INNSPUB

International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 12, No. 6, p. 83-93, 2018

RESEARCH PAPER OPEN ACCESS

Assessment of inorganic and organic fertilizers regimes on yield and yield components of sunflower in Morogoro, Tanzania

Irika M[1,2], Josiah M. Kinama[1], Habineza M. Jean Pierre*[1]

[1]*Department of Plant Science and Crop Protection, University of Nairobi, Nairobi, Kenya*

[2]*Sokoine University Tanzania*

Article published on June 30, 2018

Key words: Organic and inorganic fertilizers, Sunflower, Yield and yield component

Abstract

An experiment was conducted at Sokoine University of Agriculture to assess the effect of organic and inorganic nitrogen fertilizers on yield and yield component of sunflower in Morogoro. The treatments included the control; 2 t farmyard manure (FYM) ha^{-1} applied at planting (AAP); 5 t FYM ha^{-1} AAP; 10 t FYM ha^{-1} AAP; 20kg N ha^{-1} applied as UREA at 30 days after planting (DAP); 40kg N ha^{-1} applied as UREA at 30 DAP; 60kg N ha^{-1} applied as UREA at 30 DAP; 2 t FYM ha^{-1} AAP + 20kg N ha^{-1} applied as UREA at 30 DAP; 5 t FYM ha^{-1} AAP + 40kg N ha^{-1} applied as UREA at 30 DAP and 10 t FYM ha^{-1} AAP + 60kg N ha^{-1} applied as UREA at 30 DAP. A randomized complete block design was used and treatments were replicated three times. Data collected included: Soil fertility, plant height and number of leaves at 15, 30, 45, 60 and 75 DAP; Head diameter, biomass yield, total seed yield, thousand seeds weight. The data were subjected to ANOVA and means were separated with LSD $_{0.05}$. The application of 10 t FYM ha^{-1} + 60kg N ha^{-1} significantly increased seed yield and 1000 seeds weight in both seasons. For this reason, 10 t FYM ha^{-1} + 60kg N ha^{-1} can be recommended to farmers to produce high seed sunflower yield and yield component at Morogoro.

* **Corresponding Author:** Habineza Mpunga ✉ ir.jphaby@yahoo.com

Introduction

The importance of farmyard manure is being realized again because of the high prize of commercial fertilizers and its long term adverse effect on soil chemical proprieties. Besides suppling macronutrients and micronutrients to the soil, fertility of soil improved by using farmyard manure (Negassa *et al.* 2001; Tirol-Padre *et al.* 2007). In addition, there are enough places to replenish the soil by utilizing available sources, such as natural and bio fertilizers (Abou *et al.,* 2002). However, many information said that, organic fertilizer could increase the farmer's income and the productivity could be higher with organic fertilizer compared to the chemicals (Catur, 2014). In addition, the farmyard manure is one of the most important components of soil. Although we think it as a single compound, its composition is quite diverse since is the result of the decomposition of animals, plants and microorganisms in the soil or in off-farm materials. It is this diverse composition what makes farmyard manure important since many different products are obtained from the decomposition process which acts as the bricks of the soil that build farmyard manure (FAO, 2015). Some researchers conducted various experiments to evaluate the impact of inorganic and organic fertilizers application on sunflower (Abou *et al.,* 2002). The use of nitrogen at 100kg ha^{-1} in three equal splits at sowing, at first irrigation and at flowering and application of chemical fertilizers at 50-75-50 NPK kg ha^{-1} along with poultry manure at 8 t ha^{-1} in the first and second experiment respectively, appeared to be the most appropriate, economical and suitable nutritional management practices to obtain maximum yield of sunflower (Munir, 2007). There is need for the farmers to manage soil fertility level for sunflower cultivation with an integrated way of using organic and inorganic manure, as correcting nutrient imbalances not only leads to sustainable high crop yields, but it reduces the need to cultivate unsustainable marginal lands(Gruhn *et al.*, 2000). Sunflower (*Helianthus annuus* L.) is the fifth most important source of edible oil after soybean, rapeseed, cotton, and peanut, and due to high content of edible oil (38-50%) and protein (40-44%) and its high content of unsaturated fatty acids as well as to the lack of cholesterol has a desirable quality (Razi and Assad, 1998; Abdel-Motagally and Osman, 2010). Sunflower is one of the oilseed cash crops which have been promoted by the government and private sectors as a potential crop for improving farmers' livelihoods and ensuring availability of healthy edible oil in the country (RLDC, 2010). However, the crop is still facing low production and productivity challenges which might partly be attributed to poor soil fertility, low use of improved seeds and poor agronomic practices (RLDC, 2010). Roosal *et al.*, 2013 reported that, application of input applications farmyard manure at the rate of 10 and 20 t ha^{-1} recorded significant improvement in the plant height, leaf area index and dry matter production of sunflower after 25 days of sowing over no farmyard manure at 10 and 20 t ha^{-1} increased the oil yield by 11 and 5.4% respectively over no application. In addition, Application of nitrogen fertilizers and farmyard manure has a great impact on sunflower growth, biological yield components as well as oil content (Helmy and Ramdan, 2009). One of the limiting factors in sunflower production among majority of Tanzanian farmers is poor soil fertility and productivity. For instance Berglund (2012) reported that low sunflower yields can be caused by incorrect plant population, poor soil fertility, lack of weed control, diseases, insect damage, bird depredation, lodging, late planting and harvesting losses. Oyinlola *et al.*, (2010) also noted that nitrogen deficiency is generally the most limiting nutritional disorder which affects sunflower production. Similarly Warrick, (2001) reported that in order for farmers to obtain high and consistent sunflower yields, an adequate fertilizer program should be part of production planning . Helmy and Ramdan, (2009) also noted that use of animal wastes and nitrogen fertilizer contribute significantly in increasing sunflower seed yields and oil content. This means that, soil fertility management is essential for consistent achievement of high sunflower seed yields and high oil content. That why this study was conducted to assess the influence of inorganic and organic nitrogen fertilizers on yield and yield component of sunflower in order to know which fertilizer could help Tanzanian people to increase yield and yield component of sunflower.

