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Poljoprivreda/Agriculture

ISSN: 1848-8080 (Online)
ISSN: 1330-7142 (Print)

http://dx.doi.org/10.18047/poljo.21.1.8

Poljoprivredni fakultet u Osijeku, Poljoprivredni institut Osijek

Faculty of Agriculture in Osijek, Agricultural Institute Osijek

ISSN 1330-7142
UDK: 631/635
DOI: 10.18047/poljo.21.1.8

EFFECTS OF NEEM (*Azadirachta indica* L.) SEED CAKE ON THE GROWTH AND YIELD OF OKRA (*Abelmoschus esculentus* (L.) Moench)

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Original scientific paper
Izvorni znanstveni članak

SUMMARY

Soils of the southern Guinea savannah are generally inherently infertile owing to low vegetation cover, soil erosion and low organic matter content due to constant bush fire. Consequently, farmers move close to streams and rivers in the dry season where okra is cultivated by irrigation. Field experiments were conducted at the Teaching and Research Farm of the University of Ilorin, Ilorin Nigeria during the 2012 and 2013 cropping seasons to evaluate the effects of neem seed cake on the performance of okra. The neem seed cake was incorporated into the soil one week before sowing of the okra seeds at the rate of 0, 1, 2, 3 and 4 t/ha. The experiment was laid out as a randomized complete block design replicated thrice. Data were collected on growth parameters (plant height, number of leaves and number of branches) and yield parameters (fruit length and girth, number of fruits per plant, fruit weight per plant and fruit weight per hectare). The result indicated that applying neem seed cake significantly affected the growth and yield parameters that were evaluated. Applying neem seed cake, however gave the highest yield at 3t/ha. Percentage mean for the two years combined was 75.81% over the control.

Key-words: neem seed cake, soil properties, growth, yield of okra

INTRODUCTION

Okra (*Abelmoschus esculentus (*L.) Moench) which belongs to the Malvaceae family is the fourth most popular vegetable specie in Ghana after tomatoes, peppers and eggplants. In Sudan, the crop is the fourth most important vegetable and in Cameroun, the second most important vegetable in the market after tomatoes (Schippers, 2000). The crop is also important in India, and in Nigeria alone, it occupies 1.5 million hectares (IFA, 1992). The immature fruits which contains minerals, vitamins and high mucilage content are used for thickening soups and stews (Udo and Akpan, 2002). Young shoots and flowers are also used as food (Ndaeyo et al*.,* 2005). Young immature fruits are an important vegetable consumed cooked or fried (Grubben and Denton, 2004).

Mucilage is used medicinally as plasma replacement or blood volume expander (Grubben and Denton, 2004). The crop has a yield potential of 30 – 40t/ha if growth factors are used (IFA, 1992), but there is a wide gap between this potential yield and realized yield. There is a need to minimize the difference between this potential and obtained yield. The obstacle towards the realization of this set objective is inadequate soil nutrients.

Farmers in the tropics have adopted the use of inorganic fertilizers but intensive use of this over time have been reported to constitute a setback to soil (Isherwood, 2000) since it pollutes the underground water resources (Uma Singh and Pokhriyal, 1997) and increases soil acidity. However, vegetables cultivated by using organic manures are getting more important because of less chemical residues, better taste as well as their effect on soil health and environment (Sunanda Rani and Mallareddy, 2007). Although many organic sources are available their nutrient supplying capacity

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is not similar. It is therefore pertinent to evaluate the effects of these organic materials on the performance of individual crops. Sivaprakashan (1991) reported that plant debris, farmyard manure and compost improved crop productivity by improving nutrient status as well as increasing microbial activity in the soil. Similarly, nutrient supply through oil-based cakes which is a form of organic manure will not only reduce the dependence on chemical fertilizers but also improve the soil structure, encourage the growth and activity of beneficial organisms in the soil, alleviate the deficiency of secondary and micronutrients and sustain higher productivity due to improved soil health (Tiwari, 2002; Singh et al., 2006).

Majority of studies have indicated that crop production has benefited from the application of organic residues due to the possibility of recycling organic matter, N, P and K and other nutrients (Adeoye et al*.*, 2008). Smith et al. (2001) reported that the use of soil amendment under a humid environment significantly increased the growth and yield of okra pods.

