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. 166-174, 2018

RESEARCH PAPER OPEN ACCESS

Influence of inorganic and organic nitrogen fertilizers regimes on oil content of sunflower in Morogoro, Tanzania

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

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

[2]*Sokoine University of Agriculture, Tanzania*

Article published on June 30, 2018

Key words: Organic and inorganic fertilizers, Sunflower, Oil content.

Abstract

This study was conducted at the Sokoine University of Agriculture to assess the influence of farmyard manure (FYM) and inorganic nitrogen fertilizers on sunflower seed oil content. The treatments consisted were: control (no nitrogen fertilizer, no farmyard manure); 2 t farmyard manure (FYM)/ha applied at planting (AAP); 5 t FYM/ha (AAP); 10 t FYM/ha (AAP); 20kg N/ha applied as UREA at 30 days after planting (DAP); 40kg N/ha applied as UREA at 30 (DAP); 60kg N/ha applied as UREA at 30 (DAP); 2 t FYM/ha at planting + 20kg N/ha applied as UREA at 30 (DAP); 5 t FYM/ha at planting + 40kg N/ha applied as UREA at 30 (DAP); and 10 t FYM/ha (AAP); + 60kg N/ha applied as UREA at 30 (DAP). A randomized complete block design was used and treatments replicated three times. Sunflower variety *Record* was used as a test variety. Data collected included: soil sample before planting, plant tissue analysis, seed oil content and total seed oil yield per hectare. All data were subjected to analysis of variance (ANOVA) and means were separated using (LSD) $P \leq 0.05$. The results showed that unlike the other parameters, oil content was only increased by 10 t FYM/ha in both seasons. It was therefore recommended that farmers in Morogoro to consider application 10 t FYM/ha in order to have high seed sunflower oil content.

* **Corresponding Author:** Josiah M. Kinama ✉ ir.jphaby@yahoo.com

Introduction

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). Turuka *et al.*, 2001 reported that, of all farm management and farm input applications inorganic fertilizers alone increases yields by 35 to 40% followed by improved seeds. Application of nitrogen fertilizers and farm yard manure has a great impact on sunflower growth, biological yield components as well as oil content (Helmy and Ramdan, 2009). The crop is suited to wide range of agro ecological zones with wide range of temperatures, soil types and rainfall patterns. It ranks the third most important source of edible oil in the world after soya bean (*Glycine max* L.) and cotton (*Gossypium hirsutum* L.) (Berglund *et al*., 2007). The crop gained popularity about less than 15 years ago after increased peoples' awareness of its healthier oil free of cholesterol and rich in polyunsaturated fatty acids than other vegetable oils (Ugulumu, 2007). It contributes about 40% of total national cooking oil requirement, ranking as one of the most important cooking oils with very high value (ARI- Ilonga, 2008). 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 programme 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 signifies that, soil fertility management is essential for consistent achievement of high sunflower seed yields and high oil content. The conventional method of sunflower production in many parts of Tanzania and Africa is cultivation without considering the soil fertility management practices. In addition, farmers rely mostly on extensive cultivation to increase crop yields, the practice which leads to deforestation and soil fertility depletion. Production of sunflower oil seed in Tanzania has been increasing from 75,000 tons to 100,000 tons from 2002 to 2005, the production then increased dramatically to 350,000 tons in 2007. The main reason for this increase is due to opening up of new land under sunflower production and a bit of use of improved seeds (MAFC, 2009). This accounts for extensive cultivation rather than intensively agricultural production where farmers open up a virgin land, cultivate for three to four consecutive years and abandon the farms after depleting the soils. Further, it is estimated that 350,000 tons of oil seed produced 90,000tons of sunflower oil per year. FAO recommends annual per capita oil consumption of 5kg of vegetable oil. In 2002 census, the population was 35,000,000 in Tanzania and the equivalent oil demand was 175,000,000kg. With current Tanzania population of 44,000,000 people, the amount of oil needed is 220,000,000kg per year. Thus, the demand for vegetable oil is high and the production has not met this demand. Despite continuous increase in area under production, there is still low production per unit area, and the deficit has been compensated by oil importation from Malaysia and Indonesia. To date Tanzania is a net importer of oil. Although there is good production of other oil seeds like groundnuts and sesame, sunflower oil is mostly preferred because of its high quality and healthy oil (free of cholesterol) and has high oil content of about 40%. This makes sunflower the most important cooking oil produced in Tanzania especially in the central corridor of the country. This shows a great need to deliberately increase sunflower production through soil fertilization. That why this study was conducted to assess the influence of inorganic and organic nitrogen

fertilizers on oil content of sunflower in order to know which fertilizer could help Tanzanian people to increase the quantity of sunflower oil.