Materials and methods

The study was conducted at Sokoine University of Agriculture in Tanzania. The longitude was 60 51'5E and the latitude was 390 37'26S at 600m above sea level. In short rain 2013, 200mm of rain fall was recorded while 500 mm was recorded during long rain season 2014. The maximum temperature was 31°C. The soils were red, friable sandy clay with pH range of 5.5 to 6.0. The harvesting was done after 113 days after planting. The Spacing used was 70 cm between lines and 20 cm within plants. Farmyard manure (FYM) was applied at planting in 3 cm to 5 cm depth in a 10 cm planting hill and was covered by a thin layer of soil prior to placement of the seed. Two to three seeds were placed manually in each planting hill and were thinned to one seedling per hill in 12 days after germination as per farmers' practice. Inorganic nitrogen fertilizer in form of urea was applied/ top dressed 30 days after seedlings emergence. Manure which was analysed for nutrient content was obtained from nearby Magadu farm. Sunflower seeds were sourced from Agricultural Seed Agency (ASA) and Agro Seed International ltd. Urea was obtained from agro dealer's shops in Morogoro town. The experiment was laid out in Randomized Complete Block Design on an area of 1135m², replicated three times.

The treatments were presented as follows: Control (no nitrogen fertiliser, no farmyard manure), 2 t farmyard manure (0.01kg N) (FYM) ha^{-1} applied at planting (AAP), 5 t FYM ha^{-1}(0.03kg N) AAP, 10 t FYM ha^{-1}(0.51kg N) AAP , 20kg N ha^{-1} applied as urea at 30 days after planting (DAP), 40kg N ha^{-1} applied as urea at 30 DAP, 60kg N ha^{-1} applied as urea at 30 DAP, 2 t FYM ha^{-1} (0.01kg N) AAP+ 20 kg N ha^{-1} applied as urea at 30 DAP, 5 t FYM ha^{-1} (0.03kg N) AAP + 40kg N ha^{-1} applied as urea at 30 DAP ,10 t FYM ha^{-1} (0.05kg N) AAP+ 60kg N ha^{-1} applied as urea at 30 DAP. Data collected included: Soil fertility, Plant height and number of leaves at 15, 30, 45, 60 and 75 DAP; Head diameter, biomass yield, total seed yield, thousand seeds weight. All data were subjected to analysis of variance using GENSTAT program and means were separated with LSD test at $P \leq 0.05$.

Evaluation of inorganic and organic fertilizers on yield and yield components of sunflower

Soil sampling and analysis

Soils of the experimental site and manure were sampled and prepared for physico-chemical check one week before first planting. The soil sample was collected from the top soil 30 cm 22 depth at 15 points by using a hand hoe within a furrow slice. A 0.25kg sample from each block was air dried for two weeks, ground, sieved in a 2mm sieve and were analysed at the soil science department of Sokoine University of Agriculture. Analyzed plant nutrients include: pH, organic carbon by wet titration method, electric conductivity (E.C) nitrogen by Kjedahl method, macro nutrients (Nitrogen, Phosphorus, Potassium and Sulfur) Exchangiable bases (Mg, Ca, K) micronutrients (Fe, Zn, Mn, Cu, Bo) Cation Exchange Capacity (C.E.C) by atomic absorption method. The soil physical properties determined were particle size analysis and texture.

Sunflower plant growth parameters

The variables measured included: number of leaves per plant at 15, 30 45, 60 and 75 days after planting, plant height at 15, 30,45, 60 and 75 days after planting and head diameter at sunflower plant physiological maturity. Number of leaves and plant height were determined by sampling 5 plants falling within the four middle rows.

Plant height was measured using a 1m ruler, while all leaves (including young newly formed leaves) were counted manually. Data on the number of leaves and plant height was collected at 15 days interval until 75 days after emergence. Five sunflower plants were sampled in the four middle rows in a plot at reproductive stage 8 (R8) and the head diameter was measured. At this stage the plants were fully matured, the petals had dried and the bracts had turned brown. The diameter in cm was measured using a 30cm ruler. Data collected from each variable was subjected to analysis of variance using Gen Stat discovery edition 13 statistical packages at 5% probability level. Treatment means were compared using the least significant difference (LSD) test at 5% probability level.

Sunflower total biomass, seed yield and yield components

Data on total biomass was collected during harvesting, while seed yield and 1000 seed weight data were collected after harvesting. Sampling was carried out in three centre rows in each plot occupying area of 8m². Sunflower heads were removed using a hand knife and were kept in the 30kg manila bags during harvesting. Few seeds from the heads were removed and seed moisture content during harvesting was determined using a grain moisture meter. The harvested heads were air dried at the glass house for two weeks and then was processed to obtain sunflower seeds. The seeds obtained from each plot were weighed using a weighing balance and seed yield per plot was obtained in g/8m². 30 sub samples of 100g sunflower seeds from the seed yield were set aside and were taken to a seed counter machine. A count A Pak seed counter machine was used to count a thousand seeds from each sample. The 1000 seed counted from each sample were weighed in a weighing balance and weight of 1000 sunflower seed (g) was obtained.

