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TISSUE N-CONTENT DETERMINATION AND YIELD ASSESSMENT IN NITROGEN FERTILIZED SUNFLOWER (*Helianthus annuus* L.) IN MAIDUGURI, SUDAN SAVANNA, NIGERIA

J.W. Wabekwa

Department of Crop Production, University of Maiduguri, Nigeria

ABSTRACT

To determine N contents of various sunflower parts under nitrogen-treated field conditions, experiment was conducted during the rainy seasons of 2010 and 2011 at University of Maiduguri Teaching and Research Farm, Faculty of Agriculture in Sudan savanna of Nigeria. The treatments (0, 30, 60, 90 and 120 Kg N ha^{-1}) were arranged in Randomised Complete Block Design (RCBD) and replicated three times. Urea (46%N) was split-applied to 2 weeks after sowing (WAS) and to first flowering; and fields were kept weed-free in order to avoid nutrient loss to weed uptake. Various plant parts were collected at maturity and analysed in the laboratory to determine their N-contents. Data obtained were statistically separated using DMRT. Result on tissue analysis revealed increase in mean root N content which had 4.99% at 30 Kg N ha^{-1}, while the stem N content increased with higher N rate of 90 Kg ha^{-1} and gave 7.16% in the two years mean. Mean leaf N content for the years however influenced significantly the leaf N-content with 60 Kg N ha^{-1} which recorded 17.03% and higher nitrogen rate of 90 Kg N ha^{-1} influenced grain N uptake of 15.77% for the two years. Application of 60 Kg N ha^{-1} recorded mean 1000-grain weight (43.03g) for the two years, while higher N rate of 90 Kg ha^{-1} increased mean grain yield for the two years (1928.5 Kg ha^{-1}). It is concluded that N applied at 90 Kg ha^{-1} did not only influence increase in grain N content, but also meet plant demand for grain yield, which could mean that the grain N uptake contributed to partitioning of materials needed to fulfil the physiological requirements which translated to grain development.

Keywords: N rates; N contents; sunflower; tissue analysis.

INTRODUCTION

The potentials for yield stability depends on the ability of grain producing plants to remobilize or redistribute partitioned assimilates for grain production; and grain ability to incorporate translated carbon to embryo or endosperm (Turner *et al.*, 2000). So much of carbohydrate used for grain production comes from photosynthesis and those that are mobilized from stems and roots (Hall, 2004). It has been reported that nutrient-rich soils could increase plant tissue contents and have positive effects on yield performances (Halvin *et al.,* 2005). It has been documented that nutrients removed by crops far exceeds those added through natural fixation due to continuous cultivation (Scheiner *et al.,* 2002); and to that effect, artificial application of fertilizer remains an important measure that can temporarily correct nutrient deficiencies and replace lost nutrients.

Nitrogen is an important and indispensable constituent of numerous compounds of secondary plants metabolism, and its uptake rate is determined by physiological needs of plants (Mengel *et al.*, 2006). Nitrogen has further been described by Isirimah *et al.* (2003) as constituent of plant protein, nucleic acid and chlorophyll. Source-sink activity and grain filling rates is controlled by sucrose synthase which constitutes nitrogen compounds (Mohapatra *et al.*, 2000). It greatly influences many physiological processes which leads to yield (Kiri, 2010), and its early application promotes assimilation and prepares the plant for further development processes (Steer, 1983).

