APPROPRIATE NITROGEN (N) AND PHOSPHORUS (P) FERTILIZER REGIME FOR SUNFLOWER (*HELIANTHUS ANNUUS* L.) IN THE HUMID TROPICS

Edward AKPOJOTOR[1], Victor Idowu OLOWE[2]

[1]Department of Plant Physiology and Crop Production, Federal University of Agriculture, Abeokuta (FUNAAB), Abeokuta , NIGERIA
[2]Institute of Food Security, Environmental Resources and Agricultural Research (IFSERAR), FUNAAB, NIGERIA

owebaba@yahoo.com, olowevio@funaab.edu.ng

ABSTRACT

Application of fertilizer at the appropriate rate and time is very germane to sustainable production of crops. Two field trials were conducted on the Research Farm of the Institute of Food Security, Environmental Resources and Agricultural Research (IFSERAR), Nigeria during the late cropping seasons (June – Nov.) of 2014 and 2015 to evaluate the agronomic performance of four recently released sunflower varieties (SAMSUN-1, SMASUN-2, SAMSUN-3 and SAMSUN-4) to three fertilizer regimes: Control, Split application of 30 kg N + 28 kg P_2O_5 at 3 week after sowing, WAS and at anthesis and Single application of 60 kg N and 56 kg P_2O_5 at 3WAS. The experiment was laid out in a randomized complete block design using a 3× 4 factorial arrangement and replicated three times. Data were collected on phenology, height at flowering (R5) and physiological maturity (R9), grain yield and yield attributes. Varietal effect was only significant in 2015 with SAMSUN-2 recording significantly ($P<0.05$) higher head weight than the other varieties. Application of N and P fertilizer either as split or single significantly ($P<0.05$; *F - test*) affected plant height at R5 and R9, 100 achene weight, achene weight per head and grain yield in both years. Single application resulted in significantly ($P<0.05$) higher grain yield in 2014 than the split and control and was on par with split, and superior to control in 2015. Therefore, single application of N and P fertilizers at 21 WAS is recommended for adoption in the humid tropics for the newly released four sunflower varieties.

Keywords: grain yield, nitrogen (N), phosphorus (P), regime, sunflower

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is a major contributor to edible vegetable oil in the world market (Thavaprakash *et al.,* 2002). As at January, 2016, the total world area under sunflower was 24.7 m ha with an average yield of 1.67 tonnes per ha (NSA, 2016). The three leading world sunflower producers were Ukraine, Russia and European Union. However, sunflower grain yield had been static at 1.68 tonnes/ha between 2013/14 and

2014/15 and the area under sunflower cultivation also reduced by 6% during the same period (NSA 2016). The non-significant increase in grain yield despite the use of different inputs (improved seeds, inorganic and organic fertilizers e.t.c) could be partly attributed to inappropriate use of some of the inputs. Sunflower is not a common oilseed crop in the tropics even though it is a very rustic crop that can produce optimally under diverse agro-ecological conditions. Its production potential had however, been confirmed in the forest – savanna transition zone of the humid tropics (Olowe *et al.,* 2005a; Olowe and Adeyemo, 2009). Commercial fertilizers are usually used to boost the yield output of sunflower. According to Heffer (2013), the global application of fertilizers to oilseed crops was estimated at 19.0 Mt or 11.0% of the world consumption. The breakdown of this consumption stood at 7.3%, 14.7% and 19.8% of the world's total consumption of nitrogen, phosphorus and potassium fertilizers, respectively. However, it is very important that farmers apply the fertilizers at the appropriate rate and time in order to get the maximum output from the commodity being produced. The utilization of nutrients by sunflower varies depending on the stage of development of the crop. Sunflower utilizes the bulk of applied nitrogen from beginning of terminal bud appearance (R1 – R2) to end of anthesis (R6), phosphorus from emergence (VE) to R6 and potassium from R1 to ripening (Ustimenko-Bakumovski, 1980).