Materials and methods

The study was conducted in Morogoro- Tanzania, at Sokoine University of Agriculture, Department of soil science experimental sites. Sokoine University of Agriculture is located at longitude 60 51' 5 E latitude 390 37' 26 S, at the base of Uluguru mountains, 200km west of Dar es Salaam on an altitude of 600 m above sea level.

Morogoro region has a bimodal rainfall pattern characterised by short rains which start from mid-September to December with total rainfall amount of 700mm and 1000mm for long rains which start from mid-March to June every year. During this experimental period short rain season from October 2013 to February 2014, 200mm of rain was recorded, and 500 mm was recorded during long rain season of March to July 2014. Mean monthly maximum and minimum temperatures were 31°C and 20°C respectively. The soils were red, friable sandy clay with pH range of 5.5 to 6.0 and soil extractable P of 0.024% (P_2O_5), total N 0.12% and cation exchange capacity (C.E.C) of 17 Cmol/kg. First planting was done on 10/10/2013 and harvested on 10/02/2014 equivalent to 122 days from planting to harvesting.

The second season trial was planted on 29th March 2014 and harvested on 17th July 2014, equivalent to 113 days from planting to harvesting. In the first season primary tillage was conducted before onset of short rains by using a tractor, followed by secondary tillage / harrowing before field layout by using a hand hoe and 7 m* 5m were used. Spacing used was 20cm* 70cm and these plots were maintained for use in the second season. The residual effect of the first treatment was determined by using the extrapolation of the plant nutrient uptake and removal from the plant tissue analysis data from the two seasons. The seed beds were prepared by using hand hoe and 30cm ruler in making planting hills of 10cm depth. From seed to seed the distance was 20cm and from row to row the distance was 70cm. Farmyard manure (FYM) was applied at planting in 3cm to 5 cm depth in a 10cm 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 (*Record*) were sourced from Agricultural Seed Agency (ASA) and Agro Seed International ltd and urea was obtained from agro dealer's shops in Morogoro town. The design of an experiment was Randomized Complete Block Design laid out on an area of 1135m^2, with three blocks each block having ten 35m^2 plots arranged in a 5 by 5 lines. The treatments were presented as follows: Control (no nitrogen fertiliser, no farmyard manure, 2 t farmyard manure (0.01kg N) (FYM)/ha applied at planting, 5 t FYM/ha (0.03kg N) applied at planting, 10 t FYM/ha(0.51kg N) at planting , 20kg N/ha applied as urea at 30 days after planting, 40kg N/ha applied as urea at 30 days after planting, 60kg N/ha applied as urea at 30 days after planting, 2 t FYM/ha (0.01kg N) at planting + 20kg N/ha applied as urea at 30 days after planting, 5 t FYM/ha (0.03kg N) at planting + 40kg N/ha applied as urea at 30 days after planting ,10 t FYM/ha (0.05kg N) applied at planting + 60 kg N/ha applied as urea at 30 days after planting. Each 5m by 7m experimental plot consisted of six planting rows each row having 34 planting hills making a plant population of 204 per plot.

Two to three sunflower seeds were planted per hill and later were thinned to one plant per hill. Short rains continued and supplemental irrigation was carried out whenever long dry spell resulted. Data collected included: soil sample before planting, plant tissue analysis, seed oil content and total seed oil yield per hectare. All data were subjected to analysis of variance (ANOVA) using General Statistical Package (GENSTAT) and means were separated using the least significant difference (LSD) test at $P \leq 0.05$.

Effect of inorganic nitrogen and organic fertilizer on sunflower seed oil content

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 30cm 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.