The uptake rate of nitrogen is determined by movement of photosynthates to the grains; and remobilization of earlier stored N later contributes to yield at the reproductive phase (Moll *et al.*, 1994). The N constituents of plant tissue have been evaluated by Mengel and Kirkby (1982) as 2-4% of plant dry weight. Thrind *et al.* (2001) has reported total N content of sunflower as 67.2% and 86.7% when 30 and 60 Kg N ha^{-1} were applied, respectively, and Steer *et al.* (1984) reported that split application of N across the developmental phases influenced increases in tissue N contents than single dose. Nitrogen contents for roots, stems, leaves and grains of sunflower has also been evaluated by Wabekwa (2014) as 6.0%, 7.86%, 18.44% and 17.85%, respectively, in northern Guinea savanna of Nigeria. The application of 75 Kg N ha^{-1} has been reported to increase plant uptake in sesame which recorded 32.99 mg per plant (Shehu, 2010). Matias *et al.* (2003) has recommended split application of 70 Kg N ha^{-1} to vegetative and reproductive phases for grain yield and other agronomic parameters, while Osman and Awed (2010) recorded significant increase in 100-grain weight with the application of 60 Kg N ha^{-1}.

MATERIALS AND METHODS

Study Area

To evaluate the N contents of various plant parts and agronomic performances in nitrogen treated sunflower, field experiments were conducted during the 2010 and 2011 rainy seasons at the University of Maiduguri Teaching and Research Farm, Faculty of Agriculture (11^{o} 47'N, 13^{o}13'E), 324m above sea level in Sudan savanna, Nigeria.

Experimental Design and Field Experimentation

Nitrogen treatments (0, 30, 60, 90 and 120 Kg N ha^{-1}) were arranged in a Randomized Complete Block Design (RCBD) and replicated three times.

Seeds of sunflower (var., *Funtua*) was sourced from the Plant Science Department of Ahmadu Bello University, Zaria, and hand-sown at 75x 25cm in June, following heavy rainfall during both years, and over-seeded holes were thinned to one plant per hole at two weeks after sowing (2 WAS) during first hand-weeding. The N treatments (urea, 46%) were split-applied into two equal halves, first at early vegetative phase (2 WAS) after the first weeding and the second dose was applied at first flowering in order to meet up with the plants N demand at the reproductive phase. Fields were kept weed-free to avoid nutrient loss to weed uptake.

Data Collection and Analysis

Data for 1000-grain weight was obtained by random selection of the required number of grains from net plots at harvest and weighed on P1210 Mettle balance. Grain yield per hectare was, however, evaluated from the harvested net plots. Samples of the various plant parts (the roots, stems, leaves and grains) were collected at harvest and analysed for their relative N contents using wet-ashing method as described by Bremner and Mulvane (1982). Following the digestion, heating and cooling procedures of the grounded plant parts, 10 ml of the digest with 40% NaOH was distilled and the distillates were titrated against 0.01 N HCl to a pink end point. The percentage N content of plant parts were then calculated as follows:

$$\% \text{ N} = \frac{a - b \times N \times V_1 \times 100}{W \times V_2}$$

Where;

a = mls of HCl used in sample titration
b = mls of HCl used in blank titration
N = Normality of standardized HCl
V_1 = Total volume of digest made up to mark
V_2 = Aliquot or digest used for analysis
W = Weight of plant material used
100 = Percentage expression

Data collected for the yield parameters and the laboratory tissue analysis were further subjected to analysis of variance using “Statistix” software version 8.0, and means were separated using the Duncan’s Multiple Range Test (DMRT) at 5% level of probability (Duncan, 1955).

RESULTS

Root and Stem N-Contents

Table 1 presents data on N contents of sunflower root and stem as influenced by varying nitrogen rates in study location. Results on root contents indicate that nitrogen application did not influence its percentage N content in 2010 rainy season. In 2011 and the two years mean however, the root N contents show significant increases with the application of 30 Kg N ha^{-1} and the values recorded at this rate were 7.47% and 4.99% for 2011 rainy season and the mean, respectively.

The stem tissue analysis for N content also indicates that application of 90 Kg N ha^{-1} resulted in significant increase in stem N content in 2010 rainy season (6.20%) and in the mean (7.16%) after which further N increase did not change the stem N content significantly and lowest values were obtained from unfertilized plots. However, application of 30 Kg N ha^{-1} resulted in significant increase in the stem N content in 2011 rainy season

(8.61%). Further increase in the N-rate did not significantly change the N-content of the root.