Research results have demonstrated increased productivity of sunflower through the application of mineral fertilizers that contain the major plant nutrients (nitrogen, phosphorus and potassium) in balanced quantities (Singh *et al.,* 1977; Noor-Mohammed and Ehdaie, 1979 and Ogunremi, 1984 and 1986; Nassim *et al.,* 2012a, 2012b) and organic fertilizers (Rasool *et al.,* 2013; Oshudiya *et al.*, 2014). The optimum rates of the major nutrients especially nitrogen vary across different ecological zones such as 90kg N/ha in the lowland areas of Nigeria (Ogunremi, 2000) and 60 kg N/ha in the derived savanna zone of Nigeria (Olowe *et al.*, 2005), 80 kg N/ha in India (Faisul-ur-aRasool *et el.,* 2013), 150 kg N/ha at Islamabad, Pakistan (Bakht *et al.*, 2010), and 180 kgN/ha at Faisalabad, Pakistan (Nasim *et al.,* 2012b). The application of different fertilizers (inorganic and organic) to sunflower either as single or split vary depending on agro-ecology and farming system being practiced. From literature, fertilizers have been applied to sunflower at planting (Zubriski and Zimmermann, 1974; Ogunremi, 1984), as basal application before planting (Bahl *et al.*, 1997), basal application of phosphorus and potassium and nitrogen at four weeks after sowing (Ogunremi, 2000), three weeks after planting to coincide with first weeding (Ogunremi, 1984 & 1986; Olowe *et al.,* 2005; Oshundiya *et al.,* 2014) or at advanced vegetative stages (Yousaf *et al.*, 1986). Earlier study on the appropriate timing of nitrogen and phosphorus fertilizers to sunflower in the forest – savanna zone revealed that single application at 21 days after sowing was optimal for local and two exotic varieties of sunflower. This study was carried out to evaluate the agronomic response of four newly released sunflower varieties (SAMSUN-1, SAMSUN-2, SAMSUN-3 and SAMSUN-4) by NASC (2013) to single and split application of nitrogen and phosphorus fertilizers in the forest-savanna transition zone of the humid tropics.

MATERIALS AND METHODS

Two field trials were carried out at the Institute of Food Security Environmental Resources and Agricultural Research (IFSERAR) Farm of the Federal University of Agriculture, Abeokuta (7º 23′ N, 3º 39′ E, altitude 139 m above sea level) in south western Nigeria on a loamy sand soil between June and November, 2014 and 2015. The soils belonged to the loamy sand textural class and were low in nitrogen, medium in phosphorus and potassium based on the rating of Anon (1989). The months of September and October were the two wettest months in both years. The coolest and hottest months were August (25.3 & 26.3ºC) and November (27.5 & 28.6ºC) in 2014 and 2015, respectively. Relative humidity was slightly above 70% during the wettest months (September and October) of both years, except 2015.

The trials were a 4 × 3 factorial arrangement laid out in randomized complete block design and replicated three times. The factors were variety: SAMSUN-1, SAMSUN-2, SAMSUN-3 and SAMSUN-4 and fertilizer regime: control, split application (30 kgN/ha + 28 kgP_2O_5/ha at 21 days after sowing, DAS and at anthesis, and single application of 60 kg N/ha + 56 kgP_2O_5/ha at 21 DAS. Each plot measured 4m x 1.8m (7.2m2) and consisted of four rows.

In each year of experimentation, the site of the experiment was ploughed twice and harrowed once. Sunflower seeds were sown at a spacing of 60 cm x 30 cm giving 56,000 plants/ha. Sowing was done on June 27, 2014 and August 7, 2015 during the late cropping seasons. Thinning to one plant per stand was done at two weeks after sowing (WAS). The sources of fertilizers used in the study were urea fertilizer (46%N), single superphosphate (18.5% P_2O_5) and muriate of potash (62%K_2O). The recommended rate of 100 kgK_2O (Ogunemi, 2000) was applied on all the fertilized plots along with N and P fertilizers at 21 DAS. Weeds were controlled manually at 3 and 6 WAS and no herbicides were sprayed in order to simulate the growing conditions of the resource-constrained farmers.