The soils of southern guinea savannah are inherently infertile because of low vegetation cover, soil erosion and low organic matter content due to constant bush fire. There is therefore a need for the application of external nutrient inputs in the form of neem *(Azadirachta indica)* seed cake for the growth of vegetables as well as other arable crops. Neem seed cake is the residual matter left after neem seed kernels are crushed to extract neem seed oil. Neem seed cake contains more nitrogen (2–5%), phosphorus (0.5–1.0%), potassium (1–2%), calcium (0.5–3%) and magnesium (0.3-1.0%) than farmyard manure or sewage sludge (Radwanski and Wickens, 1981). Neem seed cake not only provides nutrition to the plant, but increases the population of earthworms and produces organic acids, which helps in the reduction of soil alkalinity (Korah and Shingte, 1968). Soon and Bottrel (1994) asserted that neem seed cake acts as natural fertilizer with pesticide properties whereas Parmar (1986) reported that neem seed cake exhibits insecticidal properties, nitrification retardation and inhibitor of pesticide degradation. Singh et al. (1986) observed that neem seed cake increased the number of branches, root length and dry matter weight of crops after ten months compared to the control. There is therefore a need to reduce the use of inorganic fertilizers. Hence, the objective of the study was to evaluate the effects of neem seed cake on the soil properties as well as on growth and yield of okra.

MATERIALS AND METHODS

The experiment was carried out during the wet seasons of 2012 and 2013 at the Teaching and Research Farm of the University of Ilorin, Ilorin (8º 49′ N, 4º 49′ E and 307 meters above sea level) in a southern Guinea savannah zone of Nigeria. The area is characterized by an annual rainfall of 1186 mm, mean annual temperature of 29°C while the average annual relative humidity is about 85%. The site was left fallow for two years after it was cropped to maize and cassava prior to the establishment of the experiment in 2012 and 2013. The soil of the experimental site was prepared before soil samples were collected from 0-30 cm depth from fifteen locations prior to planting and after harvesting within the experimental plots. These were bulked and sub-sample was taken for chemical characterization using standard scientific procedures. The results of the soil analysis are presented in Table 1. Soil of the experimental site was prepared and ridges were made. Each plot consisted of two ridges measuring 5 x 1 m separated by a 0.5-metre avenue. The neem seed cake (NSC) was incorporated into the soil at the rate of 0, 1, 2, 3 and 4t/ha using a hoe one week before sowing. Sowing of the seeds was done on the 25th of July, 2012 and 25th of July 2013 at a spacing of 30 x 30cm using NHAc variety (a recommended variety because of its early maturity) from NIHORT, Ibadan. Three-hand weedings were carried out at 3, 6 and 9 weeks after planting. Data collected on five tagged plants representing the net plot were on vegetative parameters (plant height, number of leaves and number of branches) and yield parameters (number of fruits per plant, fruit weight per plant, fruit length and girth and fruit weight per hectare). The plant height was assessed by measuring from the base of the plant to the terminal point of the stem, the number of branches and leaves were assessed by visual count of the green leaves and branches. Digital caliper was used to measure the fruit width, length, number of pods per plant was assessed by counting the number of fruits per plant at each harvest, fruit weight per plant was measured by using a sensitive balance, and the weight per hectare was extrapolated from the weight per plant. Analysis of variance (ANOVA) for all measurements were performed using Genstat software version 12 statistical package for randomized complete block design (RCBD) and mean separation was done based on the work of Steele and Torrie (1980).

Table 1. Soil properties of the experimental site before and after cropping in 2012 and 2013

Tablica 1. Svojstva tla na pokusnoj lokaciji prije i poslije sjetve u 2012. i 2013.

Year	Soil pH	Percent			Ppm	cmol/kg		
		Org C	Org. matter	Total N	P	K	Ca	Mg
2012a	6.2	0.59	1.02	0.08	3.43	0.12	2.15	0.90
2012b	6.5	1.01	1.88	0.13	3.28	0.21	3.00	0.84
2013	6.6	0.61	1.05	0.07	3.32	0.14	2.20	0.70

