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Evaluation of Plant Yield, Macro and Micronutrients concentration in Zinnia (Zinnia elegans) Plant Tissue as well as in Soil Amended with Hair as Fertilizer

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Abstract: To meet the requirement of ever increasing population modern agricultural practices rely heavily on artificial or chemical fertilizers which later on creates critical pollution problems. To avoid the use of these chemical fertilizers number of waste material and by products (such as animal manure, municipal solid waste compost and sewage sludge) are used currently in agricultural crop production. An attempt is made in this work by the use of uncomposted hair waste as nutrient source for high value plants and to evaluate the effect of these waste materials on soil microbial community. In the Pot experiment, the addition of uncomposted hair waste to soil increased yield in Zinnia flower. Addition of hair waste also increased NH_4-N and NO_3-N in soil, increased total N concentration in plant tissue and stimulated soil microbial biomass. It`s addition also increased conc. of N, S, Ca, Na and Mg in soil as well as in plant tissue. Our result suggest that the addition of 3.3 g/kg or 7392 kg/ha of hair is sufficient for Zinnia crop and can support at least 2-3 harvest of crops, without the addition of other fertilizers.
Key Words: Uncomposted hair-waste, Microbial Biomass, Zinnia, Mineral elements, NH_4-N and NH_3-N.

I. INTRODUTION

Barber Shops situated at every corner of the city generate a significant amount of human hair waste that is usually put to garbage and ultimately end up in land fill which are creating severe environmental problem as Nitrate leaching from hair can contaminate the ground water (Nitrogen is one of the component of hair composition). Hair is made up of protein which originates in the hair follicle. As the cells mature, they fill up with the fibrous protein called keratin. These cells lose their nucleus and die as they travel up the hair follicle. Approximately 91% of the hair is protein made up of long chain of amino acids, joined to each other with the help of chemical bond which are called polypeptide. There are various elements found in the hair and they are used to make amino acids, keratin, melanin and protein. The average composition of normal hair is composed of 45.2% Carbon, 27.9% Oxygen, 15% Nitrogen and 5.2 % Sulphur. The keratin found in the hair is called 'Hard Keratin'. This type of keratin does not dissolve in water and is quite resilient. So keratin is an important insoluble protein and is made from 18 amino acids. The most abundant of these amino acids is Cystine which gives hair much of its strength. Property of hair as a source of slow releasing Organic Nitrogen is a valuable soil conditioner. It has been proposed that body stores of minerals may be estimated from hair analysis because growing hair is metabolically active and is a sequestering tissue[1].

It has been also found that sweat secreated by sebaceous glands may be an important source of minerals in hair and that fatty secretion of apocrine glands may provide physical or chemical means by which exogenous mineral may bind to hair. Hair is made up of Keratin and Keratin contains disulphide bonds that may be major binding sites of minerals in hair[2]. As the protein of hair will prove to be a natural fertilizer and farmers are escaped from using expensive and harmful chemical fertilizers. With the use of composted hair as fertilizer there is considerable loss of nitrogen [3], so in our study we have utilized uncomposted hair waste as a nutrient source for high value plants. The objective of this study was to examine the effect of uncomposted hair waste as nutrient source for Zinnia plant. Zinnia (Zinnia elegans) belong to family compositae, is a flowering annual plant. Because of its economical value and the hardiness of wild relatives was selected for the experiment. Zinnia is grown commercially as a bedding plant and cut flower. It is known for its tolerance to hot and dry conditions. Zinnia is also an economically important crop[4] Type of soil, pH, N_2, P and K are dominant factor for the growth and development of plant. The use of cover crops and green manure crops is recommended to maintain the soil organic matter. Zinnia is greatly responsive to fertilizer and in the study we have provided nutrient by means of hair waste.

II. MATERIAL AND METHODS

The samples of hair waste were collected from two local shops of Mukta Prasad Colony, Bikaner. These wastes were cleaned by hand picking the polythenes, matchsticks and other types of wastes.