Fig. 1. Sunflower 1000 seed weight determination.

Five sunflower plants were sampled in the four middle rows in a plot and the plant shoots were cut above the ground using a sharp knife. The shoots from each plot together with the leaves and heads were cut into pieces and air dried in the glass house for two weeks. The shoots (together with the leaves and heads) were sliced, packed in the well labelled A3 envelopes and were oven dried at 70°C for 72 hours. The oven dried matter was weighed and the biomass yield obtained. After weighing the seeds from each biomass sample were taken back to the respective seed yield samples.

Data collected from each variable was subjected to analysis of variance using Gen Stat discovery edition 13 statistical packages at 5% probability level. Treatment means were compared by using least significant difference (LSD) test at 5% probability level.

Results

Effect of inorganic nitrogen and organic fertilizer on yield and yield components of sunflower

Soil chemical analysis

Table 1 on determination of soil fertility of the experimental blocks prior to planting during the short rain season of 2013/204 and the composition of farmyard manure showed that the soils were slightly acidic non saline with medium, sufficient and high levels of most of the nutrients except for Nitrogen and Calcium which were low and Zinc which was very low.

Table 1. Soil fertility status of an experimental site before planting and manure.

Soil chemical composition	Value
pH	5.68M
Electric conductivity (mS/cm)	0.07NS
Organic carbon (%)	1.60M
Total N (%)	0.12L
Total P bray1(mg/kg)	1467.66
Extractable P (mg/kg)	9.80M
Cation exchange capacity (cmol/kg)	17.88M
K+ (cmol/kg)	0.88H
S (mg/kg)	45.2VH
Cu (mg/kg)	1.63H
Mn (mg/kg)	119.51VH
Zn (mg/kg)	0.94VL
Fe (mg/kg)	47.12VH
Ca2+ (cmol/kg)	4.5L
Mg2+ (cmol/kg)	2.70M
K+ (cmol/kg)	0.88H
Na+ (cmol/kg)	0.43M
Composition of farmyard manure	
Total N (%)	0.512 H
P2O5 (%)	1.94M
K2O (%)	1.16M

The rating of soil analysis data L = Low, M = Medium, H = High, VH = Very High and NS = Non Saline were according to Jones, (2001)

Plant height

In the short rains fertilizer application had a significant effect (P≤ 0.05) on plant height at all sampling periods except at 15 days after planting (Table 2). In most cases, plots supplied with farmyard manure alone or in combination with inorganic N-fertilizers had significantly taller sunflower plants than the no fertilizer control plots.

Application of inorganic fertilizer alone did not increase plant height at all sampling times except at 75 days after planting where plants supplied with 40kg N ha^{-1}were 30.5% taller than the plants in the no fertilizer control plots. Plant height varied from 14.27 to 16.67, 39.73, to 53.53, 86.53 to 118.40, 138.2 to 189.1 and 142.5 to 194.7cm at 15, 30, 45, 60 and 75 days after planting, respectively. In the long rains fertilizers application had a significant effect (P≤ 0.05) on plant height at all sampling periods except at 60 days after planting (Table 2) combined application of 60kg N ha^{-1}and 10 t ha^{-1}FYM produced taller plants than all the fertilizer treatments at 15, 30 and 45 days after planting. For example plants supplied with a combination of 60kg N ha^{-1}and 10 t ha^{-1}FYM were 72.5, 70.6 and 37.5% taller than non fertilized plants at 15, 30 and 45 days, respectively. Generally application of 10 t FYM ha^{-1}, 5 t FYM ha^{-1}, 5 t FYM ha^{-1}+ 40kg N ha^{-1}and 10 t FYM ha^{-1}+ 60kg N ha^{-1}produced significantly taller plants than application of 20, 40 and 60kg N ha^{-1}. Application of 20kg N ha^{-1}had no effect on plant height relative to the no fertilizer control. At 75 days after planting sunflower plant height ranged from 270.6 to 310.7cm. The average plant was 16.66, 23.30, 39.65, 67.58, and 69.43% higher in the long rains than in the short rains at 15, 30, 45, 60 and 75 days after planting respectively.

Table 2. Effect of fertilizer application on sunflower plant height (cm) during the short rain season 2013/2014 and long rain 2014.