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

N rates (Kg ha^{-1})	Root N content (%)			Stem N content (%)		
	2010	2011	Mean	2010	2011	Mean
0	2.55	5.17^{b}	3.86^{b}	3.84^{c}	6.83^{b}	5.34^{c}
30	2.51	7.47^{a}	4.99^{a}	5.36^{b}	8.61^{a}	6.98^{b}
60	3.01	7.72^{a}	5.37^{a}	5.37^{b}	8.36^{a}	6.86^{b}
90	3.47	7.93^{a}	5.70^{a}	6.20^{ab}	8.11^{ab}	7.16^{ab}
120	3.30	7.65^{a}	5.48^{a}	6.81^{a}	8.99^{a}	7.89^{a}
SE (±)	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.

Leaf and Grain N Content

Table 2 shows results on N contents of sunflower leaf and grain tissues as influenced by the varying nitrogen rates in the study area. Nitrogen applied at 60 Kg N ha^{-1} influenced N uptake and increased leaf N contents in the individual rainy seasons and the values recorded at this rate were 15.05% in 2010 and 19.01% in 2011. In the mean data of the two years, application of 60 Kg N ha^{-1} significantly increased the leaf N-content but further increase did not change the leaf N-content significantly. The lowest value for N-content was obtained from unfertilized plots.

Table 2: Tissue N-content of leaf and grain in nitrogen-fertilized sunflower in Maiduguri, 2010 and 2011 rainy seasons and the two years mean

N rates (Kg ha^{-1})	Leaf N content (%)			Grain N content (%)		
	2010	2011	Mean	2010	2011	Mean
0	9.55^{c}	15.87^{c}	12.71^{c}	10.67^{b}	8.51^{c}	9.59^{c}
30	12.44^{b}	16.50^{bc}	14.47^{b}	12.42^{b}	12.61^{ab}	12.51^{b}
60	15.05^{a}	19.01^{a}	17.03^{a}	15.21^{a}	12.41^{b}	13.81^{b}
90	15.05^{a}	18.61^{ab}	16.83^{a}	17.50^{a}	14.05^{a}	15.77^{a}
120	15.41^{a}	20.34^{a}	17.87^{a}	17.45^{a}	13.96^{a}	15.71^{a}
SE (±)	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.

Result for grain N content in 2010 also revealed that nitrogen applied at 60 Kg N ha^{-1} resulted in significant increase in grain tissue N content which represented 15.21% of the partitionable materials; and further increase in N did not significantly influence N uptake. In 2011 and mean data of the two years, application of 90 Kg N ha^{-1} significantly increased the grain N content but further increase did not change the grain N content significantly. The lowest value for N-content was obtained from unfertilized plots.

1000-Grain Weight and Grain Yield

Nitrogen uptake recorded significant effects on the agronomic performance of 1000-grain weight and grain yield of sunflower in Maiduguri (Table 3). In 2011 application of 90 Kg N ha^{-1} increased number of filled grain and gave higher 1000-grain weight (36.13g) which was statistically similar to application of 60 and 120 Kg N ha^{-1}. The lowest grain weight was from untreated control. In the mean data for the two years, application of 60 Kg N ha^{-1} significantly increased 1000-grain weight but further increase did not change the 1000-grain weight significantly. The lowest value for 1000-grain weight was obtained from unfertilized plot.

Result for yield performance indicates that nitrogen application influenced N uptake and increased grain yield in both years and their mean. In the mean of the two years, application of 90 Kg N ha^{-1} produced significantly more grain yield (1928.5 kg ha^{-1}) than the lower rates of 30 and 60 Kg N ha^{-1},but significantly similar to that of 120 Kg N ha^{-1} which was in turn similar to 60 Kg N ha^{-1}. The least grain yield was from the untreated control.

