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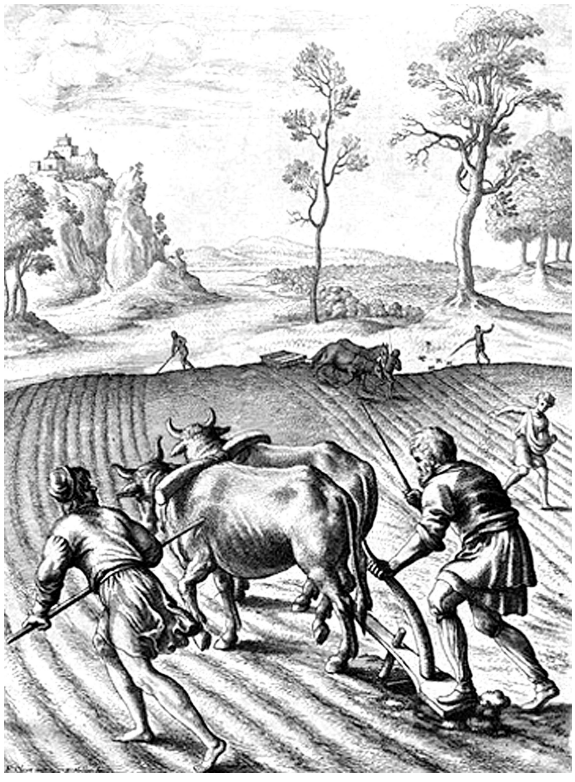

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Effect of Boron Fertilizer on Yield and Oil Content of Three Sunflower Cultivars in the Nigerian Savanna

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Abstract: Boron deficiency is prevalent in soils with low activity clay. This study was carried out to determine the response of three cultivars of sunflower (*Helianthus annuus* L.)-Record, Isaanka and Funtua to boron fertilizer. Four levels of boron-0, 4, 8 and 12 kg B ha^{-1} were applied and the experimental design was randomized complete block with 3 replications. Results obtained showed that there were cultivar differences in response to boron fertilizer. Record variety recorded the highest plant height at 8 kg B ha^{-1} while Funtua have the highest seed yield at 4 kg B ha^{-1}. The highest percentage oil content was recorded by Isaanka variety. Toxicity symptoms and reduction in yield were observed at the highest level B (12 kg B ha^{-1}) in all the varieties. Percentage oil content correlated with capitulum diameter and seed yield. Regression analysis also revealed that the optimum B rate for the three cultivars and four years of trial for the various parameters determined ranged from 5.60-8.40 kg B ha^{-1}.

Key words: Sunflower, cultivars, boron, capitulum diameter, Savanna

INTRODUCTION

Boron (B) is an important element for the growth and yield of many crops. The problem of B deficiency in Northern Nigerian savanna soils was identified through field trials (Heathcote, 1973; Lombin, 1985a). Also, as part of a global study on soil micronutrient status, Sillampaa (1982) reported generally low to deficient levels of boron from Nigeria savanna soils. Crop response to application of B has been documented (Heathcote and Smithson, 1974; Lombin, 1985b). Boron deficiency symptoms first become evident on the younger leaves which have a bronze colour and become hardened, malformed and necrotic. The capitulum is often malformed with poor seed set (Blamey, 1976; Blamey *et al*., 1987).

Although boron is essential for crop growth, the amount required depends on the type of crop. The range of proper application is rather narrow and its harmful effect can be induced by excessive application (Gupta, 1993). Yield and yield components of crops were affected positively and negatively by boron, depending upon soil status and the doses used (Gupta, 1993; Oyinlola *et al*., 1996; Marschner, 1995). Large increases in seed yield have been reported in response to the application of B fertilizer on soils low in B (Blamey *et al*., 1997).

The functions of B in the plant have been associated with water relations, sugar translocation, cation and anion absorption, pollen viability and the metabolism of N, P carbohydrates and fats (Stiles, 1961; Shkol'nik and Kopmane, 1970). Sunflower is the third most important oil crop after soyabean and oil palm. The seed yield and oil content are important parameters in sunflower because sunflower oil is a good source of vegetable oil, for cooking and manufacture of margarine. Also the extracted oil could be used in the manufacture of paints, soaps and cosmetics.