	Short rain						Long rain				
	Days after planting						Days after planting				
Treatments	15	30	45	60	75	Treatments	15	30	45	60	75
Control (No fertilizer)	15.83a	41.43b	86.53c	138.20b	142.50b	Control (No fertilizer)	13.33e	44.13d	123.40d	223.30a	281.90bc
20kgNha^{-1}	14.43a	45.83b	101.27bc	154.80b	144.90b	20kgNha^{-1}	15.27d	44.87d	127.50d	219.10a	270.60c
40kgha^{-1}	14.93a	47.10ab	105.07b	172.50ab	185.90a	40kgha^{-1}	15.80d	49.33d	130.20cd	226.50a	284.60bc
60kgha^{-1}	14.27a	39.73b	92.27c	150.90ab	153.30a	60kgha^{-1}	17.13c	57.47c	136.30cd	396.90a	294.90b
2t FYMha^{-1}	16.67a	51.17ab	118.40a	165.30ab	194.00a	2t FYMha^{-1} residual	18.53c	56.87c	137.60c	233.30a	298.50ab
5t FYMha^{-1}	16.27a	41.07b	90.00c	149.80b	157.10a	5t FYMha^{-1} residual	20.93b	67.60b	156.00b	252.20a	284.70bc
10tFYMha^{-1}	14.97a	53.53a	105.87b	189.10a	189.30a	10tFYMha^{-1} residual	20.53b	66.93b	157.10b	261.20a	310.50c
20kg Nha^{-1} +2t FYMha^{-1}	14.57a	52.47a	111.73ab	158.60b	194.70a	20kg Nha^{-1} +2t FYMha^{-1} residual	16.00d	56.87c	137.70c	399.10a	275.50c
40kgNha^{-1}+5t FYMha^{-1}	15.60a	49.67ab	97.20bc	166.70ab	161.70a	40kgNha^{-1}+5t FYMha^{-1} residual	18.13c	67.13b	149.20b	254.80a	306.30ab
60kgNha^{-1}+10tFYMha^{-1}	15.60a	53.47a	111.87ab	177.90ab	192.30a	60kgNha^{-1}+10tFYMha^{-1} residual	23.0a	75.27a	169.70a	254.70a	299.20ab
P value	0.832	0.039	<.001	0.052	0.016	P value	<.001	<.001	<.001	0.544	0.048
LSD 0.05	Ns	6.10	10.63	24.55	23.83	LSD 0.05	1.69	6.86	9.27	Ns	15.62
CV%	16.2	13.4	10.9	15.9	14.6	CV%	10.1	12.5	6.8	41	5.5

Means bearing same letters along the column are no significantly different (P < 0.05) according to Duncan's New Multiple Range Test. n.s = not significant.

Number of leaves

During short rains, fertilizer application had a significant effect (P≤ 0.05) on the number of leaves per plant at 45 and 75 days after planting but had no effect on this attribute at 15, 30 and 60 days after planting (Table 3). At 45 days after planting all the fertilizer treated plots had significantly higher number of leaves per plant than the no fertilizer (control) plots.

The number of leaves per plant ranged from 26.67 (control) to 31.87 (60 kg N ha^{-1}). At 75 days after planting application of 10 t FYM ha-^{1}had the highest number of leaves compared to all other treatments. The average number of leaves per plant ranged from 33.33 (control) to 39.67 (10 t FYM ha-^{1}). During the long rains the number of leaves per plant was affected significantly by fertilizer application (P≤ 0.05) at 15, 30 and 75 days after planting (Table 3).

A combination of 60kg N ha^{-1}and 10 t FYM ha-^{1}had significantly higher number of leaves per plant than most of the other treatments across the three sampling periods. Plants supplied with 60kg N ha-^{1}had significantly higher number of leaves than plants supplied with 20 and 40kg N ha^{-1}at 30 and 75 days after planting. In contrast there were no significant differences among 2, 5 and 10 t FYM ha-^{1}treatments in the number of leaves per plant.

The average number of leaves per plant ranged from 10.8 to 13.67, 18.80 to 24.77 and 30.80 to 38.20 at 15, 30 and 75 days after planting respectively. The short rain season had 1.12, 14.48 and 4.98% higher average number of leaves per plant than the long rains at 15, 30 and 75 days after planting respectively.

The long rain season had 3.88 and 4.62% higher average number of leaves per plant than short rains at 45 and 60 days after planting respectively.

Table 3. Effect of fertilizer application on sunflower leaves per plant during the short rain season 2013/2014 and long rain 2014.

	Short rain						Long rain				
	Days after planting						Days after planting				
Treatments	15	30	45	60	75	Treatments	15	30	45	60	75
Control (No fertilizer)	11.93a	24.00a	26.67c	31.20a	33.33c	Control (No fertilizer)	11.87bc	18.80c	26.67a	30.87a	32.87bc
20kgNha^{-1}	12.13a	24.47a	31.81ab	30.27a	35.13bc	20kgNha^{-1}	11.13c	20.27c	29.73a	30.93a	30.80c
40kgha^{-1}	11.67a	25.60a	30.33b	29.67a	36.87b	40kgha^{-1}	11.67bc	19.60c	28.60a	30.87a	32.20c
60kgha^{-1}	11.40a	23.93a	31.87ab	32.33b	35.53bc	60kgha^{-1}	11.73bc	22.33b	30.13a	31.60a	35.53ab
2t FYMha^{-1}	13.67a	24.87a	31.53ab	31.40a	36.00bc	2t FYMha^{-1} residual	11.40bc	21.87bc	28.93a	31.80a	35.40ab
5t FYMha^{-1}	12.07a	24.40a	29.63b	31.07a	35.80bc	5t FYMha^{-1} residual	12.93ab	24.13ab	31.07a	32.93a	33.35b
10tFYMha^{-1}	11.93a	26.47a	31.73ab	33.33a	39.67a	10tFYMha^{-1} residual	12.33b	21.33bc	51.47a	33.27a	36.07ab
20kg Nha^{-1} +2t FYMha-^{1}	11.53a	26.40a	31.73ab	27.07a	36.60b	20kg Nha^{-1}+2t FYMha-^{1} residual	10.80c	20.87bc	30.40 a	31.40a	31.73c
40kgNha^{-1} +5t FYMha^{-1}	12.27a	24.80a	28.93b	32.00a	34.20c	40kgNha^{-1}+5t FYMha^{-1} residual	11.93bc	23.53ab	29.27a	33.80a	35.13b
60kgNha-^{1}+10tFYMha-^{1}	12.20a	25.67a	31.13ab	29.33a	35.13bc	60kgNha-^{1}+10tFYMha^{-1} residual	13.67a	24.27a	30.93a	34.40a	30.20a
P value	0.628	0.522	<.001	0.416	0.018	P value	0.006	<.001	0.189	0.112	0.024
LSD 0.05	ns	ns	2.07	ns	2.12	LSD 0.05	1.09	1.85	ns	Ns	2.85
CV%	8.5	8.4	7.1	8.8	6.1	CV%	9.6	8.9	33.9	5.9	8.5

Means bearing same letters along the column are no significantly different (P < 0.05) according to Duncan's New Multiple Range Test. n.s = not significant.