After the first weeding at 3 WAS, five randomly selected plants were tagged in the two middle rows for plant height and yield attributes measurement at maturity. Parameters measured on plot basis were number of phonological days to flowering (R5) and physiological maturity (R9) as described by Schnieter and Miller (1981), plant height (cm) at R5 and R9, head diameter (cm), head weight (g), number and weight (g) of seeds per head, 100 seed weight (g), Shelling percent (5) and seed yield (kg/ha).

All data collected on plot basis were analysed using the MASTAC package (Freed *et al.,* 1989). The treatment means of the main effects and interactions that were found significant were then separated using the least significant difference method (LSD) at 5% probability level.

RESULTS

Effect of nitrogen (N) and phosphorus (P) fertilizer regime on phenology and height characteristics of four sunflower varieties

Fertilizer regime significantly ($P \leq 0.05$; F-test) affected plant height of sunflower at flowering and physiological maturity in 2014 and 2015. Application of N and P fertilizers either as split or single dose significantly ($P \leq 0.05$) increased sunflower plant height at flowering and physiological maturity relative to the control treatment in both years. However, fertilizer regime had no significant effect on number of phonological days to flowering and physiological maturity of sunflower in both years. Similarly, variety and Variety × Fertilizer regime effects were not significant on number of phonological days to flowering and physiological maturity and height at R5 and R9 in both years (Table 3).

Effect of nitrogen (N) and phosphorus (P) fertilizer regime on seed yield and yield attributes of four sunflower varieties

Fertilizer regime significantly ($P \leq 0.05$; F-test) number of seeds per head, seed weight per head, 100 seed weight and seed yield of sunflower in both years and average head diameter and head weight, and threshing percent of sunflower in 2015 (Table 4 and 5). Split and single application of N and P fertilizers to sunflower resulted in significantly ($P \leq 0.05$) higher values for the parameters relative to the control treatment, except seed yield in 2014. Fertilizer regime had no significant effect on head diameter, average head weight and threshing percent of sunflower in 2014. Variety effect was only significant ($P \leq 0.05$; F-test) on average head weight, number of seeds per head and 100 seed weight of sunflower in 2015. However, in 2014, variety effect was not significant on any trait measured. Similarly, Variety × Fertilizer regime effect did not affect seed yield and any yield attribute of sunflower significantly in both years.

DISCUSSION

Adoption of the appropriate fertilizer regime is very crucial for successful sunflower cultivation and the performance of the crop depends largely on the prevailing weather conditions. The late cropping season of 2014 was wetter (610.2 mm) than that of 2015 (370.0 mm). This scenario apparently contributed to the better overall performance of sunflower in 2014 than 2015. Application of N and P fertilizers either as split or single regime significantly ($P \leq 0.05$; F-test) enhanced plant height of sunflower relative to the control at R5 and R9. The availability of N on the fertilized plots apparently boosted plant growth. No significant variety effect was recorded in 2014 for sunflower on seed yield and yield attributes. All the four new varieties were able to express themselves very well under the wetter growth conditions of 2014 than 2015. In an earlier trial where two exotic varieties (Record and Isaanka) and Funtua (locally adapted variety) were subjected to similar fertilizer regimes, Funtua grew taller than the exotic varieties (Olowe *et al*., 2005b). However, during the hotter and drier late cropping season of 2015, the varieties were significantly ($P \leq 0.05$; F-test) different for head weight , number of seeds per head and 100 seed weight. SAMSUN-1 and SAMSUN-2 recorded significantly ($P < 0.05$) higher head weight and number of seeds per head than SAMSUN-4. However, these differences did not translate to significant seed yield among the varieties.

