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Toxicity, Macro and Micronutrients Analysis and Effect of Cabbage Waste on the Growth and Yield of Chilly Plant

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Abstract

Adult earthworms *Lampito mauritii* cultured in 100, 90, 80 and 70 PSR (per cent substrate ratio) of partly decomposed cabbage waste (DCW) showed diminishing size due to fragmentation of body segments leading to immediate death as a consequence of toxic principles present in the cabbage waste. To ascertain the toxic nature of cabbage waste, acute toxicity test was carried out with earthworm using DCW. Test media of DCW were prepared using decomposed cow dung (DCD) and soil as substrates and assessed the toxicity using earthworm. Attainment of equilibrium (lethal threshold) was reached in the toxicity curve between 96 and 120 hours at 11.6 and 9.8 PSR of cabbage waste mixed respectively with cow dung and soil. The pH values of DCW showed slightly basic in nature. The values of electrical conductivity measured in DCW samples showed a greater level as most of the soil have. The levels of K in macronutrients and Fe in micronutrients were relatively high when compared to other nutrients present in the samples. The chilly plants raised in pots with 0, 5, 10, 20, 30, 40 and 50 PSR doses of DCW showed relatively higher growth and yield over the plants raised in the same doses of DCD and FCD (fresh cow dung). Though the plants raised in higher PSR (40 and 50) showed increased growth and yield, but are severely affected with insect pest of saprophytic type due to their soft nature as a direct effect of more N and K present in them. The toxic effect noticed in the current study may be due to the practice of application of pesticide during cabbage harvest to protect the cabbage head from leaf poring insect.
Key words : Toxicity, Cabbage waste, Macro and Micronutrients, Chilly plant.

Sizable portion of the net annual production of vegetable is lost due to poor and inadequate transport, storage facilities and marketing practices during the haulage from harvesting places to marketing center. This loss is estimated to be about 40% of the total produced. Among this only 0.5% is converted into various by-products (Vimal and Adsule 1986) and the rest is disposed off in different ways without any use but create pollution problems besides causing inconvenience to public. Attention should be paid to these unprocessed wastes which are thrown away in the market yards. At present more importance has been given to treat these wastes chemically or biologically to obtain useful by-products before its final disposal. Such measures not only help to manage the wastes, but also play an important role in reducing the hazards of environmental pollution. India produces about 3,000 million tones of organic wastes annually which could be utilized for recovering important resources like fertilizer, fuel, food and fodder. This huge amount of waste has also the potentiality to produce 400 million tones of plant nutrients besides biogas and alcohol (Das and Senapati 1985, Bhattacharjee 2002).

The problem of soil sickness due to continuous use of large quantities of chemical fertilizer, pesticides and weedicides for the better yield of crop varieties has motivated scientists to evolve organic farming practices which could maintain higher crop yield, fertility and productivity of soil. Organic farming is attributed to the use of organic manure and biofertilizers. The production of organic manure through vermicomposting and the use of vermicompost in agriculture is a break through in the era of sustainable organic farming. Land application of vermicompost produced from diverse organic wastes could be one of the most economical and attractive methods of solving waste disposal problem and increasing the nutrient contents of soil simultaneously. However, evaluation of the nutrient status of vermicomposts is necessary to establish the real advantages of their use in agriculture. The nutrient

Table 1. Values showing the median lethal doses (LD_{50}) of the earthworm, *Lampito mauritii* exposed to decomposed cabbage waste (DCW) with DCD and soil as medium for different time periods. *Lethal Threshold Dose : PSR = Per cent Substrate Ratio.

Hours	LD_{50} values (PSR) DCW + DCD	DCW + Soil
3	70	–
6	60	55
9	46	35
12	40	30
24	25	23
36	20	20
48	20	16
72	12.6	10
96	11.6	9.8
120	11.6*	9.8*

status of vermicompost mainly depends upon the quality of organic wastes that are used as feed material for earthworms (Bano and Kale 1987). Vermicompost and worm casts utilization in horticulture has been proposed for several years (Broom 1980, Tomati et al. 1987). Edwards et al. (1985) opined that earthworm worked organic wastes have considerable potential in horticulture, as a plant growth medium. The study of vermicompost effect on plant growth and yield is essential to determine its manurial quality and nutrients status. Such a study would be an important prerequisite for large scale planning of high quality vermicompost production from specific organic waste, thereby achieving cost effective agriculture crop production. Hence to establish the quality of vermicompost/organic manure obtained from the cabbage waste collected from vegetable market after using this by earthworm or decomposed by microbes anaerobically, a pilot study was undertaken to carry out pot culture experiments using this with a horticulture plant, chilly.

