International Academic Research Consortium Journals (IARCJ)
International Journal of Agricultural Science and Technology
ISSN: 2360-9888. Volume 9, Number 5
Pages 43-53 (March, 2022)
www.arcnjournals.org

Influence of Sowing Date and NPK Fertilizer Rate on the Growth and Yield Components of Sun Flower

Abubakar A Kyari[1]., Lawan Shettima [1] „ Bunu Abdullahi [2]„ Dr. Ahmadu Bukar[3]

[1]Department of Agricultural Technology, Ramat Polytechnic Maiduguri P.M.B 1070, Borno State, Nigeria.
[2] Chad Basin Development Authority maiduguri, Borno State Nigeria
[3]Department Agricultural Technology. Mohamet Lawan College of Agriculture Maiduguri, Borno State, Nigeria

Abstract: *The field experiment was conducted at the Teaching and Research Farm of Ramat Polytechnic Teaching and Research farm Maiduguri during the dry season between February to April, 2018. Maiduguri i.e. on latitude 1 1.4°N and longitude 13.05°E it has the altitude of 354m above sea level Bashir., (2015).to evaluate the performance of sunflower as affected by different sowing dates and organic fertilizer application. The experiment was laid out Randomized Complete Block Design (RCBD). Sowing date significantly (P≤0.05) increased and reduced number of phonological days to flowering of early and late sown sunflower, respectively. Application of inorganic fertilizer significantly (P≤0.05) increased plant height of early and late sown sunflower. Delay in sowing till first week in December significantly (P≤0.05) reduced head diameter, number of seeds per head and seed yield of late sown sunflower. However, it significantly (P≤0.05) increased yield and yield attribute by 23% relative to the control in the late sown sunflower. Based on the comparatively high seed yield (850.45–1,525.78 kg/ha) recorded in our study, it is recommended that sunflower be sown in the early date is much better than other sown in middle and late date.*

Keywords: Inorganic fertilizer; sunflower; Nitrogen; Phosphorus; Potassium and Sowing date

Introduction

Sunflower (*Helianthus annuus* L.) occupies the fourth position among vegetable oilseeds after soybean, oil palm and canola in the world (Rodriguez *et al*., 2002 and Ahmad *et al*., 2011). Although sunflower is generally regarded as a temperate zone crop, it is currently cultivated on approximately 23 million hectares in 40 countries of the world, including some countries in the humid tropical Africa because it is quite rustic and can perform well under varying climatic and soil conditions (Seiler *et al*., 2008, Kaleem *et al*., 2011b). The major goal of growing sunflower is for its seed (achene) that contains oil (36–52%) and protein (28–32%) as reported by Rosa *et al*. (2009). The crop has been receiving steady attention by various scientists from diverse disciplines in recent past because sunflower oil is a premium oil with light colour and is widely used in the diets of heart patients because it contains very low cholesterol and high (90%) unsaturated fatty acid concentration (Flagella *et al*., 2002; Qahar *et al*. 2010). In recent past, there has been a steady increase in demand for organic foods globally because of the health risks posed by conventional method of production (Yiridoe *et al*., 2005). After reviewing 343 studies, it was revealed that organic crops and crop-based foods contain up to 60% higher key antioxidants than conventionally