Head diameter

During both seasons fertilizer application did not significantly (P > 0.05) affect head diameter of sunflower plants. The average head diameter ranged from 14.00 (control) to 23.47cm (5 t FYM ha-^{1}) in the short rains and 9.74 (20kg N ha^{-1}) to 12.54cm (60kg N ha^{-1}+ 10 t FYM ha-^{1}) in the long rains. The short rains had 50.82% higher average head diameter than the long rains (Table 4).

Biomass yield

In both seasons fertilizer application had a significant effect (P≤ 0.05) on sunflower shoot biomass. In the short rains 10 t FYM ha-^{1} gave higher biomass yield than all other treatments. Application of 10 t FYM ha-^{1}gave 107.9% higher biomass yield than the no fertilizer control. There were significant differences in shoot biomass among the different inorganic nitrogen fertilizer rates and also among the farmyard manure rates. In the long rains a combination of 60kg N ha^{-1} and 10 t FYM ha-^{1}had higher shoot biomass yield than all the inorganic fertilizer treatments, 2 t FYM ha-^{1}and 5 t FYM ha-^{1}. Application of 60kg N ha^{-1}o utperformed 20kg N ha^{-1} by 21.4%.

The average shoot biomass ranged from 672.13 to 967.88kgha^{-1}. The short rains had 21.25% higher average shoot biomass yield than the long rains (Table 4).

1000 seed weight

In the short rains fertilizer application had a significant effect (P≤ 0.05) on sunflower seed weight. The plots supplied with 10 t FYM ha-^{1}+ 60kg N ha^{-1} had higher 1000 seed weight than plots from the other treatments. Control had a lower 1000 seed weight than the rest of the treatments.

The 1000 seed weight ranged from 32.94 (control) to 51.61g. Treatment effect on sunflower 1000 seed weight were not significant in the long rains. The average seed weight ranged from 27.42 to 33.62g. Sunflower 1000 seed weight average was higher by 39.75% in the short rains than in the long rains (Table 4).

Sunflower seed yield

In this season 10 t FYM ha-^{1}+ 60kg N ha^{-1} showed higher seed yield than the rest of the treatments. Seed yield obtained by application of 10 t FYM ha^{-1} was also higher than the control. Control plots showed lower seed yield than all the other treatments. Sunflower seed yield was 190.7% higher in plots treated with 60kg N ha^{-1} + 10 t FYM ha-^{1} than in the control plots. No seed yield differences were noted among 20, 40 and 60kg N ha^{-1} and among 2, 5 and 10 t FYM ha-^{1}treatments. Fertilizer treatments in the sunflower seed yield were not significant in long rain season. Short rain season had 102.15% higher average seed yield than the long rain season (Table 4).

Table 4. Effect of fertilizer application on sunflower head diameter during the short rain season 2013 and long rain 2014.

Treatments	Short rain season				Treatments	Long rain season			
	Hd	Bm	Thsw	Sy		Hd	Bm	Thsw	Sy
Control (No fertilizer)	14.00a	638.25e	32.94d	431.10c	Control (No fertilizer)	11.75a	672.13d	33.62a	401.00a
20kgNha^{-1}	15.83a	977.25c	41.63c	854.00b	20kgNha^{-1}	9.74a	676.13d	27.42a	243.50a
40kgha^{-1}	16.53a	1041.75bc	49.14ab	778.60b	40kgha^{-1}	12.03a	783.88cd	32.46a	429.40a
60kgha^{-1}	16.00a	1012.13bc	45.23bc	821.50b	60kgha^{-1}	10.84a	821.12c	29.11a	384.30a
2t FYMha^{-1}	15.20a	944.88c	44.25bc	1185.80a	2t FYMha^{-1} residual	11.61a	842.75bc	31.63a	528.50a
5t FYMha^{-1}	23.47a	800.13d	42.12c	987.60ab	5t FYMha^{-1} residual	11.09a	853.13b	33.11a	553.50a
10tFYMha^{-1}	18.50a	1326.75a	48.25ab	992.80ab	10tFYMha^{-1} residual	11.41a	877.00ab	32.40a	421.90a
20kg Nha^{-1}+2t FYMha-^{1}	16.47a	1180.50b	49.89ab	839.50b	20kg Nha^{-1}+2t FYMha-^{1} residual	11.71a	676.13d	32.07a	518.00a
40kgNha^{-1}+5t FYMha^{-1}	16.60a	1061.75bc	43.50bc	801.90b	40kgNha^{-1}+5t FYMha^{-1} residual	10.94a	784.88cd	32.05	327.40a
60kgNha-^{1}+10tFYMha^{-1}	18.83a	1095.25bc	51.61a	1265.00a	60kgNha-^{1}+10tFYMha^{-1} residual	12.54a	821.12c	37.10a	567.80a
P value	0.235	<.001	<.001	0.001	P value	0.354	0.002	0.263	0.1
LSD 0.05	ns	144.30	6.32	227.50	LSD 0.05	ns	111.50	Ns	ns
C.V%	31.4	19.5	15.1	35.5	C.V%	7.5	9.7	10.8	29.5

Means bearing same letters along the column are no significantly different (P < 0.05) according to Duncan's New Multiple Range Test, Hd: head diameter (cm), Bm:Biomass (kg ha^{-1}), Thsw: Thousand seed weight (g), Sy: Seed yield (kg ha^{-1}).