Plant tissue analysis

Plant tissue analysis was conducted to determine the soil nutrient status during the two crop growth seasons. At 60 days after planting five plants were sampled randomly from which three newly matured or new fully developed leaves were sampled. Sampled leaves from each plot were placed in a paper bag and transferred to the glass house for under shade drying. The leaves were left to air dry for two weeks, and then were oven dried at 70°C for two days prior to grinding. Oven dried leaves were ground using a Wiley Mill grinding machine to a fine powder. The ground samples were weighed and digested for determination of nutrients concentrations, both macro and micronutrients content by the wet ashing procedure. The procedure consisted of digesting 0.5g of plant sample using H_2O_2 – $HClO_4HF$, heated in tubes in a block digester at 200°C for 2 hours. The digest were cooled and made up to volume (50ml). The nutrients content of the plants extracts were determined as for soils.

Sunflower seed oil content and total seed oil yield

For oil determination and quantification, 30 samples of 20g dehulled seeds from each plot were taken to food science laboratory for oil extraction by using soxhlet extraction method by Franz von Soxhlet, (1879). The seeds were ground to obtain the fine powder and 5g of ground seeds from each sample was weighed and placed in a thimble. The thimbles was covered with a cotton wool to avoid loss of the sample during oil extraction in the soxhlet apparatus and were placed in the pre weighed round bottomed flasks containing 250ml of petroleum ether as an extraction solvent and then were arranged in the soxhlet extraction apparatus. After 3 hours the flasks were removed from soxhlet apparatus and were left to cool. After cooling the flasks with crude fat plus solvents were taken to evaporator and were dipped in the 70°C boiling water until no more moving solvents could be seen. The flask with crude fat was taken to the oven at 105°C for 30 minutes to allow more evaporation of organic solvents. The flask with oil was placed in the desiccators for 45 minutes to attain the ambient temperature, and then was weighed to obtain the weight of flask + oil. Method of analysis used was as described by Leas, (1975) and fat/oil extraction manual from the department of food science and technology of the Sokoine University of Agriculture.

Fig. 1. Sunflower oil determination.

To obtain a percentage oil the following calculation was carried out. % Oil/fat Content = ((Weight of flask + oil- Weight of empty flask)/ weight of Sample) * 100. Percentage oil data obtained from each sample was subjected to analysis of variance using Gen Stat discovery edition 13 statistical package 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 sunflower seed oil content

Soil physical and 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 sandy clay, 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.

Sunflower plant tissue analysis for short rain season and long rain season 2013/2014

The amount of macronutrients determined during the short rain season ranged from medium to sufficient (Table 2). The plant materials had low levels of calcium. During the long rain season the plant material had very high levels of nitrogen, high levels of potassium and sulphur and low to medium levels of phosphorus (Table 2).

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

Properties	Block 1	Block 2	Block 3
	Value	Value	Value
A: Physical properties			
Sand (%)	48	48	48
Silt (%)	9	11	9
Clay (%)	42	40	44
Textural Class	Sandy clay	Sandy clay	Sandy clay
B: Chemical composition			
pH	5.65M	5.7M	5.7M
Electric conductivity (mS/cm)	0.07 NS	0.07 NS	0.07 NS
Organic carbon (%)	1.58M	1.58M	1.66M
Total N (%)	0.12L	0.12L	0.12L
Total P bray1(mg/kg)	676.07	1038.88	2688.04
Extractable P (mg/kg)	10.03M	9.22M	10.16M
Cation exchange capacity (cmol/kg)	18.03M	17.8M	17.8M
K+ (cmol/kg)	0.76H	0.98H	0.89H
S (mg/kg)	52.52VH	52.52VH	31.2H
Cu (mg/kg)	1.79 H	1.58 H	1.53 H
Mn (mg/kg)	112.2VH	121.6 VH	124.74 VH
Zn (mg/kg)	0.97VL	0.97VL	0.88VL
Fe (mg/kg)	49.8VH	47.13VH	44.44VH
Ca2+ (cmol/kg)	4.88L	3.9L	4.9L
Mg2+ (cmol/kg)	2.79M	2.69M	2.64M
K+ (cmol/kg)	0.76H	0.98H	0.89H
Na+ (cmol/kg)	0.2L	0.71H	0.39L
C: 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).

Table 2. Plant tissue analysis results for short rain season 2013/2014 and long rain 2014.