grown crops (Baranski *et al*., 2014). We therefore decided to explore the potential of organic sunflower in the transition zone. The productivity of sunflower in terms of seed yield, oil and protein output varies widely depending on multifarious factors of the environment such as radiation (Dosio *et al*., 2000), temperature (Kaleem *et al*., 2009 and 2011a), rainfall distribution (Lawal *et al*., 2011; Asbag *et al*., 2009; Olowe *et al*., 2013), agronomic practices like time of sowing (de la Vega and Hall, 2002; Lawal *et al*., 2011; Anjum *et al*., 2012), plant density and nitrogen nutrition (Ali *et al*., 2012), varying planting pattern (Yasin *et al*., 2013) and sowing of improved varieties and hybrids (Ali *et al*., 2011). Consequently, there is a disparity among the reported African (812 kg/ha) and Nigerian (1,000 kg/ha) averages by Olowe *et al*. (2013) and the world average of 1,520 kg/ha (USDA, 2012).Although much work has been done on sunflower agronomy in different agro-ecological locations of the world with a view to gaining insight into the effects of the cultural practices that enhance seed yield, there is still a dearth of information on the performance of newly released and improved, and locally adapted sunflower varieties as affected by organic fertilizers and varying sowing dates in the forest–savanna transition zone which is outside its traditional growing region (savanna). Earlier research works on sunflower agronomy in the tropics reported varying optimum rates of nitrogen fertilizer to be 60 kg N/ha in Nigeria (Olowe *et al*., 2005), 80 kgN/ha in India (Rasool *et al*., 2013), 150 kgN/ha at Islamabad, Pakistan (Bakht *et al*., 2010) and 180 kgN/ha at Faisalabad, Pakistan (Nasim *et al*., 2012b). Sunflower growers rarely apply organic fertilizers to sunflower despite the inherent advantage (slow nutrient release and potential improvement of soil structure and water holding capacity) of organic plot compared with the conventional plot (Posner *et al*., 2008). In fact, the resource-constrained farmers in the tropics seldom apply mineral fertilizers because of restricted access to the input and its exorbitant cost. Different brands of organic fertilizers using plant residues, municipal and abattoir wastes are now being produced in Nigeria for farmers' use in crop production and they are significantly cheaper that mineral fertilizers. Unfortunately, information is lacking on the response of sunflower to organic fertilizer application in humid tropical Africa. Recent work in India reported linear increase in seed yield as farmyard manure rate increased from 10 to 20 ton/ha, suggesting that an additional increase in seed yield with increase in rate of farmyard manure (Rasool *et al*., 2013). Similarly, plant population density (Olowe, 2005; Petcu *et al*., 2010) and planting ratio (Shakuntula *et al*., 2012) studies also indicated varying results in different locations. Optimum sowing date of sunflower as early and late season crops is relatively well known to be late May and July – Early August, respectively in the forest–savanna transition zone (Ogunemi, 2000). The seed quality of sunflower is a function of an inter play of the genetic, environmental and agronomic manipulations (Baydar and Erbas, 2005; Petcu *et al*., 2010; Olowe *et al*., 2013). However, most of the studies conducted in the humid tropics neither related the performance of sunflower to the phenology of the crop nor ascertained the quality of the seeds after imposing the various treatments. Furthermore, attempts have not been made to exploit the possibility of having two good quality sunflower crops in a year by staggering sowing dates. Consequently, part of what is still lacking now in the agronomy of sunflower in the humid tropics is a comparative study that will provide an insight into the effects of some weather parameters and manipulation of cultural practices on the phenology, seed yield and quality of sunflower. The hypothesis of the study was hinged on possibility of growing more than one crop of sunflower in a year. Therefore, this study was carried out to determine the effects of

staggered sowing and organic fertilizer application on growth, development, seed quality and yield of two sunflower varieties in a forest–savanna transition zone of the tropics.