Discussion

The increase of plant height from both seasons could be attributed to the positive effect of nitrogen element in plant growth. Nitrogen application might have led to progressive increase in internodes length and consequently increase in plant height. Similar findings have been reported elsewhere (Al-Thabet, 2006). Hussein and Thomas, (2010) in a study conducted in India reported that nitrogen application at 120kg N ha-^{1} significantly increased plant height.

Number of leaves per sunflower plant was significantly increased by nitrogen fertilization. This shows that sunflower number of leaves could significantly be increased by nitrogen levels higher than 60kg N ha^{-1}. Al-Thabet, (2006) reported that, higher sunflower number of leaves per plant was recorded at 150 and 200kg N ha^{-1}, and was attributed to an increase in vegetative growth as a result of availability of nitrogen. The results also showed that application of 10 t FYM ha^{-1} gave taller plants from 30 to 75 days after planting.

This could be attributed to the ability of FYM in rendering availability of other plant nutrients as well as chelation of humic substances in the soil. Particularly in the second season the effect of FYM became more vivid than in the first season.

This could be explained by further decomposition of FYM and the residual effect by FYM in the subsequent season. These results are in line with those reported by Brady, (2008) that addition of 8 t FYM ha^{-1} increased sunflower plant height and number of leaves which in turn increased the surface area for photosynthesis. Combination of nitrogen and FYM produced the tallest plants of all treatments. This is probably attributed to the improvement of rhizosphere environment and increased availability of nitrogen in the soil. These findings concur with those reported by Helmy and Ramdan, (2009) that, mixture of organic and inorganic fertilizers resulted in superior sunflower growth parameters including plant height and number of leaves compared to other treatments. Integrated application of organic and inorganic fertilizers has been previously reported to enhance growth of various crops including soy bean (Yagoub *et al*., 2012). The result of the study showed that; head diameter was not significantly affected by addition of nitrogen fertilizers, FYM alone or combination of both fertilizers. This shows that sunflower heads diameter is probably determined by varietal genetic composition. The diameter ranged from average of 14cm to 18cm in the first season. In this study control had 14 cm being the smallest head size, and 18.5cm at 10 t FYM and 10 t FYM ha^{-1} + 60kg N ha^{-1}. Similar head sizes due to different nitrogen fertilization were also reported by Al-Thabet, (2006) that the head sizes ranged from 12 cm in control and 17 cm in 200 kg N kg^{-1} in Saudi Arabia. The results of the present study demonstrated that; during short rains of October to February, addition of nitrogen fertilizers, significantly increased plant biomass and seed yield. This might be due to the property of nitrogen in stimulating growth and yield components. Increase in seed yield due to application of inorganic nitrogen fertilizers was also reported by Al- Thabet, (2011) that, application of nitrogen fertilizers from 0kg N ha^{-1} to 200kg N ha^{-1} increased sunflower seed yield from 1 t ha^{-1} to 4 t ha^{-1} respectively. Increase in sunflower seed yields due to application of FYM observed from this study was also reported by Rasool *et al.,* (2013) who found that sunflower seed yields were enhanced in the plots treated with FYM when compared to no - FYM plots; These findings are in agreement with previous studies by Sharma *et al.,* (1999) who reported that FYM increased plant height and seed yield in comparison to no – FYM control.

This could be due to the fact that, decomposed FYM may have released the nutrients in the plant available form and also due to enhanced uptake of plant micronutrients like boron which has been reported by Sharma *et al.,* (1999) to improve sunflower growth and yield characteristics. Ghalavand *et al*., (2011) further reported that, integrated inorganic and organic fertilizers resulted in the highest sunflower grain yield. These findings are at par with those reported by Munir *et al*., (2007) who also suggested that the positive combination effect might have resulted from the reduction of soil bulk density, increased water holding capacity and granulated soil structure which increases the efficiency of plant nutrients uptake. Sunflower achene yield was found higher in plots treated with FYM alone or in combination with chemical fertilizers than control in other studies (Esmaelian *et al*., 2012). However, 10t FYM ha^{-1} alone produced biomass yield of 108% over the control. Similar biomass yield trend was reported by Rasool *et al*., (2013) in India. Significant effect of nitrogen fertilizers on dry matter weight could have resulted from the fact that; nitrogen is the principal constitute of proteins, enzymes, hormones, vitamins and chlorophyll, which contributes to improved leaf area index and increased dry weight. Several scientists have reported the effects of nitrogen fertilizers on sunflower dry matter formation; leaf area per plant and crop growth rate (Wabekwa *et al.,* 2012). Hussain and Thomas, (2010) additionally reported that nitrogen application significantly increased plant height and dry matter yields in sunflower crop. The two finding are in conformity with the report of Filho *et al.,* (2011); who found that application of nitrogen from 0kg N ha^{-1} to 100kg N ha^{1}

