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Studies on bioavailability of nutrients in decomposed crushed seeds, oil cakes and deoiled cakes of neem (*Azadirachta indica* L.)

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Abstract
An experiment was conducted to study the "Bioavailability of nutrients in decomposed crushed seeds, oil cakes and deoiled cakes of neem (*Azadirachta indica*)" under the greenhouse condition. The three forms of neem cakes were subjected to decomposition for a period of 30, 60 and 90 days in a plastic containers of capacity five kg. The chemical composition of deoiled cake was 4.51 % N, 0.79 % P, 1.40 % K, 57 ppm Zn, 640 ppm Fe, 1.40 ppm Ca and oil content 1.09 % while in oil cake and crushed seeds 4.21 and 3.99 % N, 0.71 and 0.64 % P, 1.30 and 1.10 % K, 49 and 43 ppm Zn, 630 and 633 ppm Fe, 1.40 and 1.30 ppm Ca and oil content 10.27 and 22.53 % respectively. The nutrient release has increased by increasing number of days of decomposition and the higher nutrient release and nutrient uptake was observed in deoiled cake at 90 days of decomposition as compare to oil cake and crushed seeds at 30, 60 and 90 days of decomposition. The effect of decomposed material thus obtained after 30, 60 and 90 days of decomposition was tested on maize crop.

Keywords: bioavailability, neem cakes, decomposition, nutrient release and nutrient uptake

Introduction
India is self-sufficient in the production of food grains due to intensive cropping with increased use of chemical fertilizers under irrigated conditions. However, modern chemical based agricultural practices have led to several new challenges viz., degradation of soil, declined productivity, increased pollution hazards etc. Under such situations, organic and integrated nutrient management play significant role in improving the productivity and sustainability of soil fertility. The likely large-scale bio-energy crop plantations for producing bio-fuels following promotional activities of the government and increased awareness among the public are expected to result in the production of large quantities of by-products such as oil cakes (after oil expulsion from seeds). The resulting oil cakes can be recycled as valuable sources of major and micro-nutrients. The utility of neem oil seed cake as a fertilizer as well as a pesticide on economically important crop species is well established (Ramesh *et al.*, 2009) [9].

Neem, *Azadirachta indica* is native to the arid regions of the Indian sub-continent, where it grows to 12-24 m high at altitudes between 50 and 100 m with 130 mm of sufficient rainfall per annum for its normal growth. Neem is also called 'arista' in Sanskrit- a word that means 'perfect, complete and imperishable'. The seeds, bark and leaves contain compounds with proven antiseptic, antiviral, antipyretic, anti-inflammatory, anti-ulcer and antifungal uses. Fresh fruit yield per neem tree ranges between 37 and 50 kg per year at maturity. Neem has an ability to withstand extreme heat and water pollution is well known and it also helps to improve fertility of the soil and to rehabilitate degraded wastelands and the United Nations declared it as the "Tree of the twenty first century". Its large scale production promises to help alleviate several global environmental problems like deforestation, desertification, soil erosion and perhaps even global warming (if planted on a truly large scale). Large scale neem plantations can help in rehabilitation of degraded forest lands and vast tracts of wastelands and greening the environment.

The mobility of soil nutrients in relation to their availability to plants which mainly depends on quantity/intensity ratio of nutrient availability altered by the soil and plant dynamics. The release of nutrients from their solid phase to solution phase in soil i.e. movement of nutrients through soil solution to the plant and the absorption of nutrients by plant root-mycorrhizal system are the important process which control the availability of soil nutrients (Comerford, 1998) [3].

The soil–plant system's capacity to supply/absorb nutrients is termed as soil nutrient bioavailability and is the ability of soil–plant system to supply essential plant nutrients to a target plant or plant association during a specific period of time.

The soil controls the availability of most of the essential plant nutrients. It regulates the availability by means of bio physico chemical processes, which are functions of soil and plant properties.