Materials and methods

Growth conditions

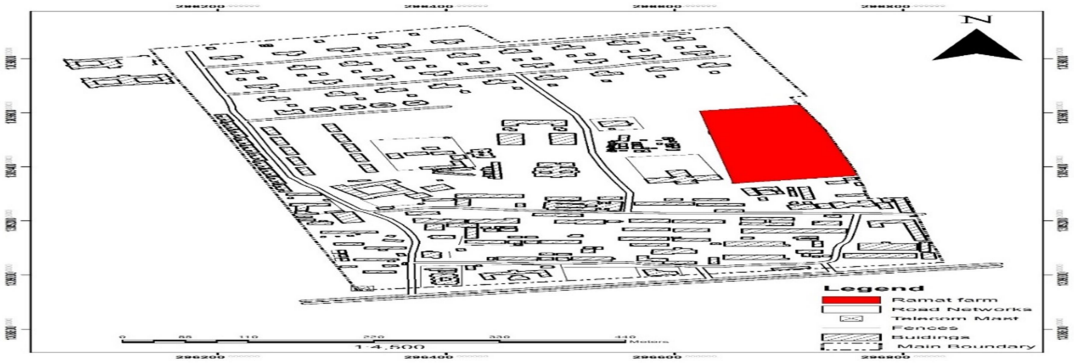
The field studies were conducted at the Teaching and Research Farm of the Federal University of Agriculture, Abeokuta (7° 15′ N, 3° 25′ E, altitude 140 m above sea level) in south western Nigeria on a loamy sand soil between June and November, 2012. The two test varieties were Funtua, a locally adapted, late-maturing variety (110–120 days) and SAMSUN-3, also late maturing (110–120 days), drought tolerant and contains good antioxidants (NASC, 2013). The soil characteristics of the two experimental plots are shown in Table 1. The soils of the experimental sites were loamy sand in texture and low to medium in nitrogen and phosphorus, and adequate in potassium based on rating for soil fertility classes as described by Anon (1989). The meteorological data for the growth period of the two experiments were collected from the Department of Water Resources Management and Agrometeorology located about 300 m away from the Research Farm. The experimental site was located in the forest–savanna transition zone with a traditional bi-modal rainfall distribution having peaks usually in July and September and a short dry spell often referred to as *august break*. Weather data during the two periods of experimentation in 2012 are presented in Tables 2–4. The months of July (155.4 mm) and October (184.7 mm) were the wettest months during the growing periods of early and late sown sunflower. The coolest and hottest months based on mean atmospheric temperature were August (25.4°C) and November (28.2°C). Relative humidity values, however, ranged between 77.5% (October) and 82.6% (August) as shown in Table 2. The amount of rainfall received by early and late sown sunflower, number of rainy days and daily sunshine duration decreased as sowing was delayed (Table 3). The growing degree days (GGD) values for early and late sown sunflower varieties during the four sowing dates are presented in Table 4. The values ranged between 2,073.39° and 2,423.07°C and 1,942.37° and 2,038.43°C for the early and late sown SAMSUN-3 variety, respectively. While for Funtua, the values were 2,067.90°–2,370.06°C and 2,052.29°–2,189.27°C for the early and late sown sunflower, respectively.

Table 1: Some Physico-chemical characteristics of the experimental fields (0–30 cm level)

Soil characteristics	Early sown field	Late sown field
Sand (%)	84.0	85.0
Silt (%)	7.0	7.0
Clay (%)	9.0	8.0
Textural class	Loamy sand	Loamy sand
pH (H_2O)	5.37	5.50
Carbon level (%)	0.5	0.85
Total *N* (%)	0.18	0.20
Available P (mg/kg)	1.49	0.80
Exchangeable K (cmol/kg)	0.23	0.67

2.0 Experimental Site Description

Field experiment was conducted at the Teaching and Research Farm, of the Ramat Polytechnic, Maiduguri, in the Sudano-Sahelian region of northern Nigeria. The site lies between latitude 1105 N and longitude 13009E (Kyari et al., 2014). The area is about 335m above sea level and lies within the lake Chad Basin formation, which is an area formed as a result of down –warping during the Pleistocene period (Waziri, 2007). It is in the tropical climate region and is characterized by three season's cool-dry season (October to March), hot season (April to June) and a rainy season (June to September)



2.1 Materials and Methods

2.2 Treatments and Experimental Design

The research was of two factorial and was laid out in a Randomized Complete Block Design (RCBD) with (20) Treatments were replicated three times, (5x4) factorial experiment with 5 rates of NPK fertilizer and 4 sowing dates 3 plots as control. A total of 63 plots was used with each plot measuring 3m×3m = 9m2.

2.2.1 Experiment (2):

Effect of rates of NPK fertilizer:

According fertilizer use and management practice for crops in Nigeria the recommended rate for NPK fertilizer in this region is;

a. 100kg Nitrogen
b. 50kg P_2O_3
c. 30 kg K_2O

Three types of fertilizers would be used namely:

a. NPK fertilizer (15:15:15)
b. Urea
c. Single super phosphate (SSP)

This would be used individually or collectively to obtain the various required rates. Full dose of P and K would be applied at the time of planting and half dose of N would be applied at planting time and the remaining half at bud initiation stage. The rates to be applied are;

FR1 = 25% of the recommended rate

FR2 = 50% of the recommended rate

FR3 = 75% of the recommended rate
FR4 = 100% recommended rate
FR5 125% of recommended rate