Experimental pots were prepared by adding 6 kg of soil to each pot along with 300 g of cow dung compost. Treatment consisted of 0 g, 20 g, 40 g and 80 g of hair waste addition to the prepared pots. Zinnia seeds were sown in these pots. The experiment had a control with same treatment but with no plant to evaluate the effect of nutrient availability on plant. Zinnia was fully developed in 2 months with a 14 hr. day and 10 hr. night photoperiod, with an average day temperature of 28^0C. These were irrigated carefully and evenly once a day with sufficient water. The plant species were harvested when they were fully grown. After the harvest, the plant species were washed under running tap water to remove soil particles and then spread on newspaper for drying. After sun drying the plants were weighed and oven dried at 70^0C for 72 hrs. The herbage was ground using a Wiley Mill to pass through a 1.0 mm screen. The powdered form was kept for mineral and trace element analysis. Fresh soil samples from all experiments were taken at harvest and kept in a cooler at 4^0C for microbial biomass and NH_4-N and NO_3-N analysis. Additional soil samples for nutrient and trace element analysis were taken at harvest, air dried (at 20^0C), and ground with a mortar and pestle to pass through 2.0 mm screen. For tissue and soil trace element analysis, plant tissues were digested in the diacid mixture of 20 ml conc. HNO_3+2-3 ml conc. $HClO_4$ [5] and extract was prepared. For soil sample extract, DTPA method was used[6]. Parameters like pH is determined by pH meter, EC is determined by electro conductivity meter, Organic carbon by Walkley and Black titration method, Phosphorus in soil by Olsen's method and in plant tissue by titrametric method, K and Na by flame photometer, Ca & Mg in soil by Versenate (EDTA) titration method and in plant tissue by AAS, Sulphur estimation in soil and plant tissue in $CaCl_2$-extractable S by Williams and Steinbergs, 1969 in spectrophotometer, Fe, Mn, Cu and Zn in soil and plant tissue by AAS and microbial biomass of soil by fumigation-incubation method.

III. RESULT AND DISCUSSION

Result from this study suggests that hair waste is an excellent soil amendment and nutrient sources for high value crops. The soil used in the pot was sandy soil with very low nitrogen content and other minerals as shown in table 1. Analysis of hair showed that it contain good amount of all nutrients required by plants (table 2) and almost all nutrients showed their positive effect except few like Phosphorus and Potassium. It also introduces a significant amount of Na into the soil.

Table - 1: The initial physical and chemical characteristics and the concentration of plant available nutrients of soil used in the pot experiments.

Parameter	pH	O C (%)	EC millimhos/cm	P Kg/ha	K ppm	Ca & Mg me/l	S ppm	Na ppm	Fe Ppm	Mn ppm	Cu ppm	Zn ppm
Conc. in soil	8.72	0.13	0.17	24	187	8.5	0.055	750.2	0.638	1.6	0.788	2.036

A. Physico-chemical and Biological parameters of soil

NH_4-N and NO_3-N of Zinnia increased with increase in conc. of doses in control as well as with plant experiment (table 3). NH_4-N ranges between 0.512-18.02 ppm in control and between 0.30-12.40 ppm in with plant soil. NO_3-N ranges between 0.054-32.5 ppm in control and 0.40-19.69 ppm in with plant soil. The increase in NH_4-N and NO_3-N in soil is due to mineralization of N in hair rather than mineralization of soil N. pH of soil decreases with the addition of high doses of hair in soil and this is good for arid and semi arid regions where soil is mostly alkaline in nature. The optimum range of pH for plants is between 5.5-7.0 [7]. pH decreased from 8.70 to 8.40 (table-3) in control experiment. The decrease in pH helps in the availability of nutrients in soil to plants. Organic carbon is a measure of organic matter which is the seat of nitrogen in soil and the permissible limit is between 0.20%-1%[8]. Our experiment showed an increase with increase in dose i.e. from 0.09%-0.17% (table-3). EC also increased with increase in dose but all values are with in permissible limit which is below 0.75 millimhos/cm[9]. The range found is between 0.14-0.55 millimhos/cm (table-3). The increase is because of liberation of sodium which increases the salinity of soil Calcium and Magnesium content in soil as well as in plant tissue increases with increase in dose. This is because hair contains a good amount of Ca & Mg. The range found of Ca & Mg in soil is 8.9-13.0 me/l (table 4). In plant tissue the maximum conc. of Ca & Mg is found at 40 g dose after that conc. decreases because excess ammonia induces Ca deficiency[10]

