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INFLUENCE OF ORGANIC AND INORGANIC NUTRIENTS AND METHOD OF APPLICATION ON CROP GROWTH AND YIELD IN OKRA-AMARANTH CROPPING SEQUENCE

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ABSTRACT

In other to evaluate the effect of mineral fertilizer, organic and organomineral fertilizer application rate and method of application in okra-amaranth cropping sequence, a field experiment was conducted in March-.October 2013. Location of the experimental site was the Teaching and Research Farm of the Delta State University, Abraka (latitude 5^0 46'N and longitude 6^0 5'E), Nigeria. The field trial was made up of three factors: six (6) nutrient sources, three (3) cropping sequences and two (2) application methods. These factors were arranged in a 6 x 3 x 3 factorial with three (3) replicates arranged in a randomized complete block design. The six (6) nutrient sources used were: control or zero application; 200kgha^{-1} NPK 20-10-10 (mineral fertilizer); 20 t ha^{-1} vermicompost; 20 t ha^{-1} green manure;10 t ha^{-1} vermicompost + 100kgha^{-1} NPK 20-10-10 and 10 t ha^{-1} green manure + 100kgha^{-1} NPK 20-10-10. Results showed that organic and organomineral based nutrient sources indicated higher vegetative growth and yield parameters in both amaranth and okra than when only NPK was used. The second crop in the sequence generally performed better than the first crop. Vegetative growth and yield parameters of both okra and amaranth were more pronounced in the double-split application compared to the single-whole applications. The study recommends 10 t ha^{-1} vermicompost + 100kgha^{-1} NPK 20-10-10 double –split for okra-amaranth cropping sequence.

Keywords: okra, amaranth, cropping sequence, vermicompost

INTRODUCTION

With increasing population pressure in Nigeria there has been increased demand for arable land leading to expansion of cropping into marginal lands, consequently resulting in soil deterioration. Poor soil fertility management is one of the major constraints to sustainable agricultural production, resulting in inadequate soil fertility level that cannot sustain crop productivity. This has remained a great challenge to Nigerian farmers. Several measures adopted by farmers to improve soil fertility include the use of organic and inorganic fertilizers, appropriate use of nutrients and increasing crop diversity through rotation of different crops.

The practice of growing two or more crops on the same field per year, commonly termed multiple cropping (Andrew and Kassim, 1975) is a growing farming system being adopted by farmers in different parts of the world. However, when the individual crops are grown in a sequence, with the one crop harvested before the next crop, its termed sequential cropping.

With increased demand for vegetables, most farmers intensify the use of available land. The crop intensification is usually only in time dimension without any intercrop competition, since the crop farmers cultivate and maintain one crop in the field at a time. Interest in diversification of crops in crop production systems has increased and has contributed to sustaining soil health and fertility, positively affects whole farm economics by reducing weed, pathogens and pest attack; allowing for timely planting and harvesting; and diversifying farm income and spreading climatic risks (Dakota Lakes Research Farm, 2012).

In the present day, organic market vegetable farming represents an important viable agricultural business opportunity for growers. Among the sources of organic manure, vermicomposting (composting with earthworms) has a special place because of the presence of readily available plant nutrients, growth enhancing substances and number of beneficial microorganisms (Cordovil, et al., 2007; Asgharipour, 2012). The use of fertilizers of organic and inorganic origin either in sole or mixture (organomineral) had been found to reduce acidity, increase soil nutrient content, reduce nutrient imbalance and minimize erosion (Babatola and Olaniyi, 1997, Senjobi et al., 2012).

Several researchers (Jama et al. 2000; Gupta et al., 2004; Chukwuka and Omotayo, 2008; Gashamura, 2009) have established the high potential of non-traditional organic resources such

as weeds in improving soil nutrient status and subsequently crop yield. Wolkowski, (2003) and Olowoake and Adeoye (2010) observed that when soil is amended with organic manures made from materials of low C: N ratio, better plant vegetative development and yield of crops are observed.