Sunflower has been found to be particularly sensitive to B deficiency and is used as an indicator crop for assessing available B in soils (Miljkovic *et al*., 1966; Tisdale *et al*., 1985). Boron requirement of sunflower in Northern Nigerian savanna soils has not been well documented. The objectives of the study were (1) To evaluate the response of three cultivars of sunflower (Record, Isaanka and Funtua) to boron fertilizer, (2) To evaluate the optimum B rates for sunflower under field condition (3) To determine the effect of B rates on the oil content of sunflower.

MATERIALS AND METHODS

Field trials were conducted during the cropping seasons of 1999, 2000, 2001 and 2002 at the Institute for Agricultural Research experimental farm, Samaru (11°11'N, 7°38'E, alt. 686 m), in the Northern Guinea savanna of Nigeria. Soils of the experimental farm in Samaru had previously been classified as Typic Haplustulf in the USDA System or Orthic Acrisol in the FAO System (Valette and Ibanga, 1984). The Samaru soil was also classified according to the USDA Soil Classification

Table 1: Physico-chemical properties of the soil of experimental site

Soil properties	1999	2000	2001	2002
pH (H_2O) 1:2.5	5.20	5.50	5.40	5.60
pH $CaCl_2$ 1:2.5	5.00	5.10	5.10	5.30
Organic carbon g kg^{-1}	7.60	6.80	6.40	7.20
Total nitrogen (g kg^{-1})	0.49	0.59	0.43	0.50
Available P (mg kg^{-1})	7.10	8.60	6.65	5.89
Exchangeable bases (cmol(±)kg^{-1})				
Ca	2.19	2.62	2.65	1.73
Mg	0.61	0.74	0.91	0.65
Na	0.17	0.24	0.25	0.12
K	0.15	0.18	0.23	0.10
CEC	5.52	5.70	5.22	4.78
Micronutrients (mg kg^{-1})				
Available B	0.09	0.13	0.17	0.10
" Cu	1.88	1.75	3.00	3.60
" Zn	3.00	2.40	2.10	3.20
" Mn	7.06	9.10	6.00	7.40
" Fe	14.40	15.30	11.00	12.50
Mechanical analysis (g kg^{-1})				
Sand	36.00	32.00	53.00	27.00
Silt	48.00	50.00	36.00	46.00
Clay	16.00	18.00	11.00	27.00
Textural class	Loam	Loam	Sandy loam	Loam

System as Alfisol (Harpstead, 1973; IAR, 1987). Details of the physico-chemical analysis of the soils are presented in Table 1.

Three promising cultivars of sunflower-Record, Isaanka and Funtua were used for the trials, four rates of boron were used-0, 4, 8 and 12 kg B ha^{-1}. Each plot area was 9 m^2 with 3 replications in a randomized complete block arrangement. The amount of nutrient applied was 120 kg N ha^{-1}, 45 kg P_2O_5 ha^{-1} and 45 kg K_2O ha^{-1}. Nitrogen was applied in 2 split doses. The boron fertilizer (Borax) was mixed thoroughly with NPK and applied at 4 weeks after planting. Hoe weeding was done for weed control.

The parameters taken were plant height, capitulum diameter and seed weight. The percentage oil contents were also determined (AOAC, 1975)

RESULTS AND DISCUSSION

Statistical analysis: The data collected were subjected to analysis of variance (ANOVA) and differences between means were evaluated using SE Simple correlation analysis was also carried out to show the relationship between the parameters determined. Also regression analysis (quadratic) was done to determine the optima B rates for sunflower cultivars.

Soil Properties: The result of physical and chemical properties of the soils of the trial sites are presented in Table 1. The soils ranged from sandy loam to loam. The soils were slightly acidic, low in organic carbon, total N, available P, CEC and available B. These values fall within the low fertility classes suggested for soils of Northern Nigeria (Enwezor *et al*., 1990). It is expected that crop will respond to additions of these nutrients in the soil.

Effect of treatment on plant height: Plant height was taken fortnightly starting from two weeks to eight weeks after sowing. The data taken for plant height are shown in Fig. 1 and 2. Boron application increased the plant height of sunflower. There was gradual increase in the height of plant with increase in age. Plant height was not significant at the early growing stages in some of the trials, but it was significant in all the four-year trials at 8 weeks. Plant height increased up to 8 kg B ha^{-1} after which there was a decline in the plant height with further increase in B rates. Similarly, Oyinlola *et al*. (1996) obtained increase in plant height of sunflower up to 4 mg kg^{-1} B in a green house study conducted but got decline in plant height at high levels of B.