Sulphur content increases in both soils as well as in plant tissue. Sulphur present in our soil is very low i.e.0.055 ppm and with addition of hair it's conc. increases but still below the permissible limit i.e. 10-20 ppm [11].The value increases from 0.055 to 0.605 ppm (table 4) and in plant tissue it increased from 28.5 to 59.0 ppm and values are below permissible limit of 0.05%-1.5%[12]. The increase in S value is due to mineralization of hair. Experimental soil is rich in sodium content i.e. 750.2 ppm and is not required further and with the addition of hair it's conc. further increases from 750.2-842.6 ppm but not beyond the critical level of 5 %[13]. In plant tissue also it increases from 132-364 ppm (table 4). Soil used in experiment is deficient in iron content i.e.0.638 ppm and is below the permissible limit of 2.5 ppm[14]. So the addition of hair is beneficial as it enrich the soil with iron content from 2.618-2.0 ppm (table 4). In plant tissue the maximum value comes at 20 g dose i.e. 160.3 ppm. Values of plant tissue are within permissible limit i.e. from 10-250 ppm[12] Manganese content in soil is found to be 1.6 ppm (table 4) which is above the permissible limit of 1.0 ppm[14],hair waste addition further increase it from 1.6-27.74 ppm and it is a good increase. In plant tissue the increase is from 11.12-25.83 ppm but the values are within the permissible limit i.e.10-1000 ppm [12]. Copper conc. increases in soil i.e from 0.788-0.816 ppm in soil and in plant tissue 20g dose shows the maximum value i.e. 2.72 ppm (table 4). All the values are within permissible limit i.e. 0.2-10 ppm in soil [14]and 1-50 ppm in plants [12]. Zinc conc. increases with increase in dose from 2.036-3.726 ppm in soil and values are above the critical level of 0.3 ppm[15]and experimental soil has Zn content as 2.036 ppm. In plant tissue it also increases from 2.72-4.52 ppm and the values are with in the permissible limit i.e. from 1 to 200 ppm [12](table 4). Microbial biomass increased in soil with plant as well as in soil without plant, this is because various chemicals secreted by plants attract myriads of micro organisms. The increase is from $3x10^4$/g to $1x10^5$/g in Zinnia grown soil and $1x10^4$/g to $255x10^4$/g in control experiment (table 3).

Table – 2: The elemental concentration of hair waste used in the pot experiment with Spinach.

Parameter	This study ^	Literature		
		Hair $	Hair #	Hair @
C	395 g/kg	413 g/kg	-	-
N	1.2 g /kg	1.3 g/kg	-	-
Ca	2.1 g/kg	2.45 g/kg	1022 micro g/g	1090ppm
Mg	70 ml/kg	78 ppm	94 ppm	105 micro g/g
K	22 ppm	72 ppm	5.3 micro g/g	11.8 micro g/g
Na	143 ppm	187 ppm	261 micro g/g	266 micro g/g
Fe	4.43 ppm	39 ppm	-	-
Cu	14.77 ppm	19 ppm	22 ppm	23 ppm
Mn	1.1 ppm	2 ppm	2.5 ppm	2.94 ppm
Zn	117 ppm	217 ppm	192 ppm	189 ppm
P	92 ml/kg	104 ppm	207 micro g/g	184 micro g/g
S	50.6 g/kg	89.6 g/kg	42300 ppm	46900 micro g/g

^ Elemental concentration of hair in this study was measured on AAS and various techniques described in material and methods following digestion in conc. HNO_3.

$ Hair mineral content as reported by Zheljazkov, V.D., 2005.

Hair mineral content as reported by Dean A. Bass, 2001.

@ Certified Value of hair mineral content as suggested by Shanghai Institute Of Nuclear Reasearch Academia Sinica (SINRAS).

Table-3- Zinnia yield, NH_4-N, NO_3-N, pH, EC, OC and Microbial Biomass as affected by hair waste addition to soil with or without Zinnia plant and total nitrogen conc. of Zinnia tissue as affected by hair waste addition to soil in pots.

Crop	Hair g/pot	Soil NH_4-N (ppm)	Soil NO_3-N (ppm)	Tissue N (%)	DM yield (kg/pot)	Microbial biomass (/g)	pH	EC (milimhos/cm)	OC (%)
No crop	0	0.512	0.054	-	-	1×10^4	8.78	0.18	0.14
	20	0.587	1.200	-	-	20×10^4	8.80	0.21	0.15
	40	1.600	3.240	-	-	23×10^4	8.60	0.28	0.17
	80	18.020	32.500	-	-	255×10^4	8.50	0.40	0.18
Zinnia									
	0	0.30	0.40	0.924	0.200	3×10^4	8.70	0.14	0.09
	20	0.49	1.19	1.512	0.345	4×10^4	8.62	0.32	0.13
	40	5.20	6.60	2.072	0.338	4×10^4	8.64	0.40	0.16
	80	12.40	19.69	2.380	0.307	1×10^5	8.40	0.55	0.17

Table-4- The phytoavailable nutrient conc. in soil (with or without plant), amended with Hair waste and total nutrient content in Zinnia tissue grown in pots with 0, 20, 40 and 80 g/pot in the hair waste pot.