Treatments	Short rain						Treatments	Long rain			
	N%	P%	K%	S%	Ca%	Mg%		N%	P%	K%	S%
Control (No fertilizer)	2.60S	0.32S	1.15M	0.24S	0.12L	0.16M	Control (No fertilizer)	4.43E	0.13L	3.79H	0.67H
20kgN/ha	2.94S	0.37S	1.19M	0.25S	0.06L	0.14M	20kgN/ha	4.41E	0.11L	4.91H	0.33H
40kg/ha	3.18S	0.34S	1.30M	0.21S	0.10L	0.16M	40kg/ha	4.47E	0.14L	3.80H	0.41H
60kg/ha	3.23S	0.37S	1.24M	0.23S	0.18L	0.17M	60kg/ha	4.75E	0.13L	5.08E	0.45H
2t FYM/ha	3.07S	0.39S	1.44M	0.24S	0.14L	0.16M	2t FYM/ha residual	3.81E	0.15M	3.99H	0.45H
5t FYM/ha	3.06S	0.40S	1.17M	0.22S	0.15L	0.15M	5t FYM/ha residual	3.19E	0.20M	4.49H	0.44H
10tFYM/ha	2.86S	0.40S	1.47M	0.24S	0.16L	0.15M	10tFYM/ha residual	3.60E	0.14L	3.71H	0.51H
20kg N/ha+2t FYM/ha	3.18S	0.37S	1.59S	0.23S	0.15L	0.14M	20kg N/ha+ 2t FYM/ha residual	4.61E	0.13L	4.33H	0.44H
40kgN/ha+5t FYM/ha	3.17S	0.39S	1.3M	0.23S	0.15L	0.19M	40kgN/ha+5t FYM/ha residual	5.56E	0.15M	3.90H	0.42H
60kgN/ha+10tFYM/ha	3.26S	0.30S	1.28M	0.21S	0.16L	0.18M	60kgN/ha+10tFYM/ha residual	4.61E	0.18M	5.15E	0.47H

N.B: the rating of plant tissue data; L = Low, M = Marginal, S = Sufficient, H = High and E = Excess were according to sunflower plant tissue interpretation.

Percent seed oil content

In both seasons fertilizer application had a significant effect (P≤ 0.05) on seed oil content (Table 3). In the short rains, 10 t FYM/ha gave a higher percent of oil content than most of the other treatments (Table 3). Percent oil content ranged from 33.67 to 47.35%. In the long rain season, control had higher percent seed oil than most of the other treatments (Table 3). Percent oil ranged from 23.71 (20kg N/ha +2 t FYM/ha) to 44.56% (control). Short rain had 23.82% higher average percent seed oil than long rain season.

Table 3. Effect of fertilizer application regime on sunflower seed oil content during the short rain season of 2013/2014 and long rain of 2014.

Treatments	Short rain season	Treatments	Long rain season
	Seed oil content %		Seed oil content %
Control (No fertilizer)	40.05c	Control (No fertilizer)	44.56a
20kgN/ha	44.24ab	20kgN/ha	26.98cd
40kg/ha	45.17ab	40kg/ha	36.63ab
60kg/ha	39.32c	60kg/ha	26.51c
2t FYM/ha	43.44b	2t FYM/ha residual	40.99ab
5t FYM/ha	33.67d	5t FYM/ha residual	27.58bc
10tFYM/ha	47.35a	10tFYM/ha residual	33.71bc
20kg N/ha+2t FYM/ha	38.69c	20kg N/ha+ 2t FYM/ha residual	23.71d
40kgN/ha+5t FYM/ha	36.97c	40kgN/ha+5t FYM/ha residual	41.87ab
60kgN/ha+10tFYM/ha	43.51b	60kgN/ha+10tFYM/ha residual	30.52bc
P value	0.028	P value	0.017
LSD 0.05	3.23	LSD 0.05	9.64
C.V%	8.1	C.V%	28.01

Means bearing same letters along the column are no significantly different (P < 0.05) according to Duncan's New Multiple Range Test.

Total seed oil yield

During short rains fertilizer application had a significant effect (P≤ 0.05) on total seed oil yield. During this season, 60kg N/ha + 10 t FYM/ha had higher total seed oil content than most of the other treatments. Total seed oil yield ranged from 182.2kg (control) to 552.1kg (60kg N/ha + 10 t FYM/ha). In the long rain season, treatment effect was not significant on total seed oil yield (P > 0.05). The oil yield ranged from 64.9 (20kg N/ha) to 223.7kg (2 t FYM/ha). The short rain had 159.70% higher total seed oil yield than the long rains (Table 4).