In a related research using plants with animal manures, Adebayo et al. (2011) reported high nutrient concentration in *Moringa oleifera* when the soil was supplied with organic amendment in form of compost made from plant residues such as (*Tithonia diversifolia, Chromonela odorata* and *Celosia cristata*) and animal manures. Olowoake et al. (2013) observed increase in number of leaves, number of branches, flower number, number of fruits and dry pepper fruit weight in pepper grown with organic and organomineral fertilizers.

Another major limitation to increased crop productivity is that many farmers lack the scientific knowledge on appropriate rate, timing and number of applications and method of application of fertilizers (Uwah and Eyo, 2014). In other to enhance efficient use of nutrients, reduce wastage, and make nutrients available when needed by crops, timing of nutrient application is very important (Brady and Weil, 2008).

Therefore, the aim of this study is to evaluate of effect inorganic fertilizer, organic and organomineral fertilizer application rate and method of application in okra-amaranth cropping sequence.

MATERIALS AND METHODS

The field experiment was located in the Teaching and Research Farm of the Delta State University, Abraka (latitude 5^0 46'N and longitude 6^0 5'E), Nigeria during the cropping season (March-October) of 2013 . The vermicompost production process using water hyacinth and cow dung has been described earlier (Oroka, 2012). In other to make green manure from water hyacinth, freshly harvested water hyacinth was chopped into pieces of 10-15cm. These were thoroughly mixed with 0-5cm of the soil layer and left for one week before sowing of the first vegetable crop.

The field trial consists of three factors: six (6) nutrient sources, three (3) cropping sequences and two (2) application methods. These factors were arranged in a 6 x 3 x 3 factorial with three (3) replicates arranged in a randomized complete block design.

The six (6) nutrient sources used were:

T-1: control or zero application;

T-2: 200kgha^{-1} NPK 20-10-10 (mineral fertilizer)

T-3: 20 t ha^{-1} vermicompost (organic fertilizer)

T-4: 20 t ha^{-1} green manure (organic fertilizer)

T-5: 10 t ha^{-1} vermicompost + 100kgha^{-1} NPK 20-10-10 (organomineral fertilizer)

T-6: 10 t ha^{-1} green manure + 100kgha^{-1} NPK 20-10-10 (organomineral fertilizer)

Three (3) cropping sequences of rotation of vegetables made up the sub-treatments. These were okra-okra, amaranth-amaranth and okra-amaranth. Varieties of crops used were okra, *Abelmoschus esculentus* (cv.V35) and amaranth, *Amaranthus hybridus* (cv. TLV).

Two nutrient application methods made up the sub-subtreatments. This consists of whole applications (100%) of nutrients on the first crop and split application (with 50% on the first crop and 50% on the second crop). Plant spacing for amaranth and okra (in both sole and intercrops) was 20cm by 20cm and 60cm by 40cm respectively. Plot size was 3m by 3m with 1m distance between and within plots. The approximate land area was 0.19ha.

Data on vegetative parameters for okra were collected at maturity of the crop. Parameters measured were plant height, number of leaves, and leaf area. Data on yield and yield components of okra were collected.

On the day of first harvest, vegetative parameters such as plant height, number of leaves, leaf area, and stem girth of amaranth were collected. Harvesting of amaranth was done by repeated cutting 10cm above the soil surface. Subsequent cutting was done biweekly. A total of four cuttings were done until shoot generation became negligible. Data collected include fresh shoot yield at each harvest. Cumulative fresh shoot yield for amaranth was done after the last harvest.

Data collected were subjected to analysis of variance appropriate for factorial designs. Means between treatments were separated using LSD at 5%.

RESULTS

Vegetative Parameters

The data in Table 1 shows the effect of treatments on the vegetative parameters of okra. The results showed that vegetative parameters of okra in rotation with okra or amaranth were significantly ($P<0.05$) affected by mineral and organic manure applications. Okra treated with

vermicompost alone indicated higher plant height, number of leaves and stem girth, though the stem girth did not show any significant variation with nutrient applications. Plant height of *Amaranthus hybridus* ranged from 69.3cm to 102.7cm for the first crop while the second crop was within the range of 63.1cm to 108.1cm.