2.2.2 Experiment (2):

Effect of sowing date on sun flower:

The sowing date considered were at interval two weeks from the first sowing date which will be as follows:

SD1 = 16th Dec,2021.
SD2 = 30th Jan,2022
SD3 = 13th Feb ,2022.
SD4 = 27th March 2022

Control was first planting date without NPK fertilizer

2.3 Crop husbandry

The experimental sites were ploughed twice and harrowed once before marking out the plots. At each sowing date, seeds of the test varieties were sown at a spacing of 60 cm×30 cm which corresponded to 56,000 plants ha^{-1}. Three seeds of the test varieties were sown per hole and later thinned to one plant per stand at 2 weeks after sowing (WAS). Each experimental plot consisted of four rows 5 m in length and measured 1.8 m×5 m (9.0 m^2). No agro-chemicals were used during both experiments in order to simulate the usual practice of the resource-constrained farmers. Organic fertilizer was applied and incorporated into the soil during seedbed preparation a week before sowing. Manual weeding was done at 3 and 6 WAS and five randomly selected plants were tagged from the middle rows of each plot for plant height measurement at flowering (R5–when 30–80% of disk flowers have completed flowering on the inflorescence) and physiological maturity (R9–when the bracts are yellow and brown) as described by Schneiter and Miller (1981). The tagged plants were later harvested and used for yield component analysis. The crop was grown under rain-fed conditions which is the usual practice of the resource-constrained farmers. There were no incidences of pests and diseases during the early and late sown cropping. This could be attributed to the fact that sunflower is still alien to this agro-ecological zone.

2.4 Data collection

The characters determined on plot basis were number of phenological days to flowering (R5) and physiological maturity (R9), plant height (cm), i.e. height from the soil surface to the tip of the head at R5 and R9, head diameter (cm), head weight (g), number and weight (g) of seeds per head, 100 seed weight (g), seed yield (kg ha^{-1}), oil and protein contents (%) in the seed and oil yield (kg ha^{-1}). Plant height, seed yield and yield components were determined on the five earlier tagged plants on plot basis.

2.5 Data analysis

The data collected were statistically analysed using the MSTATC package (Freed *et al*., 1989) and significant (P<0.05; F-test) treatment means of the main effects and interactions were separated using the least significant difference method at 5% probability level.

2.6 Results of the Expirement

2.6.1 Effect of sowing date and NPK fertilizer application on phenology and height characteristics of early and late sown sunflower

As presented in (Table 2). Sowing date significantly ($P \leq 0.05$; F-test) affected number of phenological days to flowering of early and late sown sunflower and number of phenological days to physiological maturity of late sown sunflower. However, sowing date had no significant effect on height at flowering and physiological maturity of both early and late sown sunflowers. Organic fertilizer application significantly ($P \leq 0.05$; F-test) reduced number of phenological days to flowering of early sown sunflower and increased plant height at flowering and physiological maturity of both early and late sown sunflower.

Table 2: Effects of sowing date and NPK fertilizer application on plant height and number of phonological days to flowering (R5) and physiological maturity (R9) of early and late sown sunflower

Treatment	Early sown				Late sown			
	Days to		Height (m) at		Days to		Height (m) at	
	R5	R9	R5	R9	R5	R9	R5	R9
Sowing date (SD)								
SD1 = 16th Dec,2021.	70.8	110.8	2.29	2.35	79.0	111.7	2.18	2.27
SD2 = 30th Jan,2022	72.8	114.0	2.75	2.34	71.7	105.4	2.13	2.22
SD3 = 13th Feb ,2022.	77.4	116.0	2.30	2.35	69.7	101.2	2.28	2.38
SD4 = 27th March 2022	85.2	114.6	2.25	2.30	70.2	100.9	1.81	1.86
LSD 5%	2.57**	ns	ns	ns	6.82*	3.18**	Ns	ns
Fertilizer (F)								
100kg Nitrogen	77.7	114.3	2.18	2.25	72.0	104.4	2.00	2.09
50kg P2O3	75.3	113.4	2.38	2.44	73.2	105.2	2.21	2.27
LSD 5%	1.23**	ns	0.07**	0.06**	ns	ns	0.06**	0.06**