a. Before initial cropping, b. End of first year cropping

RESULTS AND DISCUSSION

The result of the soil analysis indicated that prior to planting in 2012, the soil pH was slightly acidic, the organic carbon content was low and after cropping the organic carbon content was moderate. This could be due to the incorporation of neem seed cake that is a rich source of organic carbon hence organic matter content which is a rich source of plant nutrients. This was in agreement with the findings of Shivakumar et al. (2011) who reported an increase in organic carbon content from 0.03 to 0.06 % after the application of neem seed cake in finger millet. Wilkinson (1979) also reported the beneficial effect of organic manure could be attributed to an increase in organic matter content as a result of regeneration of CO_2 during organic development. Neem seed cake acts as a nutrient reservoir providing favourable pH, aeration and improving other physical and chemical properties of the soil (Uma Singh and Pokhriyal, 1997). Organic matter acts as nutrient reservoir and on decomposition release organic acids and the crops might absorb ions through their roots for the entire growth period leading to higher yields (Kumar et al., 2009). The total nitrogen content before cropping and the incorporation of neem seed cake was very low. At the end of the first cropping season the nitrogen content was moderately low indicating an increase in the soil fertility status because of NSC incorporation. Neem seed cake improved the soil organic matter content and fertility of the soil (Azim et al., 2011). Aderni (2006) reported that the application of organic manure significantly increased level of organic carbon and nitrogen when compared to the application of inorganic fertilizer. The application of neem seed cake may have improved the availability of nutrients to the crop by enhancing the mineralization and supply of readily available nutrients to the soil microbial community (Yusuf et al., 2011). Organic manure like oil seed cake supply micronutrients beneficial to crop growth and productivity (Das et al., 2004). The increased soil nutrients after the first cropping could be attributed to the nutrient status of the neem seed cake. Similar results have been observed by Shivakumar et al. (2011) using neem seed cake on finger millet and Lei Meng et al. (2005) using organic manures.

The phosphorus content before and after incorporation was low. The K content before cropping was very low and increased after first season`s cropping because of NSC incorporation. The Ca and Mg contents were low before and after cropping. The results of the soil analysis indicated the presence of macro and micronutrients in neem seed cake that can be absorbed by crop plants. Oil seed cake increased microbial activity and brought about increased conversion of nitrogen to nitrate form, which ultimately increased metabolic activities of plant and then plant growth (Tiayagi and Ajaz, 2004).

Growth parameters of okra

The data on the growth parameters in 2012 of okra at 4, 6, 8 and 10 weeks after planting (WAP) are presented in Table 2. The result indicated that at the four sampling periods of 4, 6, 8 and 10WAP, there was a significant ($P < 0.05$) increase in plant height, number of leaves and number of branches with increase in the rates of neem seed cake (NSC) application. There was a significant response of okra to the different levels of NSC application in the vegetative and yield parameters. This could be attributed to the contribution of the NSC, which is a form of organic amendment to supplying the plants with macro and micro nutrients which are essential for the growth, development and yield of okra. NSC brings about improvement in plant growth due to better soil nutrition status (Kumar and Khanna, 2006). Olaniyi et al. (2005) reported significant increase in plant height and number of leaves of okra when organo-mineral fertilizer (OMF), a type of organic manure was applied in Ogbomoso in South West Nigeria and optimum result was recorded at 4 t/ha. Ikeh et al. (2013) observed that the application of 8 t/ha of poultry manure resulted in significantly higher number of fruits and increased yield of chilli peppers.

Table 2. Effects of neem seed cake on the growth parameters of okra in 2012

Tablica 2. Utjecaj sjemene pogače nima na pokazatelje rasta bamije u 2012.

NSC (t/ha)	Plant height (cm)				No of leaves/plant				No of branches/plant			
	weeks after planting				weeks after planting				weeks after planting			
	4	6	8	10	4	6	8	10	4	6	8	10
0	15.92	17.61	23.02	37.59	11.00	13.33	15.72	16.67	3.00	4.00	4.78	5.78
1	18.19	19.59	25.86	43.70	11.67	14.20	16.26	19.00	4.33	5.00	5.83	6.31
2	18.78	20.97	27.24	46.72	13.67	14.40	16.96	20.10	5.33	6.67	7.37	6.68
3	19.32	24.14	32.21	57.92	15.00	15.71	18.64	23.60	6.00	7.33	8.80	7.87
4	20.32	24.20	32.22	57.27	15.33	16.13	18.67	23.48	6.00	7.33	8.41	7.95
Mean	18.50	21.30	28.11	48.64	13.33	14.75	17.25	20.57	4.933	6.01	7.04	6.92
LSD(0.05)	1.921	1.769	4.179	4.805	0.688	1.729	0.822	1.507	1.396	1.002	0.930	0.408

NSC= neem seed cake

The data on the growth parameters of okra in 2013 at 4, 6, 8 and 10 WAP are presented in Table 3. The data on plant height of okra indicated that the plant height increased significantly ($P<0.05$) at 4, 6 and 8 WAP but at 10 WAP, there was no significant response to the applied neem seed cake. The data on the number of leaves indicated that as the rates of application of neem seed increased, there was a significant ($P<0.05$) increase in the number of leaves across the four sampling periods of 4, 6, 8 and 10 weeks after planting. Data on the number of branches of okra showed that as the neem seed cake increased, there was a significant increase at 4, 8 and 10 WAP except at the 6WAP when the response to neem seed cake was not significant. This is in agreement with the findings of Uma Singh et al. (1986) who stated that neem seed cake increased the number of branches of crops compared to the control. As a result of NSC amendment, plant nutrients are released which accelerates overall plant growth of pigeon pea (Meena et al., 2009).