Table 1: Influence of nutrient sources, cropping sequence and method of application on vegetative parameters of *Abelmoschus esculentus*

	Plant height		Leaf number		Stem girth(cm)	
	1st	2nd	1st	2nd	1st	2nd
Nutrients						
Control	69.3e	63.1d	12.8d	10.3d	0.6	0.6
NPK	73.8d	79.2c	14.2c	16.1c	0.6	0.7
Vermicompost	102.7a	108.1a	19.6a	21.8a	0.8	0.9
Green manure	80.6c	97.2b	15.3b	17.2b	0.7	0.8
Vermicompost+ NPK	92.8b	100.3a	18.2a	19.8a	0.8	0.9
Green manure + NPK	85.4c	96.0b	16.1b	18.9b	0.8	0.8
Cropping sequence						
Okra-Okra	85.3	90.7	16.7a	17.1	0.9	0.8
Okra-Amaranth	82.9	-	15.3a	-	0.5	-
Application methods						
Whole	89.2a	86.3b	17.6a	15.9b	0.8	0.7
Split	79.0b	95.1a	14.4b	18.3a	0.6	0.9

Cropping sequence significantly ($P<0.05$) affected plant height, but leaf number and stem girth did not show any statistical difference. The first okra plant in the rotation had the lowest plant height, number of leaves and stem girth. At first planting, okra plants that received whole nutrient applications indicated higher plant height, leaf number and stem girth than plants which received split applications.

Vegetative growth of amaranth was significantly affected by nutrient sources and method of nutrient applications (Table 2). The more the use of organic based nutrient sources such as green manure and vermicompost the higher the plant height, number of leaves and stem girth. Vermicompost alone applied to amaranth plants showed higher plant height, number of leaves and stem girth. Plants that received organic manure alone, and those that received organic manure supplemented with mineral fertilizer performed better than those which received only mineral fertilizer.

Table 2: Influence of nutrient sources, cropping sequence and method of application on vegetative parameters of *Amaranthus hybridus*

	Plant height		No. of leaves		Stem girth	
	1st	2nd	1st	2nd	1st	2nd
Nutrients						
Control	60.1c	56.7c	47.2d	39.8d	1.9c	1.7c
NPK	69.6b	72.5b	53.5c	54.2c	2.1b	2.2b
Vermicompost	81.6a	82.9a	67.3a	67.6a	3.1a	3.1a
Green manure	66.7b	72.8b	51.8c	54.2c	1.9c	2.3b
Vermicompost+ NPK	78.8a	81.9a	67.1a	68.3a	3.0a	3.2a
Green manure + NPK	69.8b	73.4b	59.7b	60.3b	2.7b	2.8b
Cropping sequence						
Amaranth-Amaranth	71.1	74.2[a]	57.8	58.8a	2.6	2.7[a]
Okra-Amaranth	-	72.6[a]	-	56.0a	-	2.4[a]
Application methods						
Whole	76.5[a]	68.3[b]	63.2[a]	52.7[b]	2.7[a]	2.5[a]
Split	65.7[b]	78.5[a]	52.4[b]	62.1[a]	2.4[a]	2.6[a]

The highest vegetative development of okra and amaranth, increased pod yield of okra obtained from the organic manures and organominerals might be related to the positive effect of vermicompost and green manure in increasing the root surface per unit of soil volume, water utilization capacity and photosynthetic activity of the crops, which have direct effects on the

physiological processes and utilization, and accumulation of photoassimilates (Małgorzata et al. 2010;. Olowoake et al. 2013). While application methods showed significant effect on vegetative development of amaranth, cropping sequence did not significantly affect amaranth growth.

Yield and Components of Yield

The number of pods per plant and fresh pod yield of okra are shown in Table 3. The application of vermicompost and green manure made from water hyacinth and animal manures had a pronounced significant effect on number of pods per plant and fresh pod yield. The vermicompost was observed to have higher number of pods and pod yield, while the control recorded the least.

