GLOBAL JOURNAL OF PURE AND APPLIED SCIENCES VOL. 12 NO. 4 2006 : 443 - 447
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EXTRACTION OF MACRONUTRIENTS FROM OKRA (*Abelmoschus esculentus (L) moench*) AS INFLUENCED BY SOME MULCH MATERIALS IN THE ACID SANDS.

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(Received 24 August, 2005; Revision Accepted 12 May, 2006).

ABSTRACT

Two experiments conducted in September 1993 during the dry season and March 1994 during the wet season to evaluate the effect of two okra cultivars (Emerald Green and Clemson Spineless), and four mulch materials: (oil palm bunch refuse, grass, wood shavings mulches and bare ground) were studied at College of Education Farm, Akamkpa, Cross River State, Nigeria. In both experiments, soil temperatures were similar in mulch treatments; soil temperatures were reduced by about 2° C with the bunch refuse and up to 4.1° C with the wood shavings during the dry season planting. Compared to the unmulched plots, the macronutrients (N,P,K, Ca, Mg) content of okra fruits and seeds were increased by the mulch treatments and were found to enhance macronutrient content, during the dry season. In the two experiments, bunch refuse was significantly outstanding in increasing the macronutrient content of both whole pod and seeds of okra. The implications of these results are discussed in light of okra nutrient.

KEYWORDS: Macronutrients from okra and mulch materials

INTRODUCTION

Investigations have shown that mulching improves the nutritive values of fruits and seeds through enhanced soil moisture conservation, reduced soil temperature and reduction of diseases, (Hartley 1977; Wilman *et al* 1999; Hussan and Leitch 2000).

Okra is among the most commonly grown vegetables throughout Nigeria because of its nutritive importance, mucilaginous drawing fruits, much liked in soups. The crop generally grows well under most Nigerian climatic conditions including the rainforest zone of Nigeria where the bimodal rainfall results in two distinct growing seasons (dry season September to December and wet season March to September).

The crop is grown on about 2 million hectares annually in Nigeria, (James1988; FMAWRRD, 1989). The immature, young pod is the edible part of this plant. The use of organic mulches has been reported to be suitable for weed control, conservation of soil moisture and can lead to good nutritive value (Powell 2004). For greater yield and quality, application of 60kg N/ha; 20Kg K/ha will be required, (Adelena, 1985; NIHORT 1976 – 1986; Ayodele 1993 and Ubi, 2004).

The objective of this study is to determine the macronutrient content of okra pods and okra seeds of two okra cultivars planted on bare soil and under the modifying influence of three mulch materials in order to determine the suitability of the mulch materials. The three mulch materials are chosen because they are readily available and are organic wastes, which can be of economic use in vegetable production.

MATERIALS AND METHODS

The experiment was set up in September 1993 and 1994 at the farm of the College of Education, Akamkpa which lies between $8^0$14' and $8^0$20'E longitude $5^0$14'N and $5^0$18'N latitude with a rainfall over 2,000 mm in the rainforest vegetation, of the basement complex soil. The area was previously cropped with cassava followed by four years fallow in which *Centrosoma pubescence* and *Panicum maxima* (guinea grass) were the dominant fallow species. The site was manually cleared, allowed to dry for some days, then gathered together and removed. The plot size was 5m x 5m. Plots were uniformly planted to okra at inter row spacing of 50 cm and intra-row spacing of 30 cm without tillage. The experiment was a 2 x 4 factorial, laid out in randomized complete block design (RCBD) with four replications. The cultivars were Emerald (green, smooth pods) and Clemson Spineless (green, smooth ribbed pods). Four seeds of each cultivar of okra were planted per hole and thinned to 2 plants about two weeks after seed germination.

The treatments were oil palm bunch refuse, wood shavings, grass, and unmulched soil. Mulch materials were applied shortly after seed planting at the rate of 5t/ha for each season of the experiment.

Soil temperatures were recorded at 0800 hrs and 16.30 hrs daily at 5 cm depth, according to Iremiren (1982). Three months after sowing, the monthly soil moisture content in the plots was determined gravimetrically from September – December 1993 and March – June 1994. At germination, plants were sprayed weekly for 4 weeks with cymbush (cypermethrine). E. C. insecticide at the rate of 5m/10 litres of water for the control of flea beetles and other leaf-eating insects. Two weeks after planting N P.K. fertilizer (20: 10: 10) was applied at the rate of 200kg/ha by band placement, (NIHORT, 1986). At about 50% flowering, a second dose was applied by top dressing with urea (46:0: 0) at the rate of 50kg/ha. Five plants were randomly sampled and tagged for the determination of macronutrient content in fresh pods and fresh seeds. A clean knife was carefully applied to the edges of the fresh pods diagonally to avoid any damage to the seeds. The pericarp was removed and seeds taken out from the placenta, washed and dried. From the harvest of the five plants, ten fresh pods from each mulch treatment were randomly selected and another 10 fresh pods were also selected and the fresh seeds removed and both were dried at a temperature of 70° C for 72 hours in Gallen Kamp forced air laboratory oven. Samples were then ground separately in a Thomas Willey Laboratory Mill Model 4, using a 5mm mesh screen. The milled samples were then thoroughly mixed and stored in cellophane bags under dry condition for the chemical analysis, which was done with New Model Atomic Absorption spectrophotometer with printer, at Alabama Agricultural and Mechanical University, Normal, Alabama, U.S.A.

