Journal of Agriculture and Environment Vol. 13 No. 2, 2017: 67-73
ISSN 1595-465X

TISSUE P-CONTENTS AND YIELD ASSESSMENT IN PHOSPHORUS FERTILIZED SUNFLOWER (*Helianthus annuus* L.) IN MAIDUGURI, SUDAN SAVANNA, NIGERIA

J.W. Wabekwa

Department of Crop Production, University of Maiduguri, Nigeria

ABSTRACT

Field trials were conducted during the successive rainy seasons of 2010 and 2011 at University of Maiduguri Teaching and Research Farm, Faculty of Agriculture in Sudan savanna, Nigeria. This was aimed at studying the tissue P contents of sunflower roots, stems, leaves and grains cultivated under artificially applied phosphorus. The treatments (0, 20, 40, 60 Kg P_2O_5 ha^{-1}) were arranged in Randomized Complete Block Design (RCBD), replicated three times. The treatments were incorporated at land preparation as single super phosphate (SSP) in order to achieve its efficacy and fields were kept weed-free to avoid nutrient loss to weed uptake. Data were subjected to statistical analysis of variance using "statistix" software version 8.0 and the treatment means were compared using DMRT at 5% level of probability. Result from plant tissue analysis revealed that phosphorus treatments did not significantly influence P contents of roots in the mean for 2010 and 2011 rainy seasons. Similarly, tissue analysis for stem reveals non significant values ($P>0.05$) for P contents among the phosphorus treatments in the two years mean. Result for leaf tissue analysis however indicates that higher phosphorus treatment of 80 Kg P_2O_5 ha^{-1} resulted in the highest phosphorus uptake and recorded mean leaf P content of 21.31%. Grain phosphorus uptake also increased with the highest phosphorus rate (80 Kg P_2O_5 ha^{-1}) and recorded P tissue content of 26.64% for the two years mean. Application of 80 Kg P_2O_5 ha^{-1} gave the highest value for 1000-grain weight in the two years mean (50.37g). Phosphorus applied at lower rate of 40 Kg P_2O_5 ha^{-1} however gave statistically higher grain yield in the two years mean (1565.2 Kg ha^{-1}). It is concluded that P uptake increases in sunflower with higher phosphorus application; and higher P content recorded in leaves and grains herein, relative to lower part of the plant clearly suggests that phosphorus was mobilized up in large amount to meet the plants physiological demand at the reproductive phase since phosphorus plays higher role in grain development.

Keywords: P rates; Tissue P contents; Sunflower

INTRODUCTION

Fertilizers can directly influence the chemical composition of plants by increasing the uptake of nutrients from soil; and among the classified primary nutrients (N.P.K.), phosphorus has been shown to be critical element in natural agricultural ecosystem throughout the world (Brady and Weil, 2002). Phosphorus stimulates plant root proliferation and development, which improves roots capacity to explore growth environment and enhance nutrient use efficiency (Ufot *et al.*, 2003). It is also essential for biological activities in plants and acts as components of deoxyribonucleic acid (DNA), ribonucleic acid (RNA), Adenosine triphosphate (ATP) and phospholipids (Syers *et al.*, 2008). Phosphorus levels of Northern Nigerian soils have however, been rated by Oyinlola and Chude (2004) as very low with mean value of 8.11 Mg Kg^{-1}, and similar study by Kwari (2005) revealed that Nigeria's Sudan savanna soils contain very low phosphorus levels. Reports from Jalaluddin and Maria (2011) also indicates that most insoluble phosphate compounds are in unavailable forms in soils, thus the study of P uptake is important with the aim of determining how much of P applied is partitioned to various plant parts and how yield performances is being affected by the uptake.

Phosphorus application has been reported by Kumar *et al.* (1995) to enhance P uptake and increase grain P content in sunflower. Phosphorus containing compounds play critical roles in cellular membranes, and for most plant species, total leaf P contents is usually low between 0.2-0.4% of the dry matter (Brady and Weil, 2002). It has been reported by Ikisan (2000), that initial P uptake by plant is slow at early growth phase, but rapidly increases towards the attainment of maturity. Foth and Boyd (1998) however held different opinion as they observed decreases in leave P tissue contents with plant ageing (0.48%) sampled at late vegetative phase, while at tasseling, the leaves P contents recorded 0.22%. In a similar finding, Whitney (1988) has reported that P tissue contents of maize plant sampled at seedling was 1.32%, while at full growth phase, early bloom and grain formation, the tissue P contents increased to 6.2%, 14.9% and 11.4% of the applied phosphorus respectively.