Table 3. Effects of neem seed cake on the growth parameters of okra in 2013
Tablica 3. Utjecaj sjemene pogače nima na pokazatelje rasta bamije u 2013.

N S C (t/ha)	Plant height (cm)				No of leaves/plant				No of branches/plant			
	weeks after planting				weeks after planting				weeks after planting			
	4	6	8	10	4	6	8	10	4	6	8	10
0	12.69	14.60	20.80	39.74	10.33	10.67	13.17	16.67	2.33	4.67	5.44	5.53
1	13.08	15.16	22.76	42.10	11.67	12.06	14.03	19.00	3.33	5.33	5.56	6.67
2	13.69	15.96	24.07	45.07	12.33	12.62	14.87	20.10	3.67	5.33	6.21	7.21
3	14.03	16.30	27.64	46.45	14.67	13.18	15.71	23.60	4.33	6.33	6.77	8.60
4	13.87	16.57	28.26	45.75	14.67	13.25	15.74	23.48	4.67	6.33	6.80	8.87
Mean	13.47	15.72	24.71	43.83	12.73	12.36	14.70	20.57	3.67	5.60	6.16	7.38
LSD(0.05)	0.361	1.159	2.761	NS	1.975	0.791	0.811	1.847	0.729	NS	0.477	0.837

Neem seed cake is quick acting, provides slow and steady nourishment and improves yield and quality of crops (Gaur et al., 1992). Fruit harvesting started at six weeks after planting and continued until the end of the data collection period. Olaniyi et al. (2005) reported significant increase in the number of fruits and fruit yield of okra when 3 t/ha of organo-mineral fertilizer (OMF) was applied in Ogbomoso. The number of fruits per plant was slightly lower than what was reported by Olaniyi et al. (2005) (5.11-5.94 fruits per plant). Regular application of organic manure in amounts sufficient to meet the nutrient requirements of crops not only resulted in increasing the crop yield but also improved the soil fertility and organic matter content (Ramesh et al., 2009) and availability of plant nutrients as compared to chemical fertilizer (Brar et al., 2004). Sandhyarani (1998) reported that the application of higher dose (6 t/ha) of castor oil seed cake gave higher yield and uptake of nutrients in radish. Praveen Kumar (2000) also reported increased fresh weight of carrot when neem seed cake was applied. Organic fertilizer influence both yield, plant micronutrient contents, and help sustain crop productivity (Mottaghian et al., 2008). Organic amendment such as neem seed cake was reported to have increased tomato yield by 15% compared to the control in Souss- Massa region, Morocco (Laghdaf, 2004). The number of green fruits per plant and fruit weight per plant increased significantly by the application of NSC (Khan et al., 2012).

The effects of neem seed cake on the yield parameters of okra in 2012 is presented in Table 4. Data on the number of fruits per plant showed that the application of 4t/ha resulted in fruits having highest number of fruits per plant, which was significantly different ($P<0.05$) from the other treatments except the 3t/ha. Data on the weight of fruits per plant indicated that as soon as the rate of application increased, there was a significant increase in the fruit weight per plant which was significantly different ($P<0.05$) from the other treatments except the 3 t/ha which was at par. The result on the fruit diameter showed that the application of 3t/ha produced fruits with the widest diameter compared to the other treatments. NSC significantly ($P<0.05$) increased the number of fruits per plant and fruit weight per hectare with the optimum values recorded at 3 t/ha, after which slight decline occured. The application of neem seed cake influenced the number of fruits significantly ($P<0.05$).

Table 4. Effects of neem seed cake on the yield and yield components of okra in 2012
Tablica 4. Utjecaj sjemene pogače nima na prinos bamije i njegove komponente u 2012.