Neem is used as manure for improving the soil fertility and thus promoting plant growth. Neem manure is gaining popularity because it is environmental friendly and also the compounds found in it help to increase the nitrogen and phosphorous content in soil. It is rich in sulphur,

potassium, calcium, nitrogen etc. Neem cake is used to manufacture high quality organic or natural manure, which does not have any aftermaths on plants, soil and other living organisms. It can be obtained by using high technology extraction methods like cold pressing or other solvent extraction methods. It can be used directly by mixing with soil or can be blended with urea and other organic manures like farm yard manure and sea weeds for best results. It has many benefits like bio-degradability and ecofriendly, nourishes the soil and plants by providing all the macro and micro-nutrients. Helps in eliminating bacteria responsible for denitrification. Increases the yield of crops, helps to reduce the usage of fertilizers thus reducing the cost of cultivation. It has antifeedant properties that help to reduce the number and growth of insects and pests (Subbalakshmi *et al.*, 2012) [11].

Materials and Methods

Location of experiment

Experiments were conducted under greenhouse conditions (13.083727” N, 77.577329” E) in the Bio-fuel research unit, Department of Forestry and Environmental Science, UAS, GKVK, Bangalore.

Experimental Details

A pot culture experiment was conducted under greenhouse conditions with four treatments T_1-Control, T_2-Raw crushed neem seeds, T_3-Neem oil cake and T_4-Deoiled cake and five replication. Oil cake is extracted using cold press extractor and the deoiled cake using solvent extraction method and the oil content of crushed seeds, oil cake and deoiled cake of neem was determined by soxtherm method as per the standard procedure by using the formula.

$$\text{Oil content (\%)} = \{(W2-W1)/ W\} \times 100.$$

The soil samples from the treatments were collected at 30, 60 and 90 days interval after incubation and analyzed for organic C, Available -N, Available -P, Available -K, micronutrients (Zn, Fe and Cu).

Statistical analysis of the data was carried out for completely randomized design. The level of significance used in ‘F’ test was P=0.01. Critical difference was calculated wherever ‘F’ test was significant.

Result and Discussion

The chemical composition of different forms of neem oil cake were analyzed and indicated that the deoiled cake had 4.51 % N, 0.79 % P, 1.40 % K, 57 ppm Zn, 640 ppm Fe, 1.40 ppm Ca and oil 1.09 % while in oil cake and in crushed seeds 4.21 and 3.99 % N, 0.71 and 0.64 % P, 1.30 and 1.10 % K, 49 and 43 ppm Zn, 630 and 633 ppm Fe, 1.40 and 1.30 ppm Ca and oil content 10.27 and 22.53 % respectively and The initial chemical composition of soil is presented in Table 2. The analysis indicated that the soil had pH-5.46, EC-0.21 dS m^{-1}, Org.-C-0.42 %, N-281.7 kg ha^{-1}, P -25.8 kg ha^{-1}, K-61.5 kg ha^{-1}, Fe ppm-31.52, Zn ppm-2.05, Mn ppm-48.69, Cu ppm-3.74. The similar results were observed by Balakrishna *et al.* (2007) [2] reported that neem cake contains macronutrients like nitrogen 3.9 %, phosphorus 0.36 % and potassium 1.0 % and Osman *et al.* (2009) [6] revealed neem seed cake also contain micro nutrients like Iron 800 ppm, Zinc 59 ppm, Manganese 74 ppm and Boron 19 ppm, and can be utilized as a good source of manure.

Effect of oil cakes on primary nutrient status of soil at different stages of decomposition.

The changes in available N, P_2O_5 and K_2O during the process of decomposition due to different treatments at different periods is prosecuted in Table 1. There was an increased in available N, P_2O_5 and K_2O from 30 days onwards and there was no significant difference observed in available N at 0 days after decomposition (DAD). The treatment T_4 recorded significantly higher available N, P_2O_5 and K_2O which was on par with T_3 and significantly higher compared treatment T_2 and T_1 at 30 days of decomposition. Similarly at 60 days, treatment T_4 recorded significantly higher available N, P_2O_5 and K_2O which was on par with treatments such as T_3 and T_2 and significantly higher compared T_1. Similar trend was also observed at 90 days of decomposition period; the least available N, P_2O_5 and K_2O content was recorded in T_1 and significantly higher available - N, P_2O_5 and K_2O was observed in T_4 which was on par with T_3 and T_2.

Table 1: Available N, P_2O_5 and K_2O (mg kg^{-1}) Nutrient release due to decomposition of crushed seeds, oil cake and deoiled cake at different time intervals.