Table 4. Effect of fertilizer application regime on sunflower total seed oil content during the short rain season of 2013/2014 and long rain of 2014

Treatments	Short rain season	Treatments	Long rain season
	Total seed oil content Kg/ha		Total Seed oil content Kg/ha
Control (No fertilizer)	182.2b	Control (No fertilizer)	178.9a
20kgN/ha	364.5ab	20kgN/ha	64.9a
40kg/ha	350.0b	40kg/ha	159.2a
60kg/ha	316.4b	60kg/ha	100.2a
2t FYM/ha	519.7ab	2t FYM/ha residual	223.7a
5t FYM/ha	319.9b	5t FYM/ha residual	172.3a
10tFYM/ha	498.4ab	10tFYM/ha residual	126.1a
20kg N/ha+2t FYM/ha	333.2b	20kg N/ha+ 2t FYM/ha residual	113.5a
40kgN/ha+5t FYM/ha	311.9b	40kgN/ha+5t FYM/ha residual	137.6a
60kgN/ha+10tFYM/ha	552.1a	60kgN/ha+10tFYM/ha residual	166.9a
P value	0.018	P value	0.114
LSD 0.05	189.20	LSD 0.05	NS
C.V%	29.4	C.V%	39.3

Means bearing same letters along the column are no significantly different ($P < 0.05$) according to Duncan's New Multiple Range Test.

Discussion

The significant increase in sunflower seed oil content by application of 10 t FYM/ha could have resulted from beneficial wide range of nutrients of FYM in improving soil productivity and easy uptake of other nutrients like sulfur which has been reported to influence fatty acid formation processes on oil crops (Rasool *et al*., 2013). Additionally, Urea releases N to the soil rapidly and this could have improved sunflower plant growth. The oil content trend reported from this study are supported by Ghalavand *et al*., (2011) who found that higher organic nutrition levels exhibited the highest levels of seeds oil content and as nitrogen accessibility increased, the seed oil content decreased. Further, Manikandan and Thamizhiniyan (2016) in their study on effect of organic and inorganic fertilizer on phytochemichal costituents in sunflower showed that, organic fertilizer was found to be more efficient than inorganic fertilizer over control improving phytochemichal costituents in sun flower. In addition, Yaser *et al.,* (2012) in his study on comparison of sole and combined nutrient application on yield and biochemical composition of sunflower under water stress reported that, protein and seed oil content were significantly higher in sheep manure and the combination of 50% cattle manure + 50% chemical fertiliser respectively. In contrary, Akbari *et al*., (2011) reported that, the application of bio fertilizer reduced the saturated fatty acids (palmitic and stearic) and enhanced unsaturated fatty acids (linoleic acid and oleic acid) and oil content compared to control in his study on effects of biofertilizers, nitrogen fertilizer and farmyard manure on grain yield and seed quality of sunflower. However, Mahmooda *et al.,* (2015) in his study on impact of organic and inorganic manures on sunflower yield and yield components reported that, poultry manure and goat/sheep manure 6t ha^{-1} or 8tha^{-1} replacing 25% or 50% recommended dose of NPK fertilisers, respectively showed more promising results as compared to other manures increasing sunflower seed yield and seed oil content. Amjed *et al*., (2012) in his study on the effect of nitrogen on achene protein, oil, fatty acid profile, and yield of sunflower hybrids reported that crop oil yield was positively related to increased N supply with higher achene yield. Yaser *et al*., (2011) in his study of investigation the influences of manures sources and chemical fertilizers on yield, protein and oil content of sunflower under drought stress showed that, maximum achene oil content and oil yield were recorded , when crop fertilized by cattle manure alone. Amin *et al.,* (2014) in his study on effect of phosphate and nitrogen bio fertilizers on yield, yield components, oil and protein in sunflower showed that, application of nitrogen and other P biofertilizers compared to nonapplication of N biofertilizers had a better effect on biomass, seed yield, oil content and protein.