Neem seed cake t/ha	Number of fruits/plant	Weight of fruits/ plant (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit weight/ha (t/ha)
0	2.10	26.2	6.50	1.46	2.91
1	2.75	49.6	6.80	1.60	5.53
2	3.05	54.3	7.11	1.65	6.02
3	5.26	109.6	7.97	1.74	12.17
4	5.31	115.6	8.00	1.73	12.84
Mean	3.70	71.0	7.28	1.66	7.90
LSD ($P<0.05$)	0.574	7.36	0.591	NS	0.817

The data on fruit length is presented in Table 4. The values indicated that as soon as the level of application increased there was also an increase in the length of fruits. The 4 t/ha rate of application, however, produced the longest fruits which was significantly different from the other treatments except the 3 t/ha rate of application. Data on the fruit diameter is presented in Table 4. The data indicated that the application of NSC increased the fruit diameter up to the 3 t/ha rate of application but declined at the 4 t/ha. Nevertheless, there was no significant difference between the treated plots and the control. The fruit weight per hectare is presented in Table 4. The application of NSC at 4t/ha produced fruits with the highest weight which was significantly different from the other treatments except the control.

Data on the yield parameters of okra in 2013 is presented in Table 5. The data indicated that the application of NSC was significant ($P<0.05$) for all parameters evaluated. It followed a similar trend with the 2012 planting.

Data on the effects of number of fruits per plant, weight of fruits per plant, fruit length, diameter and weight per hectare indicated that there was a significant difference between the treated plots and the control except the fruit diameter. The data indicated that as the rate of application increased, there was an increase in the yield parameters. Neem seed cake being an organic fertilizer, has many advantages. Jha and Rathore (1984) observed that the dissolution of minerals in the soil takes place at increased rates in the presence of organic fertilizer.

Table 5. Effects of neem seed cake on the yield and yield components of okra in 2013

Tablica 5. Utjecaj sjemene pogače nima na prinos bamije i njegove komponente u 2013.

Neem seed cake t ha^{-1}	Number of fruits/plant	Weight of fruits/ plant (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit weight/ha (t/ha)
0	2.46	30.90	6.28	1.63	3.44
1	2.88	47.10	6.90	1.70	5.24
2	3.26	58.00	7.47	1.80	6.44
3	5.69	118.80	7.60	1.83	13.20
4	5.63	120.80	7.53	1.80	13.37
Mean	3.98	75.00	7.16	1.75	8.34
LSD ($P<0.05$)	1.438	12.91	0.467	0.044	1.438

CONCLUSION

The result of the experiment clearly shows that the use of organic materials can be gainfully employed in soil fertility restoration by small-scale farmers, especially neem seed cake. Neem seed cake can reduce the mining of soil nutrients and improve overall crop productivity. Organic manure such as neem seed cake, has a long term effect of building the organic matter content of soil which helps in improving the soil physical properties and hence increase the nutrient status of impoverished soils. Therefore it can be used in areas where the soils are very impoverished. Application of neem seed cake will also have a long lasting effect on the soil and increase the activities of macro and microorganisms and help in building up micronutrients which cannot be supplied by inorganic fertilizers.

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UTJECAJ SJEMENE POGAČE NIMA (*Azadirachta indica* L.) NA RAST I PRINOS BAMIJE (*Abelmoschus esculentus (*L.) Moench)

SAŽETAK

Tla savane južne Gvineje su općenito neplodna zbog niskog vegetacijskog pokrova, erozije tla i niskog sadržaja organske tvari, izazvanog stalnim požarom grmovitog raslinja. Stoga se u sušnom razdoblju poljoprivrednici sele u blizinu potoka i rijeka zbog navodnjavanja bamije. Terenski pokusi provedeni su na Nastavno-istraživačkoj farmi Sveučilišta u Ilorinu u Nigeriji tijekom sjetve u 2012. i 2013., da bi se procijenio utjecaj sjemene pogače nima na svojstva bamije. Sjemena pogača nima stavila se u zemlju tjedan dana prije sjetve bamijinog sjemena u omjeru 0, 1, 2, 3 i 4 t/ha. Pokus je postavljen prema slučajnom bloknom rasporedu u tri ponavljanja. Podaci su prikupljeni mjerenjem pokazatelja rasta (visina biljke, broj listova i broj grana) i prinosa (dužina ploda i opseg, broj plodova po biljci, težini ploda po biljci i hektaru). Rezultati su pokazali da je primjena sjemene pogače nima značajno utjecala na pokazatelje rasta i prinosa. Međutim, primjena sjemene pogače nima prema omjeru dala je najveći prinos. Prosječno relativno povećanje prinosa, dobiveno primjenom sjemene pogače nima, iznosilo je 75.81%.

Ključne riječi: sjemena pogača nima, svojstva tla, rast, prinos bamije

(Received on 5 May 2014; accepted on 6 May 2015 - *Primljeno 05. svibnja 2014.; prihvaćeno 06. svibnja 2015.*)