Among the yield attributes evaluated in our study, split and single application of N and P significantly ($P \leq 0.05$; F-test) enhanced only 100 seed weight relative to the control in

2014. However, in 2015 all the yield attributes were significantly ($P \leq 0.05$; F-test) enhanced by split and single application of N and P fertilizers with the split application regime resulting in higher values for most traits. According to earlier reports, application of N up to 60 kg N/ha either as split or single significantly ($P < 0.05$) increased head diameter, seed weight per head and 1000 seed weight (Olowe *et al.*, 2005b) and 112 kg N/ha head diameter (Yousaf *et al*., 1986).

According to Robinson (1978), the seed yield of sunflower is highly dependent on number of heads per hectare, number of seeds (achene) and weight per head. The fertilizer regimes evaluated in our study significantly affected these traits in both years, except number of heads per hectare which was not calculated in our study. The seed yield values (1246 – 1994.2 kg/ha) recorded in our study during the wetter and more favourable 2014 compared very well with Nigerian (1000 kg/ha), African (812 kg/ha) averages (Olowe *et al.,* 2013) and world average (1520 kg/ha) according to USDA (2012), and the more recent forecast (1410 kg/ha) for 2012/2013 by NSA (2016). However, the imposed fertilizer regimes under drier and hotter 2015 conditions resulted in seed yield values at par with only the African average (812 kg/ha). The seed yield values recorded under split and single application of N and P fertilizers were at par in both years with the split regime resulting in slightly higher value in 2015. This trend also corroborated the results of earlier experiments on sunflower (Singh *et al*., 1977, Noor-Mohammed and Ehdaie, 1979, Ogunremi, 1984 and 1986, Olowe *et al*., 2005b).

On average, the superior performance of the sunflower varieties grown on the fertilized plots over those on the control plots suggest that they had access to the three major macronutrients (N,P and K) and these nutrients apparently contributed to their growth and development on the relatively fertile experimental soils. Lack of significant Variety × Fertilizer regime interaction in this two year study suggest that the two factors were independent of each other.

CONCLUSION

The results of this two year study indicate that the growth and seed yield responses of four newly released sunflower varieties were at par when N and P fertilizers were applied as split or single regime, and were superior to plants on the control plots. Consequently, it is recommended that single regime application of fertilizers at three weeks after sowing be adopted in the forest – savanna transition zone of the humid tropics.

LITERATURE

Anonymous, 1989. Fertilizer use and management practices for crops in Nigeria (Series 2) Enwezor, W.O., Udo, E.J., Usoroh, N.J., Ayotade, K.A., Adepetu, J.A., Chude, V.O. and Udegbe, C.I. eds. Federal Ministry of Agriculture, Water Resources and Rural Development. 163pp.

Bahl, G.S., Pasricha, N.S. and Ahuja, H.L. 1997. Effect of fertilizer nitrogen and phosphorus on the grain yield, nutrient uptake and oil quality of sunflower. J. of Indian Society of Soil Sci. 45: 292- 296.

Bakht, J., Shafi, M., Yousaf, M., Shah, H.U. 2010. Physiology, phenology and yield of sunflower (autumn) as affected by NPK fertilizer and hybrids. Pak. J. Bot. 42:1909-1922.

Faisul-ur-Faisul-ur-Rasool, Hasan, B, Jahangir, I.A, Ali, T and Mubarak, T. 2013. The Journal of Agricultural Sciences, 8: 17 – 27.

Freed R., Einmensmith S.P, G.uetz S, Reicosky D., Smail V.W., Wolberg P. (1989). *User's guide to MSTATC, An analysis of agronomic research experiments*. Michigan State University, USA.

Heffer, P. 2013. Assessment of fertilizer use by crop at the global level. 2010-2010/11. International Fertilizer Industry Association (IFA). 9p.

Nasim, W., Ahmad, A., Hammad, H.M, Chaudhary, H.J. and Munis, M.F. 2012a. Effect of nitrogen on growth and yield of sunflower under semi-arid conditions of Pakistan. Pak. J. Bot. 44:639-648.