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Methods

Collection of Earthworm, Soil and Cow Dung

Collection, selection and maintenance of adult earthworm, *Lampito mauritii* were followed as described by Bakthavathsalam and Rajaraman (2003). Dry soil taken from the same site where earthworms collected was manually powdered using stone mortar. Fresh and partially decomposed cow dung was collected from the cow dung pits of local dairy farm and sun dried. It was powdered, sieved and stored in jute bags.

Table 2. Values showing the levels of pH, electrical conductivity (EC) (ds/m), macro and micronutrients present in the samples of DCW. Values are mean ± SD of six samples.

Parameter	Level / Amount Present
pH	8.3 ± 0.1
EC	6.76 ± 0.7
Macro Nutrient (ppm)	
N	264 ± 89.7
P	56.1 ± 9.4
K	4045 ± 1435
Micro Nutrients (ppm)	
Fe	21.68 ± 3.16
Mn	12.07 ± 3.01
Zn	3.18 ± 0.62
Cu	0.15 ± 0.45

Collection of Cabbage Waste

Waste of wrapper leaves along with stalk of cabbage head was collected from the Arignar Anna Vegetable Market located at Tharasuram in Kumbakonam.

Partial Decomposition of Cabbage Waste

A 500 liter capacity circular plastic tank was used for the decomposition process of cabbage waste. unwanted non-degradable waste materials, if any were removed first and the remaining was cut into small pieces. About 200 kg of cut pieces were filled in the tank and was tightly closed with a lid to prevent liberation of four smell. Once in three days the decomposing materials were thoroughly mixed with wooden rod to ensure proper decomposition. Ideal semi-decomposed organic matter can be obtained only after one month of decomposition. In

Table 3. Total number of leaves and stem length (cm) of chilly plants cultivated in pots using different doses of DCW, DCD and FCD. Values in parentheses indicate the stem length. Upper, middle and lower row values indicate the average of two plants cultivated in DCW, DCD and FCD respectively.

		Substrate Ratios					
Days	0%	5%	10%	20%	30%	40%	50%
0	10 (18)	12 (18)	13 (19)	11 (16)	13 (18)	11 (17)	13 (19)
		11 (17)	10 (15)	11 (17)	13 (17)	12 (15)	12 (17)
		15 (18)	10 (16)	14 (19)	11 (15)	12 (18)	13 (18)
30	19 (20)	31 (19)	39 (21)	40 (17)	34 (23)	39 (21)	43 (20)
		26 (20)	24 (21)	27 (18)	28 (22)	30 (18)	40 (24)
		26 (20)	22 (23)	23 (23)	26 (25)	33 (20)	38 (22)
60	27 (22)	55 (25)	75 (25)	78 (28)	158 (39)	170 (31)	201 (40)
		57 (31)	70 (30)	50 (31)	83 (39)	105 (35)	180 (48)
		50 (31)	85 (32)	80 (33)	90 (45)	205 (47)	216 (45)
90	39 (25)	78 (35)	99 (37)	109 (42)	177 (46)	202 (40)	224 (45)
		75 (36)	109 (36)	86 (45)	118 (51)	136 (43)	223 (54)
		68 (31)	113 (37)	110 (41)	122 (48)	128 (46)	139 (52)

each time at least 5 kg of dry semi-decomposed matter can be obtained. About 20 kg of dry semi-decomposed matter was collected with repeated decomposition using fresh cabbage waste collected from the same market. These compost materials were dried and manually powdered with a particle size less than 1 mm as suggested by Reinecke and Venter (1985) and stored in jute bags.