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Statistical analysis

Data were subjected to analysis of variance (ANOVA) and means compared by the use of Fisher's Least Significant Difference (LSD) at 5% probability level.

Table 1: Meteorological condition at College of Education, Cross River State University of Technology, Akamkpa, Nigeria September 1993 – June 1994

	Sept.	Oct.	Nov.	Dec.	Jan	Feb.	March	April	May	June
Total rainfall (mm)	492.6	41.3	102.2	35.6	8.1	27.8	65.2	232.6	241.0	250.1
Maximum temperature (OC)	35.4	26.5	32.7	31.6	34.8	35.2	34.7	32.9	31.6	30.2
Minimum Temperature (OC)	32.6	24.3	18.7	21.7	22.5	22.5	23.8	23.4	22.6	21.7
Mean Radiation (J/Cm2/day	1533.4	1561.2	1678.4	2519.7	157 4.7	1574.7	1578.2	17184	1671.6	1571.1C

RESULTS

The rainfall data collected about 30 m from the experimental site are shown in Table 1. Generally, by September 1993 and March 1994, the rainfall was sufficient to support crop growth.

Soil Temperature and Soil Moisture content

Compared with the unmulched soil, bunch refuse reduced the mean monthly soil temperature by about 2^0 C and up to 4.1^0 C in the wood shavings during the study period (Table 2). The temperatures were not significantly (P< 0.05) different between the mulch and unmulched treatments in the wet season planting and ranged from 30.1 – 30.4^0 C in the morning and 31.1 – 34.5^0 C in the evening. The percent moisture content in experiment- 1 declined sharply in all treatments from September to December (Table 2.) The lowest soil moisture occurred generally in the unmulched soil in all the treatments by up to 1.3%. Mulch materials were observed to conserve soil moisture to a similar extent. In experiment- 2, the % soil moisture continued increasing sharply in all treatments from March to June. The treatments used in this study have provided ideal growth conditions through enhanced soil moisture conservation, reduced soil temperature, improved soil texture.

Table 2a: Soil temperature (^{0}C)

Month	Bunch refuse	Grass	Wood shavings	Unmulched soil	LSD (P < 0.05)
Experiment 1- dry season (September to December) 1993					
September	32.6	36.9	36.0	38.5	1.2
October	33.8	33.6	32.4	36.7	1.6
November	28.5	32.4	30.6	36.5	1.4
December	28.2	30.8	28.5	35.6	1.3
Experiment 2 Wet season (March – June) 1994					
March	31.5	30.4	30.6	30.6	NS
April	31.2	31.5	31.2	31.1	NS
May	32.6	32.6	33.5	33.7	NS
June	34.8	33.9	34.9	34.5	NS

Table 2b: Soil Moisture Content (%)

Experiment 1 (Dry Season) 1993

Month	Bunch refuse	Grass	Wood shavings	Unmulched soil	LSD (P = 0.05)
September	5.2	4.3	4.7	3.4	0.7
October	4.7	4.4	5.1	3.4	0.7
November	4.1	4.0	4.3	2.3	NS
December	3.2	3.1	3.4	2.6	NS
Experiment 2 (Wet season) 1994					
March	4.3	4.8	4.9	3.4	0.3
April	5.3	4.6	4.8	3.7	0.8
May	6.7	5.7	6.8	3.5	0.6
June	6.8	5.4	6.9	3.6	NS

Table 3a: Macronutrient (mg/Kg) content of okra fresh pods planted in September to December, 1993. Experiment 1 (dry season) September – December 1993

Cultivars	Bunch refuse	Wood shavings	Grass	Unmulched soil	L S D (P<O .05)
Emerald			**Fresh pods (whole)**		
N	2.65	2.14	2.34	1.32	0.20
P	62.0	43.0	54.0	31.0	3.60
K	302.0	253.0	295.0	151.0	21.00
Ca	83.0	61.0	78.0	42.0	12.00
Mg	57.0	48.0	51.0	26.0	6.20
Clemson spineless					
N	2,61	2.04	2.14	1.30	0.40
P	58.0	41.0	51.0	30.0	5.00
K	286.0	248.0	257.0	112	10.00
Ca	73.0	55.0	76.0	34.0	4.00
Mg	52.0	46.0	50.0	25.0	4.00

Table 3a: Macronutrient content of okra raw (mg/kg).