2.6.2 Effects of staggered sowing and organic fertilizer application on seed yield, some yield attributes and seed quality of early and late sown sunflower

As shown in (Table 3). Sowing date did not affect seed yield, yield attributes and quality of sunflower, except protein content ($P \leq 0.05$; F-test) of early sown sunflower. However, application of organic fertilizer significantly ($P \leq 0.05$; F--test) affected seed yield, yield attributes and quality of early sown sunflower, except oil yield. Application of organic fertilizer resulted in significantly ($P < 0.01$) higher values for all the traits measured relative to the control, sunflower in the late season significantly ($P \leq 0.05$; F-test) affected head diameter, number of seeds per head and seed yield. Therefore, application of NPK fertilizer significantly ($P \leq 0.05$; F-test) increased seed yield, all yield attributes, and seed quality of late sown sunflower.

Table 2: Effects of sowing date and NPK fertilizer application on sunflower seed yield and yield attributes

Treatment	Head diameter (cm)	Head weight (g)	No. of seeds per head	Weight	100 seed weight (g)

Treatment	Head diameter (cm)	Head weight (g)	No. of seeds per head	Weight	100 seed weight (g)
Sowing date (SD)					
SD1 = 16th Dec,2021.	16.4	87.5	1,150.6	79.2	7.9
SD2 = 30th Jan,2022	16.6	94.9	1,143.5	87.5	8.4
SD3 = 13th Feb ,2022.	16.3	90.5	1,158.9	82.8	7.9
SD4 = 27th March 2022	14.6	72.8	884.4	64.4	6.9
LSD 5%	1.28*	ns	93.25**	ns	ns
Fertilizer (F)					
100kg Nitrogen	15.3	80.1	1,017.0	70.6	7.3
50kg P2O3	16.6	92.8	1,151.7	86.4	8.3
LSD 5%	0.62**	5.25**	36.15**	6.77**	0.51**

2.7 Discussion of the Experiment

The productivity of sunflower is largely determined by the prevailing weather conditions throughout its life cycle and imposed cultural practices (Kaleem *et al*., 2011a). Cultural practices like sowing date and fertilizer application and some environmental factors (temperature and rainfall) are major factors which affect plant growth and development. In our study, varying responses were observed on the two test varieties to these factors. Although, temperature is not a limiting climatic factor in the tropics, delay in sowing resulted in lower values of GGD of late sown sunflower. The lower values could be attributed to heavier cloud cover in the tropics compared to the temperate region. As sowing was delayed, number of phenological days to flowering of early sown sunflower significantly ($P \leq 0.05$) increased. Whereas number of phenological days to flowering and physiological maturity of late sown (SD4) sunflower significantly ($P \leq 0.05$) decreased. This trend could be attributed to increased vegetative growth in early sown sunflower relative to the late sown crop. Early sown(SD1) flowered and was also significantly ($P \leq 0.05$) taller at flowering and physiological maturity in both early and late sowing dates. However, the application of NPK fertilizer significantly ($P \leq 0.05$) hastened number of phenological days to flowering of early sown sunflower by 2 days and also enhanced plant height of early and late sown sunflower. Among the seed yield attributes evaluated, only number of seeds per head, head diameter and head weight were significantly affected by sowing date×variety. Number of seeds per head had earlier been reported to contribute greatly to variation in sunflower oil yield by de la Vega and Hull (2002). Delay in sowing in both early and late sown sunflower did not affect oil yield even though sowing date has been reported to be the main source of variation for oil yield by de la Vega and Hull (2002). Application of inorganic fertilizer significantly ($P \leq 0.05$) increased oil yield by 23% relative to the control in the late sown sunflower. The seed yield range (852.45–1,525.78 kg/ha) recorded in our study was on par with the Nigerian (1,000 kg/ha), African (812 kg/ha) averages (Olowe *et al*., 2013) and world average (1,520 kg/ha) according to USAD (2012). This performance confirmed the potential of sunflower especially when sown in early December or second to third week in March.