Crop	Hair g/pot	Na ppm	S ppm	Ca&mg me/l		Fe ppm	Zn ppm	Mn ppm	Cu ppm
No crop (soil)	0	750.2	0.055	8.9		0.638	2.036	1.60	0.788
	20	838.2	0.119	11.2		0.762	2.790	4.60	0.790
	40	842.6	0.450	12.2		1.134	3.404	9.00	0.810
	80	890.4	0.605	13.0		1.380	3.726	27.74	0.816
Zinnia (soil)	0	761.2	0.245	8.1		2.618	2.172	10.370	1.168
	20	732.6	0.375	9.6		2.370	6.550	9.330	1.102
	40	765.6	0.425	10.4		1.876	1.804	8.080	0.978
	80	710.6	0.750	12.8		2.000	3.986	13.284	1.086
Total concentration of nutrients in plant tissue									
				Ca ppm	Mg ppm				
Zinnia	0	132.0	28.5	3594.51	293.40	160.3	2.72	11.12	2.72
	20	132.0	33.5	4007.97	296.21	155.4	3.17	12.57	2.05
	40	286.0	48.0	4971.76	295.95	148.0	3.76	14.39	1.78
	80	364.0	59.0	4119.63	296.28	48.97	4.52	25.83	1.78

B- Analysis of Plant Tissue

Zinnia (Zinnia elegans) belong to family compositae, is a flowering annual plant. Because of its economical value and the hardiness of wild relatives was selected for the experiment. Type of soil, pH, N_2, P and K are dominant factor for the growth and development of plant. The yield was maximum in 20 g dose and number of flowers and health of plant is also good in 20 g. pH decreases from 8.70 to 8.40 with increase in conc. EC increase with increase in conc. but the values are within permissible limit. At 20 g dose the values of parameters are as –NH_4-N in control as well as in with plant is 0.587 ppm and 0.49 ppm respectively, NO_3-N in control and with plant soil is 1.20 ppm and 1.19 ppm respectively, Plant tissue nitrogen-1.512%, Ca – 4007.97 ppm, Mg – 296.21 ppm, S – 33.5 ppm, Na – 132 ppm, Fe – 155.4 ppm, Mn – 12.57 ppm, Cu – 2.05 ppm, and Zn- 3.17 ppm. 4×10^4/g is the microbial biomass at 20 g dose. In Zinnia plant tissue the conc.of N_2, Ca, Mg, S, Na increases with application of hair.

IV. CONCLUSION

The results from this study suggest that addition of hair waste not only increased macro and micro nutrients in soil and plant tissue but also enrich the soil with microbial biomass. Study concluded that 20 g dose of hair in 6 kg soil is sufficient in Zinnia for their appropriate growth. Following conclusions are drawn from the results-

A. We added 0-80 g of hair waste in Zinnia and observed that Zinnia gave best results with maximum growth at 20 g dose, the reason being it is a decorative plant and does not require more fertilizer, with more addition of fertilizer the number of leaves increases but number of flower decreases. So yield of Zinnia flower was maximum in 20 g dose.

B. If we apply this dose in field it will be equivalent to 3.3 g/kg or 7392 kg/ha (or 20 g of hair waste in 6 kg soil). The use of a large quantity of human hair waste as a nutrient source for crop production used for direct human consumption (e.g. vegetables) may be questioned; these might be point of issue with marketability and social acceptance. As there are specific guidelines and regulations for the use of sewage sludge or industrial waste, similar guidelines should be developed for the use of these waste materials in agricultural crops. But this is not applicable to Zinnia as it is a decorative plant.

C. Our results also demonstrated that the addition of large amount of hair waste to soil would depress soil pH due to mineralization and oxidation of Sulphur and Nitrogen containing compounds. But this is good for arid and semi-arid regions where soil is mostly alkaline in nature. In acidic soil the application of higher dose of hair is not recommended.

D. Study also showed that there is increase in Organic carbon % with the addition of hair waste which not only help in the increase of organic matter but also increases the water holding capacity of soil.