The increasing trend in plant height observed in all cultivars was attributed to the positive effect of lower rates of B applied, which was sufficient to correct the initial deficiency level of B in the soil. However, with subsequent increase in the level of the element in the soil, toxic conditions began to set in, thereby exerting adverse effect on plant metabolic activities which consequently affect plant height negatively. However Record cultivars recorded the highest plant height of 222 cm at 4 kg B ha^{-1} in 2000 trial. Whereas Isaanka and Funtua cultivars recorded highest plant height of 179 and 198 cm respectively in 2000 trial at 8 kg B ha^{-1} (Fig. 1b).

Capitulum Diameter (CD): The capitulum diameter which is also the diameter of the flower head increased with increase in rates of B up to 8 kg B ha^{-1} (Table 2 and 3). The increase was statistically significant in 1999 and 2001 trials. In 1999 and 2000, record cultivar treated with 4 and 8 kg B ha^{-1}, respectively gave the highest CD of 20 cm (Table 2). Whereas Isaanka and Funtua recorded their highest CD of 19.3 and 20 cm at 8 kg B ha^{-1} respectively in the year 2000. In a similar study conducted for 56 days in the greenhouse. Oyinlola *et al*. (1996) had earlier reported the highest CD of 5.8 cm for Isaanka variety at 2 mg kg^{-1} B.

Seed yield: Seed yield increased with the application of B up to 8 kg B ha^{-1}. Application of 12 kg B ha^{-1} resulted in no further benefit, but tended to decrease seed yield in comparison with 8 kg B ha^{-1} (Table 2 and 3). This could be due to toxic effect as a result of excess B. In 1999, the highest seed yield of 1400 kg ha^{-1} was obtained at 4 kg B ha^{-1} from Record cultivar, while seed yield of

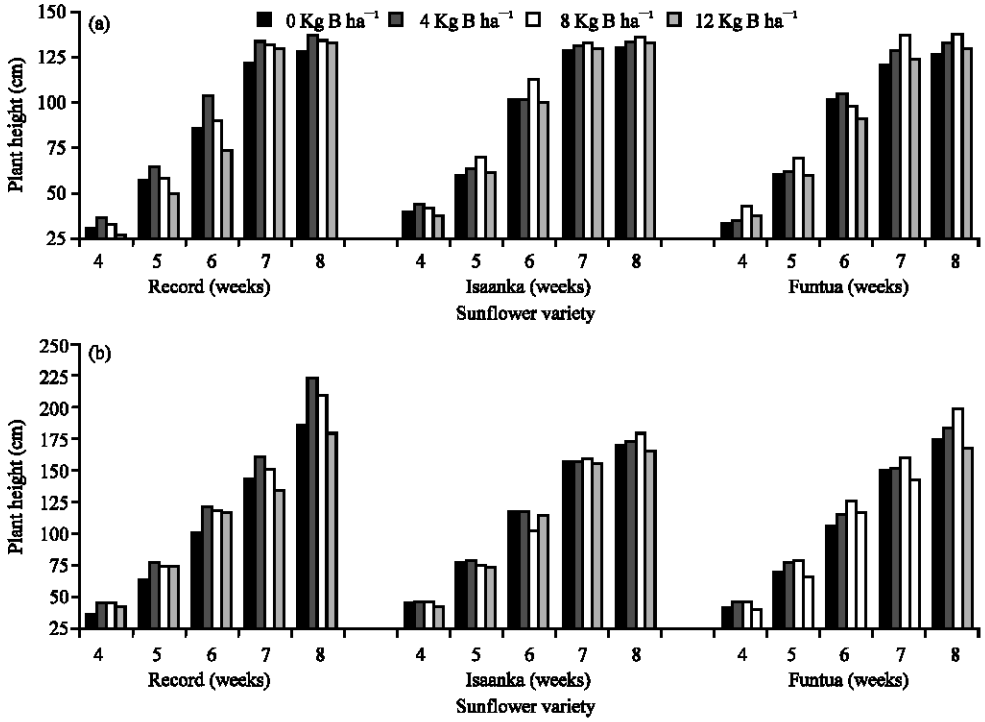

Fig. 1: Effect of Boron (B) fertilizer on plant height of sunflower during (a) 1999 and (b) 2000 cropping seasons