Preparation of different Substrates for Earthworm Culture

Based on the observation made by Hartenstein (1983) in the earthworm, *Eisenia fetida,* 2 kg of each substrate was provided in the present study to support the culture of 10 earthworms for 30 days. Four substrate media such as 70, 80, 90 and 100% were prepared from partly decomposed cabbage waste (DCW) using dry soil with weight by weight basis. For assessing the rate and time of cocoon laying and survival of earthworms, 10 mature worms were introduced into each substrate medium which was kept in polythene bag. Control (soil as substrate) experiment with 10 mature earthworms was also carried out simultaneously along with these media. Sufficient volume of water was added to the above media to maintain optimum condition as described by Martin (1982) until the termination of this experiment. Mortality and cocoon production of earthworms kept under different substrate media were observed regularly.

Acute Toxicity Test

Two substrates such as soil and partly decomposed cow dung (DCD) were selected for this toxicity test. Twenty two doses of different per cent substrate ratios (PSR) such as 2.5, 5, 7.5, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 25 30, 35, 40, 45, 50 55 and 60 were selected for this acute test based on the culture study previously made with the same earthworm species with partly DCW. For the preparation of 1 kg of selected test dose medium, required amount of dry soil or partly DCD and partly DCW was taken in a polythene bag. Sufficient volume of water was added to the test medium to maintain the optimum condition as described by Martin (1982). For assessing the toxicity of the selected doses (based on exploratory test) prepared from cabbage waste with soil or partly DCD, 10 earthworms were introduced into each test medium. Behaviors of earthworm were observed continuously and the number of survivals was also noted at the end of 1, 3, 6, 9, 12, 24, 36, 48, 72, 96 and 120

Table 4. Total fruits present in chilly plants cultivated in pots using different doses of DCW, DCD and FCD. Values are the average of two plants ; *Plants cultivated in this ratio are of other chilly variety.

Manu-			Substrate Ratios				
res	0%	5%	10%	20%	30%	40%	50%
DCW		22*	20	25	37	36	56
DCD	4	22*	29*	17	17	19	48
FCD		1	8	18	31*	27*	26

hours of exposure. Earthworms were considered dead if they did not response to gentle mechanical stimulus.

Determination of LD_{50} Values

A linear regression curve was constructed taking test doses and the per cent mortality and this plot was utilized to estimate LD_{50} values for different time periods. Lethal threshold dose was also obtained by adapting the producers of Eaton (1970).

Macro and Micronutrient Analysis

The levels of pH and electrical conductivity (EC) were measured in the samples taken from partly DCW. Macronutrients such as nitrogen (N), phosphorus (P) and potassium (K) and micronutrients such as zinc (ZN), iron (Fe), copper (Cu) and manganese (Mn) were also estimated at Soil Testing Laboratory, Soil Research Institute, Aduthuri, Thanjavur district, Tamil Nadu. The contents of macro and micronutrients were expressed as ppm.

Growth Study of Chilly Plant with Cabbage Waste and Cow Dung

Six circular pots with size, 22 cm diameter and 23 cm height were taken for each of partly DCW, partly DCD and FCD (fresh cow dung) and to each 3.5 kg of dry soil was transferred. Six doses namely 5, 10, 20, 30, 40 and 50 g of these organic wastes were selected and mixed well in the pot soil. In all the selected doses, another set of experiment was made simultaneously to duplicate the data. Control experiment was also carried out in duplicate along with this experiment using soil alone as substrate. Siblings of 30 days old chilly plant were purchased from the local sibling shop at Kumbakonam. One healthy sibling was transplanted in each pot at a depth of 4 cm from the top and sufficient water was added in all the pots. The pots were regularly poured with sufficient water to ensure proper growth until the plants get harvested (90 days after transplantation). After 7 days of transplantation, all plants in the pots were counted their leaves and fruits. Similar counting was also made at regular week intervals in all the plants until the termination of this study.

Results and Discussion

Earthworm Culture

The earthworm, *Lampito mauritii* kept in all media prepared from partly DCW and dry soil showed diminishing size due to fragmentation of body segments in response to toxic principles present in the exposed media and all of them were died within a short span of 3 hours. This adverse effect may be attributed with the application of pesticide at the time of harvest to safe guard the cabbage head from invasion of leaf poring insect during transportation. Since all the worms kept in these media showed no sign of life not even for a day and hence we discontinue the vermiculture and vermicomposting study.