Nasim, W., Ahmad, A., Bano, A., Olatinwo, R., Usman, M., Khaliq, T., Wajid, A., Hammad, H.M., Mubeen, M. and Hussain, M. 2012b. Effect of nitrogen on yield and oil quality of sunflower (Helianths annuus L.) hybrid under sub humid conditions of Pakistan. American J. of Plant Science. 3:243-251.

National Agricultural Seeds Council (NASC). 2013. Sunflower In: Catalogue of crop varieties released and registered in Nigeria. Vol. 5 p.41. 3: 21 – 24.

National Sunflower Association. 2016. http://www.sunflowernsa.com/health/stats/world-supply.

Noor-Mohammed ad Ehdaie, B. 1979. Effect of nitrogen and phosphorus fertilizers on sunflower seed yield and agronomic characters. The Sunflower Newsletter of the International Sunflower Association

Ogunremi, E.A. 1984. Response of sunflower (*Helianthus annuus* L.) to nitrogen, Phosphorus and potassium fertlizers in southern Nigeria. East African Agric. And For. Journal 45: 264 – 268.

Ogunremi, E.A. 1986. Effects of nitrogen fertilization and harvest time on sunflower yield and hollow seededness. Field Crop Res. 13: 45 – 53.

Ogunremi, E.A., 2000. *Sunflower, Kenaf and Sugar-cane in Nigeria: My Experiences* In: Agronomy in Nigeria. (M.O. Akoroda ed), Univ. of Ibadan, Ibadan, Nigeria, 130-142.

Olowe, V.I.O., Kabiru, A.A. and S.O. Opayemi (2005) The influence of timing of nitrogen and phosphorus fertilizers on grain yield and yield components of sunflower (*Helianthus annuus* L.) in the transition zone of south west Nigeria *International Journal of Tropical Agriculture* 3:259 - 267.

Olowe V.I.O., Adebimpe O.A., Obadiahi T.E. 2005. Response of sunflower (*H. annuus* L.) to nitrogen and phosphorus application in a forest –savanna transition zone of south west Nigeria. Nigerian Journal of Horticultural Science 10: 23-29.

Olowe, V.I.O and Adeyemo, A.Y. (2009). Enhanced crop productivity and compatibility through intercropping of sesame and sunflower varieties. *Annals of Applied Biology Journal.*155:285-291.

Olowe, V.I.O. Folarin, M.O, Adeniregun, O.O. Atayese, M.O and 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 Biology* 163:394-402.

Oshundiya, F.O., Olowe, V.I.O., Sowemimo, F.A. and Odedina, J.N. 2014. Seed yield and quality of sunflower (*Helianthus annuus* L.) as influenced by staggered sowing and organic fertilizer application in the humid tropics. Helia, 37: 237 – 255

Robinson, R.G. 1978. Production and Culture In: Carter, J.Inc. Publishers Madison, USA., pp. 89 – 143.

Schneiter, A.A. and Miller, J.F. 1981. Description of sunflower growth stages. Crop Science 21: 901-903.

Thavaprakash, N., Siva Kumar, S.D, Raja, K and Kumar, S. 2002. Effect of nitrogen and phosphorus levels and ratios on seed yield and nutrient uptake of sunflower hybrid Dsh-1. Helia, 25: 59 -68.

United States Department of Agriculture (USDA). 2012. Statistics on Oilseeds, Fats and Oils http://www.nass.usda.gov/Publications/Ag_Statistics/2012/chapter03.pdf

Ustimenko-Bakumovsky, G.V. 1980. Sunflower In: Plant growing in the Tropics and Sub-tropics. Mir Publishers, Moscow. 261 – 267.

Yousaf, M., Akhtar Beg and Shakoor, A. 1986. Effect of spacing and nitrogen on the yield and yield components of sunflower under rainfed conditions. Helia 9: 53 – 56

Zubriski, J.C. and Zimmerman, D.C. 1974. Effects of nitrogen, phosphorus and plant density on sunflower. Agronomy Journal 66: 798 - 801.