Table 3: Influence of nutrient sources, cropping sequence and method of application on number of pods and fresh pod yield of *Abelmoschus esculentus*

	Number of pods/plant		Fresh pod yield (t/ha)	
	1st	2nd	1st	2nd
Nutrients				
Control	11.1d	9.7d	10.6e	9.3d
NPK	18.7b	19.3c	15.3d	16.9c
Vermicompost	26.8a	30.1a	18.3a	20.5a
Green manure	17.6c	20.2c	16.5c	18.0b
Vermicompost+ NPK	20.6b	22.7b	17.4b	19.3a
Green manure + NPK	18.3b	19.9c	16.8c	18.7b
Cropping *sequence*				
Okra-Okra	19.0a	20.3	16.5a	17.1
Okra-Amaranth	18.8a	-	15.1a	-
Application methods				
Whole	20.3a	18.9b	17.5a	15.9b
Split	17.5b	21.7a	14.1b	18.3a

Rotation of okra did not show any significant effect on number of pods and pod yield of okra. However plants that received whole applications (100%) showed higher number of pods and fresh pod yield at the first cropping, while okra plants that received split (50%) applications recorded higher yield and yield component in the second cropping.

Table 4 shows data on number of offshoots and fresh shoot yield of amaranth as influenced by nutrient applications, cropping sequence and application methods. Number of offshoots and fresh shoot yield were observed to be higher in the vermicompost applications. The use of green manure and vermicompost supplemented with NPK indicated higher number of offshoots and fresh shoot (marketable) yield than use of only NPK. The reduction in vegetative growth parameters, the yield and components of yield from the plants that received only NPK fertiliser as compared to plants under vermicompost, green manure and organomineral might be due to the leaching and runoff effect on the applied mineral fertilizer which makes the nutrients unavailable to the crops especially at final vegetative growth stage of the amaranth and pod production of the okra (Olowoake et al., 2015).

No significant effect of cropping sequence on number of offshoots and fresh shoot yield of amaranth was observed in the study, however application methods significantly affected these plant parameters. A cursory look at the number of applications (single whole and double-split) showed that the vegetative growth and yield parameters of both okra and amaranth were more pronounced in the double-split application compared to the single-whole applications. This was expected because in single application, most of the soluble nutrients may have been utilized by the crop at the early stages of growth in the season, leached beyond the root zone of the crop or volatilized. The split application of the mineral fertilizers, organominerals and organic manures however, made the nutrients more beneficial to the plant at various stages of its growth and hence the superior performance recorded. This is in consonance with the reports of Havlin et al. (2006) which noted that fertilizers should be applied at the right time so as to reduce nutrient losses to the environment and maximize utilization by the crop. Similar results were also observed by Uwah and Eyo, (2014).

Table 4: Influence of nutrient sources, cropping sequence and method of application on number of offshoots and fresh shoot yield of *Amaranthus hybridus*

	No. of offshoots		Fresh shoot yield (t/ha)	
	1st	2nd	1st	2nd
Nutrients				
Control	13.7d	12.2d	13.9d	12.3d
NPK	15.4c	16.7c	17.8c	18.1c
Vermicompost	20.9a	21.8a	21.7a	22.9a
Green manure	16.2c	17.9c	17.3c	18.5c
Vermicompost+ NPK	20.3a	21.3a	19.2b	20.6b
Green manure + NPK	18.3b	19.9b	16.4c	18.3c
Cropping sequence				
Amaranth-Amaranth	17.5	18.8a	17.7	18.9a
Okra-Amaranth	-	17.6a	-	18.1a
Application methods				
Whole	19.3a	16.6b	18.9a	16.8b
Split	15.7b	19.8a	16.5b	20.2a

CONCLUSIONS

The study has shown that vermicompost used alone or in mixture with NPK improved vegetative growth and yield production of Amaranth and okra. However there was no significant difference between 20 t ha^{-1} vermicompost (organic fertilizer) and 10 t ha^{-1} vermicompost + 100kgha^{-1} NPK 20-10-10 (inorganic fertilizer) for most of the parameters studied. The study therefore recommends 10 t ha^{-1} vermicompost + 100kgha^{-1} NPK 20-10-10 double –split for okra-amaranth cropping sequence.

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