	2050±127.75	648±10	-1402	NS
WV	2050±127.75	276±77	-1774	*
WK	2050±127.75	851±623	-1199	NS
GC	2050±127.75	490±186	-1560	*
GS	2050±127.75	1049±154	-1001	*
GV	2050±127.75	3228±2733	1178	NS
GK	2050±127.75	2972±2675	922	NS

Note: Confidence level 95%; - indicates decrease; *= significant; NS= not significant

Table 11. Total Potassium (ppm) (Mean ± SEM).

Treatment	Initial soil	Final soil	Increase in K (ppm)
WC	792±34.26	1011±410	219
WS	792±34.26	853±35	61
WV	792±34.26	725±25	-67
WK	792±34.26	834±296	42
GC	792±34.26	685±15	-107
GS	792±34.26	996±64	204
GV	792±34.26	1103±408	312
GK	792±34.26	1046±481	254

Note: Confidence level 95%; - indicates decrease

Potassium increase in the treatments in the soil was not relevant, although there was a decrease in WV and GC (Table 11). The increase in potassium uptake by vermicompost application may be due to the enhancement in potassium availability by shifting the equilibrium among the forms of potassium from relatively exchangeable potassium to soluble potassium forms in the soil (Bhasker et al. 1992).

In conclusion, the evaluation of the use of vermicompost on the crop production of 2 varieties of Pak choi (*Brassica rapa* var. *chinensis*) proved that the plants treated with vermicompost had similar results as those treated with cow manure and chemical fertilizer. The plant nutrient concentrations of Ca and Fe were in range of sufficient or normal concentrations of macro and microelements that should occur in mature leaf tissue. The soil parameters (pH, OC, N) did not indicate a significant increase or decrease of the elements in the soil. P did decrease significantly and K increase in the treatments in the soil was not relevant. This research should be continued to evaluate the use of vermicompost in the production of other vegetables.

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