Experiment 2 (Wet season) March- June 1994

Emerald	Bunch refuse	Wood shavings	Grass	Unmulched soil	LSD (P < 0.05)
N	2.15	1.53	1.64	1.03	0.30
P	60.0	40.0	42.0	26.0	2.00
K	185.0	152.0	158.0	91.0	6.00
Ca	75.0	58.0	60.0	36.0	2.00
Mg	51.0	64.0	48.0	25.0	2.00
Clemson spineless					
N	2.04	1.33	1.42	0.81	0.60
P	54.0	36.0	38.0	26.0	2.00
K	171.0	145.0	153.0	126.0	7.00
Ca	68.0	51.0	56.0	31.0	4.00
Mg	47.0	42.0	45.0	24.0	3.00

Table 4a: Macronutrient content of fresh okra seeds (mg/ kg)

Experiment 1 (dry season) September - December 1993

Cultivars	Bunch refuse	Wood shavings	Grass	Unmulched soil	LSD (P < 0.05)
Emerald		**(Fresh okra seeds)**			
N	2.15	1.08	1.64	1.02	0.05
P	51.0	40.0	48.0	35.0	5.00
K	260.0	234.0	251.0	137.0	15.00
Ca	72.0	34.0	68.0	36.0	10.00
Mg	51.0	31.0	45.0	32.0	4.00
Clemson spineless					
N	2.01	1.13	1.52	1.00	0.12
P	55	36	47.0	25.0	4.00
K	296	249	286.0	139.0	10.00
Ca	70	52	64.0	30.0	12.00
Mg	51	42	46.0	24.0	4.00

Table 4b: Macronutrient content of okra raw (mg/kg).

Experiment 2 (Wet season) March- June 1994. Emerald	Bunch refuse	Wood shavings	Grass	Unmulched soil	LSD (P < 0.05)
N	2.02	1.41	1.62	0.8	0.20
P	47.0	36.0	40.0	31.0	4.00
K	162.0	143.0	148.0	136.0	5.00
Ca	72.0	53.0	60.0	32.0	7.00
Mg	47.0	41.0	45.0	28.0	3.00
Clemson spineless					
N	1.84	1.02	1.24	0.63	0.22
P	52.0	32.0	34.0	27.0	2.00
K	162.0	131.0	142.0	80.0	9.00
Ca	61.0	45.0	48.0	22.0	3.00
Mg	43.0	24.0	28.0	21.0	4.00

Macronutrient content of fresh Okra pods

The results of macronutrient content of okra as influenced by mulch treatments during the dry season planting, September to December 1993 are presented in Tables 3a and b. Mulching exerted significant (P< 0.05) influence on the macronutrient content of fresh okra pods. Highest macronutrients (N 2.65; P 62.0; K 302.0; Ca 83.0; and Mg 57.0) mg/kg, on the average, was obtained from the Emerald cultivar where bunch refuse was applied and this was significantly (P < 0.05) higher than those of the other mulch treatments and those of Clemson spineless. Wood shavings performed poorly within the mulch treatments and the macronutrient content of fresh okra pods obtained from these plots, on the average, were significantly low, but higher than the unmulched plots. While the macro nutrient content of fresh pods between grass and wood shavings treatment were slight, the macronutrient content between bunch refuse and unmulched soil was doubled in the two okra cultivars (Tables 3a - b).

In experiment 2, wet season planting (March – June 1994), the mulch treatment effect was significant (P < 0.05) on macronutrient content of okra fresh seeds (Tables 4a & b). The total macronutrients in Emerald cultivar in plots that received bunch refuse treatment were significantly higher than those of the other mulch treatments and those of Clemson Spineless cultivar. While the macronutrient differences due to mulch treatments of wood shavings and grass had become virtually reduced, macronutrients differences imposed by bunch refuse compared with unmulched plots was becoming more emphasized. Thus, plots that received bunch refuse treatment had on the average, (N 2 15;P 60 0; Ca 75.0 and Mg 51.0) mg/kg, and these were significantly (P < 0.05) more than double that of unmulched plots in the two cultivars. Wood shavings treatment had the lowest macronutrient content in both cultivars during the wet season.