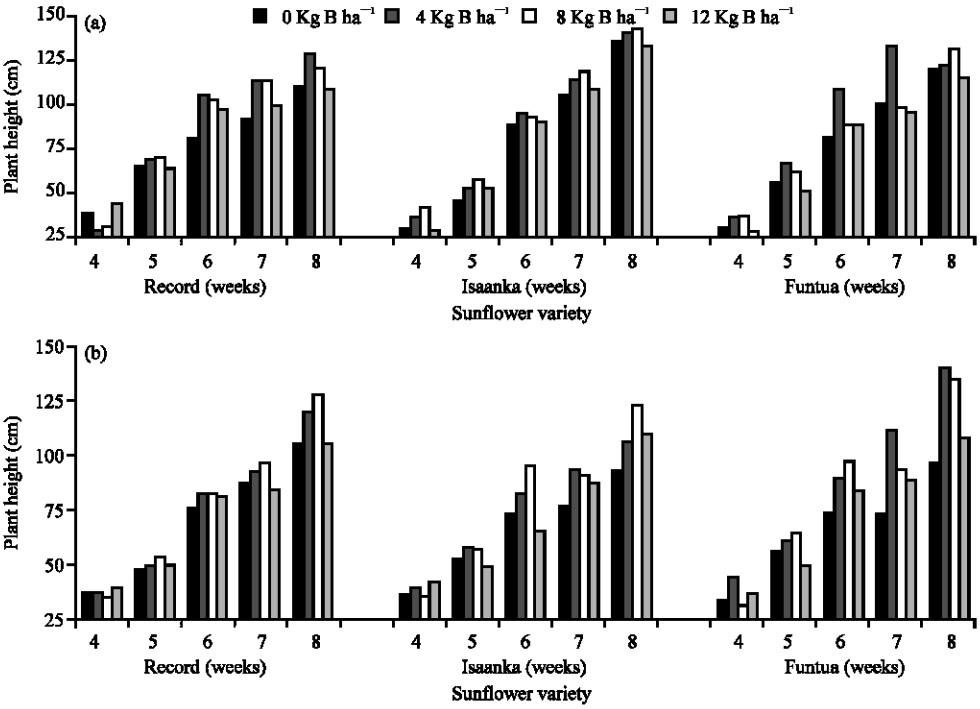

Fig. 2: Effect of Boron (B) fertilizer on plant height of sunflower during (a) 2001 and (b) 2002 cropping seasons

2667 kg ha^{-1} was obtained in 2000 at 4 kg B ha^{-1} from Funtua cultivars. High seed yield of 1360 and 1333 kg ha^{-1} were obtained at 8 kg B ha^{-1} from record and Funtua cultivars in 2001 and 2002, respectively. The result of

Table 2: Effect of Boron fertilizer on three varieties of sunflower in 1999 and 2000

		1999			2000		
Treatments kg B ha^{-1}	Variety	Capitulum diameter (cm)	Seed yield (kg ha^{-1})	Oil content (%)	Capitulum diameter (cm)	Seed yield (kg ha^{-1})	Oil content (%)
0	Record	15.00	1066.0	50.00	16.3	1781	45.00
4		20.00	1400.0	55.00	17.0	2333	57.00
8		19.00	1178.0	54.00	20.0	2445	60.00
12		18.00	1144.0	49.00	18.0	2110	50.00
0	Isaanka	14.00	1179.0	52.00	17.0	1888	55.30
4		16.00	1255.0	57.00	18.3	2221	57.00
8		18.00	1311.0	58.00	19.3	2222	66.00
12		15.00	1289.0	52.00	18.0	1780	54.00
0	Funtua	13.00	1079.0	48.00	19.3	2000	50.30
4		15.00	1180.0	54.00	18.0	2667	60.00
8		16.00	1367.0	58.00	20.0	2333	59.00
12		15.00	1255.0	50.00	17.0	2223	57.20
SE (0.05)		0.46**	26.9*	0.56**	NS	NS	0.55**

* 5% level of significant, ** 1% level of significant

Table 3: Effect of Boron fertilizer on three varieties of sunflower in 2001 and 2002