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

N rates (kg ha^{-1})	1000-grain weight (g)			grain yield (kg ha^{-1})		
	2010	2011	Mean	2010	2011	Mean
0	50.13	19.73^{d}	34.93^{c}	1586.7^{c2}	541.7^{c}	1064.2^{d}
30	51.80	25.63^{c}	38.72^{bc}	1880.1^{b}	555.3^{c}	1217.7^{cd}
60	53.47	32.60^{b}	43.03^{ab}	2229.6^{ab}	755.3^{b}	1492.5^{bc}
90	51.67	36.13^{ab}	43.90^{ab}	2508.6^{a}	1348.4^{a}	1928.5^{a}
120	54.20	41.04^{a}	47.62^{a}	2162.3^{ab}	1393.2^{a}	1777.7^{ab}
SE(±)	2.568	2.467	3.688	188.28	58.663	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

This study reveals that lowest nitrogen rate applied as 30 Kg N ha^{-1} increased the N content of root (4.99%), which implies that N requirements for secondary root proliferation was fulfilled at this rate and excesses might have been remobilized to shoot and grains. Tagliavini *et al.* (1991) previously reported that large supply of fertilizer can influence luxury uptake by plants. Since the stem is a key player and an intermediary in source-sink activities in plant (Moll *et al.*, 1994), it is important to suggest herein that the stem N content (7.16%) at 90 Kg N ha^{-1} was due to higher N demand, most probably to fully equip the stem conducting tissues and other excesses might be stored in vacuoles. Other related studies have also revealed that lower parts of the plant store materials that might be later remobilized for grain yield (Hall, 2004). The second N dose applied at peak growth period might as well influence excess uptake by stem beyond its actual requirements especially if fertilizer needs by upper plants was fulfilled without further demand. Mengel *et al.* (2006) previously reported that plants demand and uptake rate for fertilizer is determined by their physiological needs.

The leaf tissues recorded its highest N contents at 60 Kg N ha^{-1}, which suggests that leaf N demand for photosynthesis which translated to higher yield might have been fulfilled at this rate. It was also observed that the grain had highest N uptake and tissue contents at higher nitrogen rate of 90 Kg N ha^{-1} which translated to higher grain yield by fixing of the materials during grain filling. Report from Aishatu (2015) indicated that grain nutrient content contributed largely to grain yield. Furthermore, Turner *et al.* (2000) previously hinted that yield stability of grain crops depends on its ability to incorporate and fix translocated carbon to its embryo or endosperm. The highest value recorded in 1000-grain weight with 60 Kg N ha^{-1} might not be unconnected to the above reasons discussed in grain yield parameter, especially as carbon fixation processes would influence grain filling; besides, nitrogen compounds have been reported to play key role in grain filling activities (Mohapatra *et al.*, 2000).

The shoot and grain N contents out-valued those of lower plant part herein due to the fact that the second N dose was administered at peak growth phase when production of new tissues have ceased and marked by possible diversion of applied N for grain development (Moll *et al.*, 1994). Total N uptake by plants was evaluated as 44.95% of the applied N in this study, which implies that N loss was higher (55.05%). The loss recorded may be due to larger pores between the sandy soils of Maiduguri, the experimental location, or due to mid-rainy season drought, a condition which is rife in Nigeria’s savanna agroecology with its attendant consequences such as low plant nutrient uptake which leaves larger part of applied N as immobilized or residual N in soil. Report form Javadi *et al.* (1991) indicated that permeability of cell membrane in plants could be reduced due to soil and ontological factors which adversely interfere with nutrient uptake.

CONCLUSION

In conclusion, it is noteworthy herein, that 90 Kg N ha^{-1} increased grain N-content and grain yield which clearly shows that the grain N-uptake by plants contributed to partitionable materials that are needed to fulfil the physiological requirements which finally translated to grain yield.

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