played a significant role in increasing sunflower stem, leaves and head dry weight in Brazil. The increase in sunflower biomass formation from 10 t FYM ha^{-1} could be explained by the fact that FYM not only supply both of macro and micro nutrients in the soil but also improves soil physical conditions for better plant nutrient uptake hence increased growth and yields in field crops. Experiment conducted in Nigeria by Agele and Taiwo, (2013) on applications of FYM in sunflower crop production showed similar results. However Rasool, (2013) reported that,incorporation of farmyard manure FYM 10 or 20 t ha^{-1} being at par significantly improved growth parameters over the control. The dry matter production with 10t ha-1 FYM was 9.5% higher over control. This might be due to better crop growth, facilitated by the improvement in soil physical, chemical and biological properties as well as plant nutrition with the addition of organic manure. In this study, weight of 1000 sunflower seeds was significantly affected by addition of fertilizers only during the short rains season probably due to the fact that high biomass produced might have remobilized and partitioned for grain filling and incidence of hollow seed formation was reduced.

The difference in 1000 seed weight between the two seasons could be attributed to severe crop lodging which occurred at early grain filling stage during the long rains season. It took place when assimilates had not been fully translocated to grain formation and this may have lowered the yields. HGCA, (2005) reported that, crop lodging can cause economic yield loss in cereal crops of up to 75% loss, depending on the crop growth stage at which lodging occurred. 80% yield reduction was also reported by Tams *et al.*, (2004) on field crops in United Kingdom (UK). Effect of yield loss due to crop lodging was reported by Sterling and Baker, (1998), Pinthus, (1973) and Berry *et al.,* (2004). 1000 Seed weight range obtained from this study (32g to 52g) is in line with the range that was reported by Ramulu *et al.,* (2011) who found out that weight of 1000 sunflower seeds were between 21g to 60g; the difference might also depend on genetic potential of the seed variety. However, some findings also showed that; increase in 1000 seeds weight was not significantly affected by nitrogen fertilizers although weight increased as nitrogen rates were increased in Nigeria. Wabekwa, (2012) and Filho *et al.,* (2011) reported that; number of seeds per head as well as biomass, 1000 seeds weight was not significantly affected by nitrogen fertilization in Brazil. Additionally Nobre *et al.*, (2014) reported a significant increase in 1000 seed weight due to application of nitrogen maximum being 44g. Ebrahim *et al.*, (2003) reported a significant increase of 1000 seeds weight due to application of nitrogen fertilizers in Sudan. These findings concur with those reported by Helmy and Ramdan, (2009) that, mixture of organic and inorganic fertilizers resulted in superior sunflower growth parameters including plant height and number of leaves compared to other treatments. Integrated application of organic and inorganic fertilizers has been previously reported to enhance growth of various crops including soybean (Yagoub *et al.*, 2012). The result of the study showed that; head diameter was not significantly affected by addition of nitrogen fertilizers, FYM alone or combination of both fertilizers. This shows that sunflower heads diameter is probably determined by varietal genetic composition. The diameter ranged from average of 14 cm to 18cm in the first season.

In this study control had 14cm being the smallest head size, and 18.5cm at 10 t FYM and 10 t FYM ha^{-1} + 60kg N ha^{-1}. Similar head sizes due to different nitrogen fertilization were also reported by Al-Thabet, (2006) that the head sizes ranged from 12 cm in control and 17cm in 200kg N kg^{-1} in Saudi Arabia.

Conclusion

This study showed that organic and inorganic fertilizers on sunflower production had positive impact on yield and components. Therefore the combination between 10 t FYM ha^{-1} and 60kg N ha^{-1} showed the best result followed by FYM and finally nitrogen (Combination > FYM> Nitrogen). 10 t FYM ha^{-1} and the combination between 10 t FYM ha^{-1} and 60kg N ha^{-1} played a significant role in sunflower seed yields and other yield components and gave the best results. Lower levels of nitrogen 20kg N ha^{-1} and 40kg N ha^{-1} showed no significant effect on sunflower crop yields.

It was therefore recommended that farmers in Morogoro to consider the combination between 10 t FYM ha^{-1} and 60kg N ha^{-1} in order to have high seed sunflower yield and yield components.

Acknowledgements

This publication was made possible through financial support provided by USAID- Innovative Agricultural Research Initiative (iAGRI) and Regional Universities Forum (RUFORUM).

References

Abdel-Motagally FMF, Osman EA. 2010. Effect of nitrogen and potassium fertilization combination of productivity of two sunflower cultivars under east of El-ewinate conditions. American-Eurasian Journal of Agricultural & Environmental Science **8(4),** 397-401.

Agele SO, Taiwo TG. 2013. Effects of Methods of Seedbed preparation and organic amendments on soil properties, growth and yield of sunflower in a humid zone of Nigeria. Department of crop, soil and pest management. Federal university of technology, Akure Nigereia.

Agricultural Research Institute (ARI)- Ilonga. 2008. Sunflower oil consumption preference. Tanzania.

Al-Thabet SS. 2011. Effect of Nitrogen levels on growth and yield of sunflower. Crops and range management College of Agriculture and Food Science. King Faisal University. Al- Hassa Saudi Arabia.

Al-Thabet SS. 2006**.** Effect of plant spacing and nitrogen levels on growth and yield of sunflower (*Helianthus annus* L.) J. King Saudi Univ. Agric Sci **19,** 1-11.

Berglund D. 2012**.** Irrigated sunflowers. North Dakota State University. US.