The most important method of increasing the grain contents of sunflower is through adequate phosphorus application (Gunes and Inal, 2009). Studies have shown that sunflower grains constitute about 79% P if applied at 100 Kg P_2O_5 ha^{-1} (Hocking and Steer, 1983). Report from Agrawal *et al.* (2000) indicated that P contents of sunflower foliage and grains increased with the application of 60-90 Kg P_2O_5 ha^{-1}, and Gadallah (1994) reported higher shoot P content than other plant parts in sunflower. Akporhonor *et al.* (2005) also evaluated P content of maize stems sampled at 30, 45 and 60 DAS as 0.13%, 0.19% and 0.08% respectively. Wabekwa (2014) has made recommendation of lower phosphorus rate (20 Kg P_2O_5 ha^{-1}) for higher performance of 1000-grain weight, and recommended 40 Kg P_2O_5 ha^{-1} for grain yield in Northern Guinea savanna of Nigeria. reports from Heramati (1993) and Zhera (2011) however indicated that higher grain yield were recorded with the application of 30 and 50 Kg P_2O_5 ha^{-1} respectively.

MATERIALS AND METHODS

Study Area

To evaluate the P contents of plant parts and agronomic performances in phosphorus fertilized sunflower in Sudan savanna Nigeria, field trials were conducted during 2010 and 2011 rainy season at Teaching and Research Farm of the Faculty of Agriculture, University of Maiduguri (11^0 47'N, 13^0 13'E), 324m above sea level. Maiduguri, the study area is geographically located in Sudan savanna vegetation belt of Nigeria, with mean annual rainfall of 547mm and temperature of 31^{o}C (NIMET, 2014)

Experimental Design and Field Experiments

Four levels of phosphorus application were considered as treatments (0, 20,40, 60 and 80 Kg P_2O_5 ha^{-1}) and the experiment was laid out in a Randomised Complete Block Design (RCBD) and replicated three times.

At land preparations, the treatments were incorporated as single super phosphate (SSP) and seeds of sunflower (var. *Funtua*) were obtained from the Plant Science Department of Ahmadu Bello University, Zaria, and hand-sown in June. Over-seeded holes were thinned to one seedling per stand at 2 weeks after sowing (WAS) during first weeding, and fields were kept weed-free in order to avoid nutrient loss to weed uptake. Although incidences of pests and diseases were not recorded in this study, field inspections were considered to avoid their outbreak.

Data Collection and Analysis

Samples of plant roots, stems, leaves and grains were collected from net plots at plant maturity (14WAS) and analysed for their various tissue P contents using dry-ashing method by adding vonadomolybdate reagents to 5ml of prepared digests from the plant samples and diluted with distilled water in 25ml volumetric flask. The P reading was taken on spectrometer at 400nm wavelength with stable colour development of the settled solution and graph of percentage transmission against concentration was plotted using P standards to obtain tissue P contents for each plant sample (A.O.A.C, 1970). Net plots were also harvested to determine grain yield, and the required number of grains were randomly selected from the harvested grains and weighed on Mettle balance P1210 to determine the 1000-grain weight.

Data obtained were all subjected to statistical analysis of variance using "Statistix" software version 8.0 and the treatment means were compared using Duncan's Multiple Range Test (DMRT) at 5% level of probability (Duncan, 1955).

RESULTS

Table 1 shows the contents of P in roots and stems of sunflower as influenced by varying phosphorus treatments in Maiduguri. Results on root tissue analysis indicate that application of 80 Kg P_2O_5 ha^{-1} increased fertilizer uptake and had the highest P content of 3.6% in 2010 rainy season. In 2011 rainy season however, lower phosphorus treatment of 40 Kg P_2O_5 ha^{-1} gave the highest significant increase in root P tissue content of 7.44%, while the mean P content for the two years was not significantly different ($P>0.05$) among the treatments.

Tissue analysis of sunflower stem also reveals that phosphorus applied at 60 Kg P_2O_5 ha^{-1} increased the uptake of P which had tissue content of 6.88% in 2010 rainy season; while lower phosphorus treatment of 40 Kg P_2O_5 ha^{-1} recorded 9.62% of the partitionable P in 2011 rainy season. Mean stem P content for the two years was not statistically significant between the treatments.