Acute Toxicity Test

The values of median lethal dose (LD_{50}) for the earthworm, *Lampito mauritii* exposed to different PSR media prepared from partly DCW with DCD/soil as substrate have been worked out for different time periods and are given in Table 1. The LD_{50} values observed in all the periods were relatively high in the medium containing DCW with cow dung when compared to medium containing DCW with soil. From this result, it is inferred that though both substrates exert toxic effects, the effect observed in the DCW and soil media was relatively high when compared to the substrate containing DCW and cow dung as revealed by lower and higher LD_{50} values. The reason for this difference may be due to inhibitory effect of cow dung or accelerated effect of soil.

While constructing acute toxicity curve for the earthworm exposed to two substrates (cow dung and soil) containing DCW using LD_{50} values and their respective time periods, asymptote was reached during 120 hours in both the substrates respectively at 11.6 and 9.8 PSR values due to attainment of lethal threshold (equilibrium). Similar lethal threshold was also noted during 120 hours for the same species exposed to substrates such as soil alone, cow dung + soil, pressmud + soil and organic mixture + soil mixed with neem seed powder (Bakthavathsalam and Ramakrishnan 2004). Similar lethal threshold was also noted but at 144 hours in the same species, *Lampito mauritii* exposed to carbofuran mixed with different substrates namely soil, pressmud + soil, farm yard manure + soil and coir waste + soil by Bakthavathsalam and Rajaraman (2003) respectively in the carbofuran concentrations, 5.3, 15, 23 and 60 mg active ingredient/kg dry substrate. Similar but earlier attainment of equilibrium was also noted in the same species treated with neem cake powder mixed with pressmud + soil and neem seed powder mixed with farmyard manure + soil at 65 gm/kg dry substrate dose during 72 hours and during 96 hours in substrates such as neem sawdust + soil and farmyard manure + soil mixed respectively with 65 and 70 g of neem cake powder/kg dry substrate, and pressmud + soil and neem sawdust + soil mixed with 55 g of neem seed powder/kg dry substrate doses (Bakthavath-salam 2003), and substrates such as cow dung + soil, pressmud + soil and organic mixture + soil respectively mixed with 70, 85 and 65 g neem cake powder / kg dry substrate (Bakthavathsalam and Ramakrish-nan 2004).

Evidently, the time at which attainment of equilibrium (lethal threshold) reached may vary from toxicant to toxicant and from one substrate to another. From the LD_{50} values obtained among the two substrates, it is inferred that the substrate, cow dung had the abi-lity to reduce the toxicity of DCW. Bakthavathsalam (2003) has also reported similar ability to reduce the toxicity of neem products using the same species with farm yard manure as substrate. Similarly Bakthavathsalam and Rajaraman (2003) have also reproted similar ability to reduce the toxicity of carbofuran using the same species with pressmud and coir waste. The observed difference in the ability of substrates to reduce the toxicity of pesticides (Bakthavathsalam 2003), or its inability Bakthavathsalam and Ramakrishnan 2004) may be due to the difference in the nature of toxic products present/used. Over all the toxicity results revealed that the DCW exert only little toxic effect to *Lampito mauritii* as evidenced by high doses of g values and hence these materials may be used as manure to plants or toxicant to insect pests.

Macro and Micronutrients Analysis of Cabbage Waste

The levels of soil parameters such as pH, electrical conductivity, macronutrients (N, P, K) and micronutrients (Fe, Mn, Zn and Cu) present in the samples of DCW are given in Table 2. The pH values measured in the samples showed slightly basic in nature. The values of electrical conductivity (as a measure of soluble salts level) measured in these samples showed a greater level as most of the soil have. The availability of several plant nutrients and the levels of other elements present in any soil depends upon the pH value of organic manure. The pH value at neutral level should be considered important in retaining nitrogen since it is lost as volatile ammonia at high pH (Haimi and Huhta 1987) and the pH range, 6—7 seems to promote the availability of plant nutrients (Brady 1988). In the present analysis, the pH levels observed were slightly high 8.3 ± 0.1 when compared to the range suggested by Brady (1988) and hence the cabbage waste used in decomposed form is not safe for the plants to get available free nutrients for their better growth. But the current study revealed that the cultivation of chilly plants in pots using DCW exhibit somewhat better results due to soil with neutral pH.