3.0 Conclusion and Recommendations

Based on the results obtained it can be concluded that the application of sowing date SD1+ NPK F_1 kg/ha, resulted in higher growth and acquisition of the highest yield of sunflower in the study area. However, and significantly ($P \leq 0.05$) hastened number of phenological days to flowering of early sown sunflower by 2 days and also enhanced plant height of early and late sown sunflower.

3.1 Recommendations

(i)Since this experiment is season study in a single environment, further research over seasons are required so as to develop reliable values.
(ii) The experiment should be repeated in similar agro-climatic condition in order to confirm findings.

References

Agele, S.O., 2003. Sunflower responses to weather variations in rainy and dry cropping seasons in a Tropical rainforest zone. IJOP32: 17–33.Search in Google Scholar

Ahmad,M., Iqbal,J., Kaleem,S., Wasaya,A., Ishaque,M., 2011. Qualitative analysis of spring planted sunflower hybrids as influenced by varying nutritional area. Pakistan Journal of Nutrition10: 291–295.10.3923/pjn.2011.291.295Search in Google Scholar

Ali, A., Ahmad, A., Khaliq, T., Akhatar, J., 2012. Planting density and nitrogen rates optimization for growth and yield of sunflower (*Helianthus annuus* L.) hybrids. The Journal of Animal and Plant Sciences22: 1070–1075.Search in Google Scholar

Ali,A., Afzal,M., Rasool,I., Hussain,S., Ahmad,M., 2011. Sunflower (*Helianthus annuus* L.) hybrids performance at different plant spacing under agro-ecological conditions of Sargodha, Pakistan. International Conference on Food Engineering and Biotechnology9: 317–322.Search in Google Scholar

Anjum, A.S., Muhammad, S., Imran, M., Arshadullah, M., 2012. Performance of early and late sown sunflower hybrids under organic farming system in rainfed area. Science Technology and Development31: 26–28.Search in Google Scholar

Anonymous1989. Fertilizer use and management practices for crops in Nigeria (Series 2). *In*: Enwezor, W.O., Udo, E.J., Usoroh, N.J., Ayotade, K.A., Adepetu, J.A., Chude, V.O., Udegbe, C.I. (eds) Federal Ministry of Agriculture, Water Resources and Rural Development. Bobma Publishers, Ibadan, Nigeria, p. 163.Search in Google Scholar

Asbag, F.T., Gorttapeh, A.H., Fayaz-Moghadam, A., Saber-Rezaie, M., Feghnabi, F., Eizadkhah, M., Jahannavard, S., Parvizi, S., Moghadam-Pour, S.N., 2009. Effects of planting date and irrigation management on sunflower yield and yield components. Research Journal of Biological Sciences4: 306–308.Search in Google Scholar

Bakht, J., Shafi, M., Yousaf, M., Shah, H.U., 2010. Physiology, phenology and yield of sunflower (autumn) as affected by NPK fertilizer and hybrids. Pakistan Journal of Botany42: 1909–1922.Search in Google Scholar

Balalic, I., Crnobarac, J., Duzanic, N., 2007. Planting date effects on oil yield in sunflower (Helianthus annuus L.). Helia30: 153–158.10.2298/HEL0747153BSearch in Google Scholar

Balalic, I.M., Crnobarac, J.Z., Miklic, V.J., 2010. Interaction hybrid×planting date for oil yield in sunflower. Journal of Agricultural Science55: 9–15.10.2298/JAS1001009BSearch in Google Scholar

Baydar, H., Erbas, S., 2005. Influence of seed development and seed position on oil, fatty acids and contents in sunflower (*Helianthus annuus* L.). Turkish Journal of Agriculture29: 179–186.Search in Google Scholar

Branski, M., Srednicka-Tober, D., Volakakis, N., Seal, C, Sanderson, R., Stewart, G.B., Benbrook, C., Biavati , B., Markellou, E., Giotis, C., Gromadzka-Ostrowska, J., Rembialkowska, E., Skwarlo-Sonta, K., Tahvonen, R., Lanovska, D., Niggli, U., Nicot, P., Leifert, C., 2014. Higher antioxidant and lower cadmium concentrations and lower incidence of pesticide residues in organically grown crops: A systematic literature review and meta-analyses. British Journal of Nutrition112: 794–811.10.1017/S0007114514001366Search in Google Scholar