Insignificant effect from the combination of FYM and UREA on increasing sunflower seeds oil content was contrary to other investigations which reported that; application of organic fertilizers and their combinations increased oil content over the control in Egypt (Helmy *et al.,* 2009). Similar results were also reported by Munir, (2007) who studied the effect of different fertilizer levels on sunflower oil content that combination and control treatments had higher and lower oil contents respectively. The trend of 60 kg N/ha producing lowest oil content from both seasons might have been caused by sunflower crop lodging which occurred at early grain filling stage, 76 days after planting. Lodging has been reported to affect all crop yield components by HGCA, (2005) including seed oil percentage.

Conclusion

Organic and inorganic fertilizers generally in sunflower production has showed a positive impact on seed sunflower oil content and total seed sunflower oil content. All fertilizer regimes applied from both sources gave higher response than the control. Oil content showed peculiar behavior, which was only increased by the 10 t FYM /ha in both seasons. It was therefore recommended that farmers in Morogoro to consider application of fertilizers in 10 t FYM/ha in order to have high seed sunflower oil content.

Acknowledgements

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

References

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

Akbari P, Ghalavand A, Modarres Sanavy AM, M, Agha A. 2011. The effect of biofertilizers, nitrogen fertilizer and farmyard manure on grain yield and seed quality of sunflower (*Helianthus annus* L.). Journal of Agricultural Technology **7(1),** 173-184.

Amin F, Mehrdad M. 2014. Effect of Phosphate and Nitrogene Bio-fertilizers on yield, yield. components, oil and protein in sunflower (*Helianthus annus* L.). Bull. Env. Pharmacol. Life Sci. **3(5),** 110-117.

Amjed A, Sami U. 2012. Effect of nitrogen on achene protein, oil, fatty acid profile, and yield of sunflower hybrids. Chilean journal of agricultural research **72(4).**

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.

Bray RH, Kurtz LT. 1945. Determination of total, organic and available forms of phosphorus in soils. Soil Sci **59,** 39-45.c.

Bremner JM, Mulvaney CS. 1982. Total nitrogen In: Method of Soil analysis part 2. 2nd ed. Agronomy monograph. American Society of Agronomy. Madison, Wisconsin **9,** 595-622.

Chapman HD. 1965. Cation Exchange Capacity In: Method of Soil analysis (Edited by Black, C. A.). American Society of Agronomy. Madison, Wisconsin **9.** 891-901.

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.

Helmy AM, Ramdan MF. 2009. 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.

Leas R. 1975. Food Analysis: Analytical and quality control methods for the food manufacturer and buyer. Leonard Hill Books, London.

Mahmooda B, Mehar ul N, Abdul W, Ashifa S, Allah W, Shahabudin K. 2015. Impact of organic and inorganic manures on sunflower yield and yield components. Sci.Int. (Lahore) **27(4),** 3267-3270.

Manikandan S, Thamizhiniyan P. 2016. Effect of organic and inorganic fertilizer on phytochemical constituents in sunflower. Journal of Applied and Advanced Research **1(4),** 18-20.

Ministry of Agriculture Food and Cooperatives (MAFC). 2008. Sunflower production and oil consumption in Tanzania. Tanzania.

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.

Murphy J, Riley JP. 1962. A modified single solution method for the determination of phosphate in natural waters. Analytica Chimica Acta **27,** 3-36.

Nelson DW, Sommers LE. 1982. Total carbon and Organic carbon, In: Methods of soil analysis, Part 2. Chemical and Microbiological Properties (Edited by Page A. L. Miller, R. H. And Keeney D. R.) American Society of Agronomy. Madison. 539-579.

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

Petersen L. 1996. Soil analytical methods. Soil testing, Management and Development, Soil Resources Development Institute, Dhaka, Bangladesh.

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.

Turuka FM, Kilasara M. 2002. Determinants of fertilizer use in small holder agriculture in Tanzania and policy implications. Paper presented at the strategic regional planning workshop for agricultural inputs policies with specific reference to fertilizers. Hilton hotel Nairobi 8 -11.

Ugulumu ES. 2008. Sunflower Value Chain in Tanzania. MsM, Expert Centre.

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

Yaser E, Ali R, Mohammad R, Ebrahim A. 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).**

Yaser E, Hamid N, Ebrahim A, Masoud M, Akbar B, Mahdi B, 1Abolfazl T. 2011. Investigation the Influences of Manure Sources and Chemical Fertilizers on Yield, Protein and Oil Content of Sunflower under Drought Stress. Australian Journal of Basic and Applied Sciences **5(10),** 1084-1089.