Of the three macronutrients (N, P and K) and four micronutrients (Fe, Mn, Zn and Cu) analyzed in the samples of DCW, the levels of K and Fe were relatively high as compared to other nutrients. More amount of K was noticed in the samples of partly decomposed paddy chaff and weed plant materials (Bakthavathsalam and Geetha 2004), pressmud and cow dung (Bakthavathsalam 2007), paddy straw waste (Subramaniyan 2008), green gram waste (Jayaseelan 2008) and *Ipomoea carnea* plant materials (Aralvizhi 2008). The results of Uthayakumar (2006) and Arulvizhi (2008) respectively studied in vegetable market waste and *Ipomoea carnea* were also in confirmation with the present results of higher Fe values over other micronutrients (Mn, Cu and Zn). The chemical analysis revealed that the cabbage waste served as a best raw material for the production of nutrients rich organic fertilizer/manure with sufficient quantity of necessary macro and micronutrients as conformed by better growth and yield of chilly plants (Tables 3 and 4).

Effect of Cabbage Waste on the Growth and Yield of Chilly Plants

Stem length and total leaves and fruits yield in the chilly plants cultivated in pots using 0, 5, 10, 20, 30, 40 and 50 PSR of DCW, DCD and FCD are given in Tables 3 and 4 respectively. The plants raised in soil alone (0 PSR) showed poor growth and yield over other plants raised in different media and in different organic manures. The results observed in all the manures revealed a differential growth and yield of chilly plants with a trend in accordance with PSR. Among the three organic manures studied. the DCW showed relatively higher growth and yield values over other manures. One important observation noted in the growth of chilly plants with DCW was that the plants raised in higher PSR (40 and 50) though showed increased growth and yield, but their leaves were severely affected with insect pest of saprophytic type due to soft nature. The adverse effect in leaves and the beneficial effect in fruits yield may be attributed with more N and K present in the DCW respectively (Table 2). Similar adverse effect was also noticed in the studies made by Uthayakumar (2006) in black gram cultivation using 25 and 50 PSR of decomposed vegetable market waste. The results proved that the application of DCW has a positive role on the growth and yield of chilly plants. There have been numerous experiments in which plants have been grown in pots with earthworm cast or vermicompost, where an increase in plant growth has occurred. Kale and Bano (1986) found that the vegetative growth of plants was influenced by *Eudrilus eugeniae* worm cast in a better way than the chemical fertilizers. Line (1994) reproted that vermicompost of wood waste and seastar waste showed an excellent growth of tomatoes and lettuce. Kale (1994) has recorded an excellent growth and yield of cereals, pulses, oil seeds, spices, vegetables, fruits, ornamental plants, cash crops and plantation crops cultivated in vermicompost added soil. Arulmurugan (1996) has recorded an increase in plant height, root length, root volumes, number of seeds per plant, protein and oil content of seeds together with increased uptake of NPK by soybean plants. Vadiraj et al. (1996) noticed pronounced influence of vermicompost on the growth and yield of turmeric plant. Recently Ramalingam (1997) has studied the differential effect of organic manures (cattle dung, farmyard manure and pressmud) and vermicomposts (obtained from farmwaste + pressmud, water hyacinth + pressmud and water hyacinth + pressmud slurry) on the growth parameters of tomato from transplantation and found a many fold increase in the growth parameters of plants raised in soil with vermicompost over plants raised in soil with organic manure. Recently Bakthavathsalam and Deivanayaki (2007) have also noticed a significant influence of vermicompost with or without rhizobium on the growth and yield of black gram raised in pots.

From the adverse effect noticed in the current study, it is inferred that if the practice of application of pesticides during cabbage harvest continues, naturally the consumers of cabbage/wrapper leaves may get health hazards. As a precautionary measure, it is suggested that cabbage producing farmers should keep their cabbage heads free from pesticide while cultivation or harvest to safeguard the interest of cabbage consumers.

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