Table 1: Tissue P contents of root and stem of phosphorus-fertilized sunflower in Maiduguri, 2010 and 2011 rainy seasons and the two years mean

	Root P content (%)			Stem P content (%)		
P_2O_5 (Kg ha^{-1})	2010	2011	Mean	2010	2011	Mean
0	2.02^{c}	5.99^{c}	4.01^{a}	3.10^{c}	6.15^{b}	4.63^{a}
20	2.52^{c}	6.48^{bc}	4.49^{a}	3.09^{c}	6.86^{b}	4.98^{a}
40	3.43^{b}	7.44^{ab}	5.44^{a}	6.47^{b}	9.62^{a}	8.05^{a}
60	3.27^{b}	8.06^{a}	5.67^{a}	6.88^{ab}	9.41^{a}	8.14^{a}
80	3.60^{a}	7.99^{a}	5.79^{a}	8.03^{a}	8.86^{a}	8.44^{a}
SE ($\pm$)	0.49	0.64	0.40	0.68	0.68	0.48

Means in a column followed by the same letter(s) are not significantly different at 5% level of probability according to DMRT

Table 2 presents the results on influence of phosphorus treatments on P contents of leaf and grain of sunflower in Maiduguri, which shows that the treatment, 60 Kg P_2O_5 ha^{-1} increased the leave P contents which had 17.55% of the partitionable phosphorus in 2010 rainy season. In 2011 rainy season and the two years mean, 80 Kg P_2O_5 ha^{-1} increased P uptake and gave its highest leaf content of 23.69% in 2010 rainy season and 21.31% in the two years mean.

Results for grain P content reveals that higher phosphorus treatment of 80 Kg P_2O_5 ha^{-1} increased P uptake and recorded higher tissue contents of 31.11% in 2010 rainy season, 22.17% in 2011 and 26.64% in the two years mean.

Table 2: Tissue P contents of leaf and grain of phosphorus-fertilized sunflower in Maiduguri, 2010 and 2011 rainy seasons and the two years mean

	Leaf P content (%)			Grain P content (%)		
P_2O_5 (Kg ha^{-1})	2010	2011	Mean	2010	2011	Mean
0	6.95^{c}	10.30^{d}	8.63^{e}	4.17^{d}	3.47^{d}	3.82^{d}
30	8.65^{c}	14.61^{c}	11.63^{d}	3.43^{d}	3.31^{d}	3.37^{d}
40	15.42^{b}	19.79^{b}	17.61^{c}	12.68^{c}	12.92^{c}	12.80^{c}
60	17.55^{a}	21.95^{b}	19.75^{b}	21.87^{b}	19.65^{b}	20.76^{b}
80	18.92^{a}	23.69^{a}	21.31^{a}	31.11^{a}	22.17^{a}	26.64^{a}
SE ($\pm$)	0.99	1.19	0.78	1.31	0.78	0.76

Means in a column followed by the same letter(s) are not significantly different at 5% level of probability according to DMRT.

Table 3 revealed that phosphorus application increased plant P uptake and influenced the performances of 1000-grain weight and grain yield of sunflower in

Maiduguri. In 2010 rainy season, application of 40 Kg P_2O_5 ha^{-1} increased number of filled grains significantly and increased 1000-grain weight (54.40g). Higher phosphorus treatment of 80 Kg P_2O_5 ha^{-1} gave higher values for 1000-grain weight in 2011 rainy season (44.87g) and in the mean (50.37g).

Result on grain yield indicates that application of 40 Kg P_2O_5 ha^{-1} in 2010 rainy season and the two years mean significantly increased grain yield and had 1565.2 Kg ha^{-1} in the mean. In 2011 rainy season however, highest phosphorus treatment of 80 Kg P_2O_5 ha^{-1} out yielded all other treatments (1153.6 Kg ha^{-1}).

Table 3: 1000-grain weight and grain yield of phosphorus-fertilized sunflower in Maiduguri, 2010 and 2011 rainy seasons and the two years mean

	1000-grain weight (g)			Grain yield (kg ha^{-1})		
P_2O_5 (kg ha^{-1})	2010	2011	Mean[1]	2010	2011	Mean
0	49.40[b2]	24.60[c]	37.00[bc]	1791.8[b]	795.1[c]	1293.5[b]
20	49.87[b]	21.27[c]	35.57[c]	1880.1[b]	824.0[c]	1352.1[b]
40	54.40[ab]	30.33[b]	42.37[bc]	2289.1[a]	841.4[c]	1565.2[ab]
60	51.73[ab]	34.07[b]	42.90[b]	2157.2[ab]	979.8[b]	1568.5[ab]
80	55.87[a]	44.87[a]	50.37[a]	2421.9[a]	1153.6[a]	1787.8[a]
SE (±)	2.568	2.467	3.688	188.28	58.66	198.10