E. S, Fe, Cu, Mn & Zn conc. increases both in soil as well as in plant tissue because of high amount of these nutrients in hair.

So our study will help Barbers and Farmers as Barbers get the better way of disposing waste and in turn get the monetary benefit by selling it. On the other hand, Farmers will get a better option for chemical fertilizers as the hair waste is not only inexpensive but also enrich their fields chemically and biologically. Overall our results suggest that uncomposted hair waste can be an excellent soil amendment and nutrient source for high-value crops.

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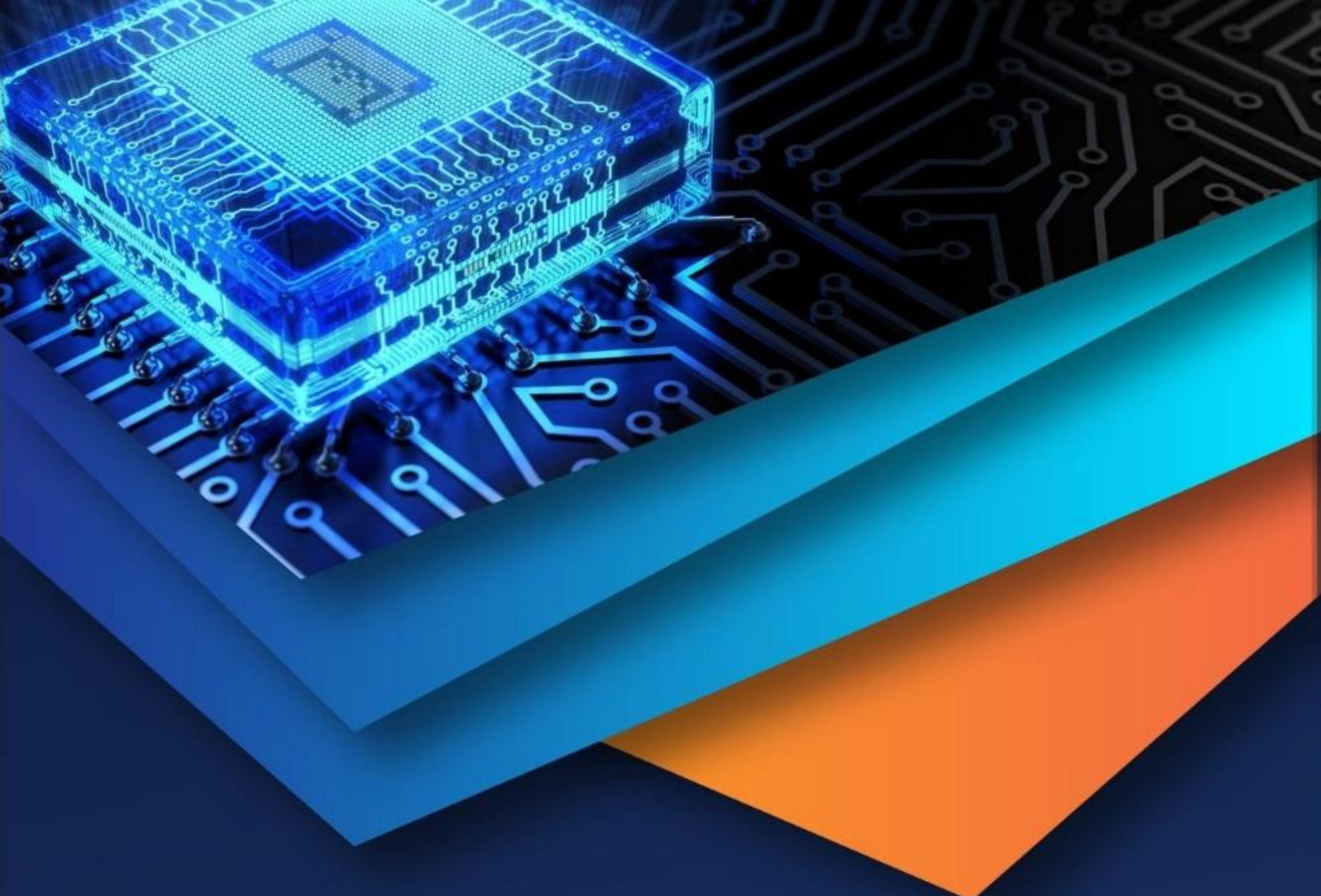

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