Canavar, O., Ellmer, F., Chimeileski, F.M., 2010. Investigation of yield and yield components of sunflower (*Helianthus annuus* L.) cultivars in the ecological conditions of Berlin (Germany). Helia33(53): 117–130.10.2298/HEL1053117CSearch in Google Scholar

de la Vega,A., Hall,A.J., 2002. Effects of planting date, genotype, and their interactions on sunflower yield: II. Components of oil yield. Crop Science42: 1202–1210.10.2135/cropsci2002.1202Search in Google Scholar

Dosio,G.A.A., Aguirrezabal,L.A.N., Andrade,F.H., Pereyra,V.R., 2000. Solar radiation intercepted during seed filling and oil production in two sunflower hybrids. Crop Science40: 16637–1644.10.2135/cropsci2000.4061637xSearch in Google Scholar

Egan,H., Kick,R.S., Sawyer,R., 1981. Soxhlet extraction method. *In*: Person's Chemical Analysis of Food, 8th ed. Livingstone Publishers, London, pp. 507–547.Search in Google Scholar

Flagella, Z.T., Rotundo, E., Tarantino, R., DiCaterina. De Caro, A., 2002. Changes in seed yield and oil fatty acid composition of high oleic sunflower (*Helianthus annuus* L.) hybrids in relation to the sowing date and water regime. Agronomy Journal17: 221–230.10.1016/S1161-0301(02)00012-6Search in Google Scholar

Freed,R., Einmensmith,S.P., Guetz,S., Reicosky,D., Smail,V.W., Wolberg,P., 1989. User's guide to MSTATC, An analysis of agronomic research experiments. Michigan State University, East Lansing, Michigan.Search in Google Scholar

Kaleem, S., Hassan, F.-u., Ahmad, M., Mahmood,I., Wasaya, A., Randhawa, M.A., Khaliq, P., 2011a. Effect of growing degree days on autumn planted sunflower. African Journal of Biotechnology10: 8840–8846.10.5897/AJB11.608Search in Google Scholar

Kaleem, S., Hassan, F.-u., Mahmood,I., Ahmad, M., Ullah, R., Ahmad,M., 2011b. Response of sunflower to environmental disparity. Nature and Science9: 73–81.Search in Google Scholar

Kaleem, S., Hassan, F.U., Saleem, A, 2009. Influence of environmental variations on physiological attributes of sunflower. African Journal of Biotechnology8: 3531–3539.Search in Google Scholar

Lawal,B.A., Obigbesan,G.O., Akanbi,W.B., Kolawole,G.O., 2011. Effect of planting time on sunflower (*Helianthus annuus* L.) productivity in Ibadan, Nigeria. African Journal of Agricultural Research6: 3049–3054.Search in Google Scholar

McMaster, G.S., Wilhelm, W.W., 1997. Growing degree days: one equation, two interpretations. Agricultural Forestry and Forest Meteorology87: 291–300.10.1016/S0168-1923(97)00027-0Search in Google Scholar

Nasim, W., Ahmad, A., Bano, A., Olatinwo, R., Usman, M., Khaliq, T., Wajid, A., Hammad, H.M., Mubeen, M., Hussain, M., 2012a. Effect of nitrogen on yield and oil quality of sunflower (*Helianthus annuus* L.) hybrid under sub humid conditions of Pakistan. American Journal of Plant Science3: 243–251.10.4236/ajps.2012.32029Search in Google Scholar

Nasim, W., Ahmad, A., Hammad, H.M, Chaudhary, H.J., Munis, M.F., 2012b. Effect of nitrogen on growth and yield of sunflower under semi-arid conditions of Pakistan. Pakistan Journal of Botany44: 639–648.Search in Google Scholar

National Agricultural Seeds Council (NASC), 2013. Sunflower. *In*: Catalogue of crop varieties released and registered in Nigeria, Vol. 5. Proexpand Publishers, Ibadan, p. 41.Search in Google Scholar