Mean in a column followed by the same letter(s) are not significantly different at 5% level of probability according to DMRT

DISCUSSION

Higher contents of P recorded in leaves (21.32%) and grains (26.64%) with the highest phosphorus rate (80 Kg P_2O_5 ha^{-1}) was clear indication that larger part of applied P were partitioned to shoot and grain and most probably stored in the vacuoles to later meet up with plants requirement at reproductive phase. Bucvic *et al.* (2003) noted that P application influenced higher P contents of flag leaves. It also reconfirms that during reproductive phase largest concentration of nutrients and photosynthates are found in upper parts of the plants due to remobilization (Ikisan, 2000; Whitney, 1988). Previous reports from Oyinlola (2004) also indicated that about three-forth of total P in above ground part has been evaluated to be concentrated in grains. The above result further implies that sunflower demand for physiological activities herein, which translated to higher grain yield was achieved at higher phosphorus application (80 Kg P_2O_5 ha^{-1}). The implication of this finding however is that, if additional P rates beyond 80 Kg P_2O_5 ha^{-1} were considered, the shoot and grain P requirements might exceed the present limit. Nevertheless, higher leaf and grain contents were necessary for photosynthesis and grain filling activities (Syers *et al.*, 2008). This also confirms the results of regression studies by Aishatu (2015) which indicated the contribution of leaf and grain P contents to grain yield by 41.1% and 25.5% respectively.

The highest value for 1000-grain weight recorded (50.37g) at 80 Kg P_2O_5 ha^{-1} in this study was not unconnected with higher grain P uptake reported at similar fertilizer rate above, since phosphorus plays key role in grain filling processes (Karadogan *et al.,* 2009). The grain yield recorded herein (1565.2 Kg ha^{-1}) with lower phosphorous rate of 40 Kg P_2O_5 ha^{-1}, relative to higher grain p content could still suggest that grain P requirements for quantitative increase in dry matter got fulfilled at lower phosphorus rate (40 Kg P_2O_5 ha^{-1}), which therefore, mean that the grains involved in luxury P uptake, most probably due to higher fertilizer application. Tagliavini *et al.* (1991) reported that large supply of P influences luxury uptake by plants. Heramati (1993) and Zhera (2011) recommended lower phosphate rates which included 30 and 50 Kg P_2O_5 ha^{-1}, respectively for grain yield; and the slight variations in these reports reaffirms that climatic and soil factors play significant roles in crop yield since the recommendations were based on crop performances from different environments (Udo and Ogunwale, 1995).

CONCLUSION

In conclusion, further field trials need to be conducted to reconsider high phosphorus application beyond 80 Kg P_2O_5 ha^{-1} herein, in order to investigate whether the shoot P uptake could exceed the present limit of fertilizer rate (80 Kg P_2O_5 ha^{-1}) by leaves in order to further improve yield through photosynthetic efficiency.

REFERENCES

A.O.A.C. (1970). Association of Official Analytical Chemists. Official methods of analysis. Ed II., Washington, D.C.62pp

Agrawal, M.M., Verma, B.S., Kumar, C. and Kumar, C. (2000). Effects of phosphorus and sulphur on yield, N, P, and S contents and uptake by sunflower (*Helianthus annuus* L.). *Indian Journal of Agronomy,* 45(1): 184-187

Aishatu, B. (2015). Nutrient uptake, growth and yield responses in sorghum as influenced by organic and inorganic fertilizers in the semi-arid region of Nigeria. M.Sc Thesis, School of Postgraduate Studies, University of Maiduguri, Nigeria. 63pp

Akporhonor, E.E., Egwaikhide, P.A. and Odilora, C.A. (2005). Studies on the variation of micronutrients uptake level of maize stem with age. *Journal of Applied Science and Environmental Management,* 9(1):197-199

Brady, N.C., and Weil, R.R. (2002). *The Nature and Properties of Soil*. 13th Ed. Pearson Education Pte Ltd., Delhi, India.556pp

Bucvic, G., Anthnovic, M. Pupovic, S. and Rastiya, M. (2003). Effect of phosphorus and zinc fertilization on biomass yield and its uptake by maize lines *(Zea mays* L.). *Plant-Soil Environment,* 49:505-510