Table 1: Number of phonological days to flowering (R5) and physiological maturity (R9), and plant height of sunflower as influenced

by variety and fertilizer regime in 2014 and 2015

Treatment	2014				2015			
	Days to		Height (cm) at		Days to		Height (cm) at	
	R5	R9	R5	R9	R5	R9	R5	R9
Variety (V)								
SAMSUN-1	60.7	161.6	103.0	174.8	99.6	148.6	70.6	109.7
SAMSUN-2	60.9	148.9	103.2	161.8	107.3	147.2	71.1	109.4
SAMSUN-3	60.2	155.3	103.0	173.7	114.2	164.9	71.0	110.1
SAMSUN-4	60.3	157.2	102.7	174.3	106.4	158.9	70.2	110.8
LSD 5%	ns	ns	ns	ns	ns	ns	ns	ns
Fertilizer Regime (FR)								
Control	59.8	141.7	102.2	156.6	98.6	144.0	71.0	109.9
Split	60.9	164.8	103.1	180.7	115.6	168.9	70.4	109.8
Single	60.9	160.7	103.5	176.2	106.3	151.7	70.7	110.3
LSD 5%	ns	8.16**	ns	10.79**	13.31*	20.32*	ns	ns
Interaction								
V × FR	ns	ns	ns	ns	ns	ns	ns	ns

Notes: **, * Significant at P ≤ 0.001 and 0.05, respectively, ns – non-significant

Table 2: Sunflower seed yield and yield attributes as influenced by variety and fertilizer regime in 2014

Treatment	Head diameter (cm)	Head weight (g)	No. of seeds per head	Seed weight per head (g)	100 seed weight (g)	Threshing percent (%)	Seed yield (kg/ha)
Variety (V)							
SAMSUN-1	12.4	326.8	442.4	39.4	6.2	16.2	1746.9
SAMSUN-2	11.4	365.5	410.9	34.2	4.9	9.0	1527.4
SAMSUN-3	12.0	347.8	341.9	36.8	4.7	8.7	1652.2
SAMSUN-4	11.1	357.4	423.4	36.3	4.5	10.6	1595.5
LSD 5%	ns	ns	ns	ns	ns	ns	ns
Fertilizer Regime (FR)							
Control	11.1	296.5	352.4	27.8	3.9	10.3	1246.9
Split	12.3	361.8	411.8	36.7	5.8	10.2	1650.4
Single	11.9	389.9	449.8	45.5	5.6	12.9	1994.2
LSD 5%	ns	ns	79.19*	9.97**	1.54*	ns	425.94
Interaction							
V × FR	ns	ns	ns	ns	ns	ns	ns

Notes: **, * Significant at P $\leq$ 0.001 and 0.05, respectively, ns – non-significant

Table 3: Sunflower seed yield and yield attributes as influenced by variety and fertilizer regime in 2015

Treatment	Head diameter (cm)	Head weight (g)	No. of seeds per head	Seed weight per head (g)	100 seed weight (g)	Threshing percent (%)	Seed yield (kg/ha)
Variety (V)							
SAMSUN-1	8.4	22.3	440.2	10.8	2.5	49.5	506.1
SAMSUN-2	7.8	22.9	413.6	12.0	3.0	50.2	506.7
SAMSUN-3	7.5	16.5	442.5	11.3	3.1	63.9	606.5
SAMSUN-4	6.8	17.1	192.6	8.0	4.2	46.2	599.3
LSD 5%	ns	4.80*	163.99*	ns	1.19*	ns	ns
Fertilizer Regime (FR)							
Control	6.6	13.5	227.3	6.7	2.8	41.4	361.9
Split	8.5	26.3	463.3	14.2	4.0	60.9	704.9
Single	7.8	19.2	426.0	10.6	2.8	55.1	597.0
LSD 5%	1.04**	4.16**	142.0**	2.71**	1.04*	13.09*	126.67**
Interaction							
V × FR	ns	ns	ns	ns	ns	ns	ns

Notes: **, * Significant at P $\leq$ 0.001 and 0.05, respectively, ns – non-significant