Macronutrient content of fresh okra seeds

Tables 4a and 4b show the macronutrient contents of fresh okra seeds as influenced by mulch treatments during dry season (experiment 1) and wet season (experiment 2). Mulching exerted significantly (P< 0.05) influenced on the macronutrient content of fresh okra seeds in the two cultivars during the study period. Wood shavings had the least micronutrients content (N 1.08; P 40.9 K 234.0; Ca 34.0; and mg 31.0) mg/kg from emerald cultivar, in experiment 1, and (N 1.41, P, 36.0, K 143.0, Ca 53.0 and Mg 41.0) mg/kg in experiment 2 and their values were significantly low, but higher than those of unmulched plots in both dry and wet season (experiments 1 & 2), and in the Clemson Spineless cultivar. Bunch refuse treatment throughout the experimental periods maintained the highest macronutrient content in the fresh okra seeds (N 2.15, P 58.0, K 260.0, Ca 72.0 and Mg 51.0) mg/kg from the Emerald cultivar and their values were significantly higher than those of other mulch treatments and of Clemson Spineless cultivar.

DISCUSSION

A similar soil temperature in the mulched and unmulched treatments in experiments 2 (wet season) March – June suggests that the prevalent high rainfall (Table 1) suppressed the impact of the incident solar radiation on soil temperature. On the contrary, low rainfall in the early months of the dry season planting favoured reflection of solar radiation by the mulched materials and an attendant reduction in soil temperature by different degrees. Again, the differences between the mulched treatments were more apparent in the dry season planting.

The differences between macronutrients composition in the fresh okra pods and seeds and within mulched treatments may be partly due to soil temperature effects as treatment with lower soil temperature generally performed better through enhanced soil moisture conservation, thereby improving the nutritive value of fruits and seeds, (Hartley, 1977). Cook, (1991) reported that slower phase of mineral absorption by plant cells was sensitive to soil temperature and anaerobiosis.

In spite of the fact that mulching did not lower the soil temperature in the wet season, in the second experiment, it however improved the soil moisture regime during the dry season, probably by directly decreasing the losses caused by evaporation losses might have accompanied the higher soil temperature of the unmulched soil in the first planting season leading to water - stress and eventual impairment of assimilate and macronutrients translocation to fresh okra pods and seeds. Wilman et al (1998) reported some differences between eight grasses within the *Lolium-Festuca* complex when sown in conditions of severe water shortage.

Gates (1988) reported that, in tomato plants, at least the supply of phosphorus to plant cells was drastically reduced by moderate water - stress. In both experiments, however, the pattern of partition of assimilates between the roots and the shoots of mulched and unmulched plants were similar. Hence the overall stress suffered by plants of the unmulched soil was not detrimental enough to favour either the macronutrients within the root surface (soil solution) or within the tissue cells of okra. Although some mulch materials were bound to create a negative effect of immobilization, in which nitrate nitrogen is used up by microflora, but in this study, a very positive effects was observed due to the application of the mulch treatments bringing about mineralization. The availability of N, P, K, Ca and Mg within the mulch treatments therefore became a function of their concentration.

The use of wood shavings as mulch material gave rise to immobilization process in the soil in which microbial organisms used up nitrate nitrogen in the soil during breaking down processes and can account for the low level of N recorded in wood shaving treatment. It is believed in this study that during mineralisation by microflora and immobilization process within the wood shavings medium, other macronutrients, apart from N, might have been lost. This might have accounted for the low values of macronutrients obtained by wood shaving treatments in both fresh okra pods and seeds, throughout the study period. In a similar experiment, Hewitt. (1991), reported that impaired reduction of N is associated with deficiencies of several elements including Ca, K and Mg.

Emerald cultivar showing more macronutrients values in all mulch treatments than Clemson spineless is suggested to be due to genetic improvement of the cultivar to absorb macronutrients sufficiently and stored some within plant tissues. Similar result was reported by Hassan, and Leitch, (2000), in their study on the influence of seedling density on content and uptake of N.P.K in linseed, (*Linum usitatissimum, L)*

CONCLUSION

The results from this study has shown that the macronutrients content of okra cultivars follow closely the treatment applied, the genetic composition, rate of absorption of assimilates from the soil and soil moisture regime.

Environmental factors – high temperature, heavy rainfall that may result to leaching of exchangeable cations, light intensity, drought and the nature of mulch material used could exert a significant effect on the absorption and retention of macronutrients by plant cells and root surfaces in the soil and was suggested to be responsible for the macronutrients levels in the plant tissues reported in this study.

Apparently the rate of macronutrients absorption rather than transport limits macronutrients accumulation in the fresh okra pods and seeds. The available report from this study shows that commercial production of okra will be better in the experiment 1 September to December (dry season) with Emerald cultivar for high nutritional value. Much more critical work needs to be done before the influence of soil moisture, temperature and mulch materials on the macronutrients content of fresh okra pods and seeds could be satisfactorily assessed.

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