Berglund DR. 2007. Sunflower production and Marketing Extension. N.D. Agricultural Experiment station. North Dakota State University. US.

Brady NC, Weil RR. 2008. Nature and properties of soils 14th edition . Pearson education Inc. Prentice Hall. India. New Delhi.

Cantur 2011. The benefits of organic fertilizer application: case Indonesia: Garut and Sragen Regencies. Gadjah Mada University.Conference paper 1-24.

Ebrahim LEEl, Absawy EA, Salem AH, Gaaffar NA. 2003**.** Effects of Nitrogen and Phosphorus fertilization levels on growth, photosynthetic pigments, yield and yield components of sunflower *Helianthus annuus* Zagazig Journal of Agricultural Research **30,** 122 -1271.

Esmaelian Y, Mohammad R, Asghripour MR, Amiri E. 2012. Comparison of Sole and Combined Nutrient Application on Yield and Biochemical Composition of Sunflower under Water Stress. International journal of applied science and technology **2(3).**

FAO. 2015. Farmer's compost handbook, Experience in Latine America, Santario. Book, 1-112**.**

Filho DHG, Chaves LHG, Campos VB, Junior JAS, and Oliveira TL. 2011**.** Production of Sunflower and Biomass Depending on Available Soil Water and Nitrogen Levels. Iranica Journal of Energy and Environment. Department of Agricultural Engineering Federal University of Campina Grande, Brazil **2(4),** 313-319.

Ghalavand A, Akbar P, Modares, AM, Sanavy M, Aghaalikhani S, Shoghi, Alkhoran K. 2011**.** Comparison of different nutritional levels and effect of plant growth promoting rhizobacteria on the grain yield and quality of suflower. Agronomy Department, University of Tehran- Iran.

Gruhn P, Goletti F, Yudelman M. 2000. Integrated Nutrient Management, Soil Fertility, and Sustainable Agriculture: Current Issues and Future Challenges, 2020 Brief **6,** 1-3.

Helmy AM, Ramdan MF. 2000. Agronomic performance and chemical response of sunflower to some organic nitrogen sources and conventional sunflower fertilizers under sandy soil conditions. Zagazig University. Egypt.

Home Grown Cereals Authority–HGCA. 2005. Factors affecting lodging in winter wheats. Pentonville road- London UK.

Hussain SS, Thomas T. 2010. Influence of Nitrogen and Sulfur on Growth, Biomass Yield and Oil Content of Sunflower (*Helianthus annuus* L.) in Inceptisol. Research Journal of Agricultural Sciences. Department of Soil and Environmental Science, Allahabad Agricultural Institute (Deemed University) Allahabad, India **1(2),** 155-157.

Munir MA, Malik MA, Saleem FM. 2007. Impact of Intergration of crop manuring and Nitrogen Application on Growth Yield and Quality of Spring Planted Sunflower. University of Agriculture-Faisalabad, Afghanstan.

Munir MA. 2007. Nutritional management studies on spring planted sunflower (*Helianthus annuus* L.). Proc. Symp. Sunflower Agron 227.

Nobre GR, Da Sousa DW, De Lima GS, Gheyi HR, Dias AS, Pinheiro PWA. 2014**.** Sources and doses of nitrogen in the production of sunflower plants irrigated with saline water. Brasilia.

Oyinlola EY, Ogunwole JO, Amapu IY. 2010. Response of sunflower to nitrogen application in Savanna Alfisols. Ahmedo Bello University. Nigeria.

Pinthus MJ. 1973. Lodging in wheat, barley and oats: the phenomenon its cause and preventive measures. Advances in agronomy **(25),** 209-263.

Ramulu N, Krishna M, Jayadeva HM, Ravi Kumari HS. 2011. Seed yield and Nutrient uptake of sunflower (*Heliathus annuus*) as influenced by different levels of nutrients under irrigated conditions of eastern dry zone Karnataka, India.

Rasool F, Hassan B, Jahangir IA, Ali T, Mubarak T. 2013. Nutriotional Yield and Economic Responses of sunflower to integrated levels of Nitrogen, Sulphur and Farm Yard Manure. University of Agricultural Sciences and Technology of Kashmir, India. 191-121.

Razi H, Asad MT. 1998. Evaluation of variation of agronomic traits and water stress tolerant in sunflower conditions. Agricultural and Natural Resources Sciences **2,** 31-43.

Rural Livelihood Development Company (RLDC). 2008. Sunflower Sector and Market Development Strategy. Dodoma, Tanzania.

Sharma KR, Srivastava PC, Ghosh M, Gangwar MS. 1999. Effect of Bororn and Farmyard manure application on growth, yields and boron nutrition of sunflower, Journal of Plant Nutrition **4(5),** 633-640.

Tams AR. Mooney SJ, Berry PM. 2004**.** Effect of Lodging in cereals on morphological properties of the root-soil complex. Division of Environmental sciences. Nottingham. NG7 2RD, UK.

Wabekwa JW, Degri MM, Dangari LC. 2012. The effects of Nitrogen mineral on yield performance of sunflower in Bauchi State. Nigeria.

Warrick EB. 2001. Sunflower production Guide for West Central Texas. Agrilife Research and Extension center. San Angelo.

Yagoub OS, Ahmed WMA, Mariod AA. 2012**.** Effect of Urea, NPK and compost on growth and yield of soyabean (*Glycine max*) in semi-arid region of Sudan. International scholarly research Network. Agronomy. Khartoum Sudan.