		2001			2002		
Treatments kg B ha^{-1}	Variety	Capitulum diameter (cm)	Seed yield (kg ha^{-1})	Oil content (%)	Capitulum diameter (cm)	Seed yield (kg ha^{-1})	Oil content (%)
0	Record	10.0	910	51.2	8.2	1000	54.60
4		12.0	1253	54.4	9.7	1056	56.40
8		13.0	1360	56.2	10.5	1222	57.00
12		14.0	1073	50.0	9.8	1023	56.00
0	Isaanka	9.0	730	53.2	9.8	889	55.40
4		10.0	933	54.3	11.0	980	56.50
8		11.0	1000	59.2	10.0	1111	57.70
12		12.0	693	50.2	9.0	722	56.00
0	Funtua	8.0	620	52.3	9.8	778	54.40
4		10.0	933	55.1	11.0	1222	56.00
8		12.0	1021	56.0	9.2	1333	57.20
12		12.0	783	51.4	9.2	833	54.60
SE (0.05)		1.9	NS	0.24	NS	NS	0.64

* 5% level of significant, ** 1% level of significant

Table 4: Correlation among the growth and yield parameters

	Plant height	Capitulum diameter	Seed weight	Oil content (%)
Plant height	-			
Capitulum diameter	0.342*	-		
Seed weight	0.662**	0.225	-	
% oil content	0.297	0.357*	0.615**	-

* 5% level of significance, ** 1% level of significance

this study is in line with the report of Blamey (1976) who also got a highly significant increase in the seed yield of sunflower with the application of borax, at 10 kg borax ha^{-1}, but got a decrease in seed yield with the application of 30 kg borax ha^{-1}.

There was significant cultivar difference in seed yield of sunflower with the application of boron, only in 1999.

Percentage oil content: The effect of B rates on the percentage oil content of sunflower was highly significant ($p = 0.01$) in all the years of the trial (Table 2 and 3). The highest percentage oil content of 58.00 and 66.00% was obtained at 8 kg B ha^{-1} in 1999 and 2000, respectively. The increase at 8 kg B ha^{-1} were 13.4 and 23.2% relative to the control in 1999 and 2000, respectively. In 2001 and 2002, Isaanka cultivar produced the highest percentage oil content of 59.2 and 57.7% at 8 kg B ha^{-1}. These gave increase of 11.3 and 5.0% relative to the control, respectively.

The effect of B rates on the oil contents of the three cultivars of sunflower were significant in all the years. Nevertheless, variety Isaanka produced the highest percentage oil content of 58.00 and 66.00% in 1999 and 2000 and 59.2 and 57.7% in 2001 and 2002, respectively.

Correlation analysis: The result of the correlation analysis revealed that plant height and percentage oil content correlated with capitulum diameter and seed weight, as shown in Table 4. Also in 2000 seed weight correlated highly significantly with the plant height at

1st week to 5th week (r = 0.616**, 0.630**, 0.682, 0.670**, 0.662**).

Regression analysis: The regression analysis data shows that all the parameters determined could be used for predicting optimum B rate for sunflower (R^2>70%). The optimum B rate obtained from the various parameters ranged from 5.60 to 8.40 kg B ha^{-1} but because the effect of B on % oil content was significant in all the 4 years trial, therefore, % oil content was used to predict the optimum B rate for sunflower. Using the regression equations and equating each of the derivatives to zero and solving for B (where B = Applied boron rates) will result in the following optimum rates of B for the cultivars.

$Y_1 = 50.09+2.173B-0.172B^2$
$R^2 = 99.23\%$
$B = 6.3$

$Y_2 = 53.35+1.782B-0.146B^2$
$R^2 = 72.33\%$
$B = 6.1$

$Y_3 = 51.21+1.926B-0.145B^2$
$R^2 = 99.26\%$
$B = 6.7$

Y_1, Y_2, Y_3-stand for regression equations for Record, Isaanka and Funtua cultivars, respectively. The optimum rates are 6.3, 6.1 and 6.7 kg B ha^{-1} for Record, Isaanka and Funtua cultivars, respectively.

CONCLUSIONS

Result of this study indicated that, sunflower responded to optimum rates of boron, but at high rate (12 kg B ha^{-1}) there was a sharp drop in parameters determined. From the result of the regression analysis, it could be concluded that the optimum rate of B for sunflower is between 5.60-8.40 kg B ha^{-1}. Record variety recorded the highest plant height, whereas Isaanka variety recorded the highest percentage oil content. Among the years, the highest value of the parameters measured was recorded in 2000.

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