Treatments	0 DAD			30 DAD			60 DAD			90 DAD		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Control-T_1	125.52	11.52	27.46	125.07	11.52	27.65	125.77	11.72	27.65	124.80	11.79	27.45
Crushed seeds -T_2	125.84	11.52	27.50	126.13	11.70	27.81	130.25	12.90	28.84	131.74	13.19	29.33
Oil cake-T_3	125.46	11.65	27.59	128.05	12.49	28.49	132.21	13.24	29.60	135.31	14.09	29.96
Deoiled cake-T_4	126.24	11.83	27.72	131.75	12.87	29.64	137.68	13.46	30.49	139.25	15.43	32.10
SEM	2.42	0.25	0.66	1.45	0.22	0.50	2.63	0.28	0.59	2.66	0.24	0.65
C.D.(0.05)	NS	NS	NS	4.35	0.67	1.50	7.90	0.85	1.79	7.99	0.73	1.96

Note: DAD – Days after decomposition.

The increase in the available nitrogen might be because of weight loss during decomposition as the carbon oxidized due to the microbial activities and higher surface area of deoiled cake (Rajbanshi and Inubushi, 1998; Anil and Sreenivasa, 1998; Balakrishnan *et al.*, 2007) [7, 1, 2]. With respect to P content revealed by Jha and Rathor (1984) [4] stated deoiled seed cake being used as organic manures have dissolution of minerals mainly phosphorus and increased rate in soil detoxification on harmful substances. Moreover, leaching of plant nutrients also reduced in the presence of organic substances in soil. The increase in the K content might be because of direct manifestation of mass loss during decomposition as lot of carbon from the substrate was oxidized to carbon dioxide due to increased biological activity (Anil and Sreenivasa, 1998; Balakrishnan *et al.*, 2007) [1, 2].

Nutrient uptake

Application of deoiled cake and oil cake of neem had positive impact on nitrogen, phosphorous and potassium uptake however, results (Table 2) were revealed that at 90 DAD the significantly higher uptake of NPK was recorded in treatment T_4 which received deoiled cake compared to T_3 fallowed by T_2 which is on par with T_1 and in case of 30 DAD and 60 DAD the treatment T_4 showed significantly higher uptake over T_3 fallowed by T_1 which is on par with treatment T_2. Similarly at 0 DAD the treatment T_4 was significantly higher compared to all the treatments.

Maize has high demand for N as indicated by the high N uptake compared to P across all treatments. The high uptake of N is linked to the high demand for protein production being utilized in crop development (vegetative and reproductive stages) while P is mostly required to boost early root development resulting in uptake of other soil nutrients for plant growth and development. The uptake trend for K study confirms that maize has higher requirement of K after nitrogen. Compared to oraganic fertilizer like cakes to inorganic fertiliser, previous studies also showed that organic amendments (cakes) treated treatments shows significantly higher NPK uptake may be due to more balanced available nutrient for plant uptake (Lehmann. 2006) [6].

Table 2: Effect of different forms of neem cake decomposed at different time intervals on N, P and K uptake (mg kg^{-1}) by maize

Treatments	0 DAD			30 DAD			60 DAD			90 DAD		
	N	P	K	N	P	K	N	P	K	N	P	K
Control-T_1	14.69	0.76	6.45	17.93	0.78	6.81	20.92	0.79	5.97	21.24	0.87	7.62
Crushed seeds-T_2	9.86	0.86	2.99	12.28	0.99	3.90	17.73	1.59	5.27	24.95	2.18	7.26
Oil cake-T_3	17.29	1.20	7.79	25.10	1.49	11.38	26.36	1.53	9.94	39.57	2.37	13.60
Deoiled cake-T_4	35.58	2.20	12.39	42.76	2.91	15.84	44.46	3.76	16.20	53.40	4.31	17.64
SEM ±	1.53	0.12	0.15	2.18	0.16	0.19	2.32	0.20	0.18	2.71	0.28	0.25
C.D @ (0.05)	4.59	0.36	0.44	6.56	0.48	0.58	6.97	0.61	0.55	8.15	0.86	0.76

Note: DAD – Days after decomposition.

Conclusion

The higher nutrients release was observed by deoiled cake at 90 days of decomposition and higher nutrient uptake was also recorded under the treatment deoiled cake at 90 DAD compare to 60, 30 DAD and compare to oil cake and crushed seeds, it has better decomposition. Hence a higher nutrient release and decomposition was observed in 90 DAD we can effectively use in short duration crops like vegetables or we can effectively plan according to critical crop growth period.

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