Duncan, D.B. (1955). Multiple range and multiple "F"-tests. *Biometrics,* 2:1-42

Forth, H.D. and Boyd, G.E. (1998). *Soil fertility*. John Wiley and Sons Inc., New York. 90-169pp

Gadallah, M.A.A. (1994). Effect of industrial and sewage waters on the concentration of soluble carbon, nitrogen and some mineral elements in sunflower plants. *Journal of Plant Nutrition,* 17(8):1369-1384

Gunes, A. and Inal, A. (2009). Phosphorus efficiency in sunflower cultivars and its relationship with phosphorus, calcium, iron zinc and manganese nutrition. *Journal of Plant Nutrition,* 32:1201-1218

Heramati, I. (1993). Effects of fertilizer on sunflower yield. *Agro-chem,* 42:282-292

Hocking, P.J. and Steer, B.T. (1983). Uptake and partitioning of selected mineral elements in sunflower (*Helianthus annuus* L.) during growth. *Field Crops Research*, 6:93-107

Ikisan (2000). Maize nutrient management. http://www.ikisan.com/link/ap-maizenutrients%2520managaement.shtl

Jalaluddin, M. and Maria, H. (2011). Effects of adding inorganic, organic and microbial fertilizers on seed germination and seedling growth of sunflower. *Pakistan Journal of Botany*, 43(6):2807-2809

Karadogan, T., Akgun, I. and Altindal, N. (2009). Effects of leaf removal on sunflower yield and yield components and some quality characters. *Turkish Journal of Field Crops*, 14(2):45-54

Kumar, S., Singh, A.K. and Vyas, A.K. (1995). Effects of N and P application on their uptake and biomass production by sunflower (*Helianthus annuus* L.). *Annals of Agricultural Resources*, 16(4): 513-514

Kwari, J.D. (2005). Soil fertility status in some communities in Southern Borno. Final report submitted to PROSAB, Maiduguri, Nigeria. 21pp

NIMET (2014) Nigeria Meteorological Services, Federal Ministry of Aviation, Maiduguri, Borno State.

Oyinlola, E.Y. (2004). Response of irrigated tomato (*Lycopersicon lycopersicum karst.*) to boron fertilizer II: Growth and nutrient concentration. *Nigeria Journal of Soil Research*, 5:62-69

Oyinlola, E.Y. and Chude, V.O. (2004). Response of irrigated tomato (*Lycopersicon lycopersicum karst.*) to boron fertilizer I: yield and fruit quality. *Nigeria Journal of Soil Research*, 5:53-61

Syers, J.K., Johnson, A.E. and Curtin, D. (2008). Efficiency of soil and fertilizer phosphorus use, reconciling changing concepts of soil phosphorus behaviours with agronomic information. Fertilizer and Nutrition Bulletin No.18. FAO, Rome, Italy.

Tagliavini, M., Hogue, E.J. and Neilson, G.H. (1991). Influence of phosphorus nutrition on root zone temperature and growth and mineral uptake of peach seedlings. *Journal of Plant Nutrition*, 14:1267-1275

Udo, E.J. and Ogunwale, J.A. (1995). Phosphorus fractions in selected Nigerian soils. *Soil Science Society of America Journal*, 41:1141-1146

Ufot, U.O., Awe, O.A. Chukwu, G.O. (2003). Effects of phosphorus on the basal and apicalinternodes of maize (*Zea mays* L.*)* on a hapic acrisol. Proceedings of the 28th Annual Conference of the Soil Science Society of Nigeria, held on 4th – 7th November, 2003 at Federal University of Agriculture, Umudike. Pp103-106

Wabekwa, J.W. (2014). Effects of nitrogen and phosphorus application on nutrient uptake, growth, yield components, yield and oil qualities of sunflower (*Helianthus annuus* L.) in the Sudan and Northern Guinea savanna, Nigeria. Unpublished Ph.D. Thesis, School of Postgraduate Studies, University of Maiduguri.288pp

Whitney, D.A. (1988). Phosphorus facts. Soils, plants and fertilizer. Kansas State University Cooperative Extension Services. http://www.oznet.ksu.edu/library/crops12/c665.pdf

Zhera, E. (2011). P-solubilizing bacteria and phosphorus fertilizer to sunflower improves seed set, seed filling efficiency and concentration of macro and micro nutrients of seeds. *Turkish Journal of Field Crops*, 16(2):183-189