Ogunremi, E.A., 2000. Sunflower, Kenaf and sugar-cane in Nigeria: My experiences. *In*: Akoroda, M.O. (ed) Agronomy in Nigeria. University of Ibadan, Ibadan, Nigeria, pp. 130–142.Search in Google Scholar

Olowe, V.I., Folarin, O.M., Adeniregun, O., Atayese, M.O., Adekunle, Y.A., 2013. Seed yield, head characteristics and oil content in sunflower varieties as influenced by seeds from single and multiple headed plants under humid tropical conditions. Annals of Applied Biology163: 394–402.10.1111/aab.12064Search in Google Scholar

Olowe, V.I.O., 2005. Effect of plant population densities on growth and yield of sunflower (*Helianthus annuus* L.) in the transition zone of south west Nigeria. Tropical Agricultural Research and Extension8: 37–44.Search in Google Scholar

Olowe,V.I.O., Adebimpe,O.A., Obadiahi,T.E., 2005. Response of sunflower (*Helianthus annuus* L.) to nitrogen and phosphorus application in a forest – Savanna transition zone of south west Nigeria. Nigerian Journal of Horticultural Science10: 23–29.10.4314/njhs.v10i1.3405Search in Google Scholar

Petcu, E., Babeanu, N., Popa, O., Partal, E., Pricop, S.M., 2010. Effect of planting date, plant population and genotype on oil content and fatty acid composition in sunflower. Romanian Agricultural Research27: 53–57.Search in Google Scholar

Posner, J.L., Baldock, J.O., Hedtcke, J.L., 2008. Organic and conventional production systems in Wisconsin integrated cropping systems trials I. Productivity 1990–2002. Agronomy Journal100: 253–260.10.2134/agronj2007.0058Search in Google Scholar

Qadir, G., Hassan, F.-u., Malik, M.A., 2007. Growing degree days and yield relationship in sunflower (*Helianthus annuus* L.). International Journal of Agriculture and Biology9: 564–568.Search in Google Scholar

Qahar, A., Khan, Z.H., Anwar, S., Badshan, H., Ullah, H., 2010. Nitrogen use efficiency, yield and other characteristics of sunflower (*Helianthus annuus* L.) hybrids as affected by different levels of nitrogen. Biological Diversity and Conservation3: 121–125.Search in Google Scholar

Rasool, F.-u., Hassan, B., Jahangir, I.A., Ali, T., Mubarak, T., 2013. Nutritional yield and economic responses of sunflower (*Helianthus annuus* L.) to integrated levels of nitrogen, sulphur and farmyard manure. The Journal of Agricultural Science8: 17–27.10.4038/jas.v8i1.5373Search in Google Scholar

Rodrigues, D., Romero-Garcia, J., Rodriguez-Garcia, R., Angualo-Sanchez, J.L., 2002. Characterization of proteins from sunflower leaves and seeds: relationship of biomass and seed yield. *In*: Trends in New Crops and New Uses. Proc. AAIC Fifth National Symposium, Purdue Univ., West Lafayette, IN, pp. 143–149.Search in Google Scholar

Rosa, P.M., Antoniassi,R., Freitas,S.C., Bizzo,H.R., Zanotto,D.L., Oliveira,M.F., Castiglioni, V.B.R., 2009. Chemical composition of Brazilian sunflower varieties. Helia32: 145–156.10.2298/HEL0950145RSearch in Google Scholar

Schneiter, A.A., Miller, J.F., 1981. Description of sunflower growth stages. Crop Science21: 901–903.10.2135/cropsci1981.0011183X002100060024xSearch in Google Scholar

Seiler, G.J., Jan, C., Gulya, T.J., 2008. Use of world Helianthus species in sunflower breeding. *In*: Proceedings of the International Conference on Conventional and Molecular Breeding of Field and Vegetable crops, November 24–27, 2008, Novi Sad, Serbia, Pp. 71–76.Search in Google Scholar

Shakuntala, N.M., Vyakaranahal,B.S., Shankergoud,I., Deshpande,V.K., Pujari,B.T., Nadaf, H.L., 2012. Influence of planting ratios and staggered planting on seed yield and quality in hybrid seed production of sunflower hybrid RSFH-130. Karnataka Journal of Agricultural Science25: 52–57.Search in Google Scholar