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NITROGEN UP-TAKE BY QUALITY PROTEIN MAIZE (*Zea mays* L.) AS INFLUENCED BY VARIETY AND SULFUR FERTILIZER INTERACTION

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ABSTRACT
Field trials were conducted in 2006, 2007 and 2008 wet seasons, at the Institute for Agricultural Research Farm, Samaru in the Northern Guinea savanna of Nigeria to determine the effect of interaction between maize variety and Sulfur fertilizer on up-take of Nitrogen by QPM maize. Treatments consisted of four (4) rates each of nitrogen (0, 60,120 and 180 kg N/ha) and sulfur fertilizer (0, 5, 10 and 15 kg S/ha) and two QPM varieties (Obatampa and EV – 99), laid out in a split plot design with variety and nitrogen in the main plots and sulfur in the sub plots and replicated three times. The results showed that interaction between variety and sulfur significantly influenced up-take of sulfur in all the three years of the trials. Ear leaf, Flag leaf and Grain laboratory analysis indicated higher N and S content from the interaction between both varieties and 0 kg S/ha. This showed no difference in terms of interaction between QPM maize varieties and sulfur fertilizer with regard to N and S uptake. It can be concluded that interaction between variety and sulfur rate significantly influenced uptake of both N and S.

KEY WORDS: Quality Protein Maize, Variety, Nitrogen, Sulfur and Interaction.

INTRODUCTION

During the 1st millennium AD, maize (*Zea mays* L.) cultivation spread from Mexico to United States and a millennium later into north east and south eastern Canada, transforming the landscape as Native Americans cleared large forest and grassland areas for the new crop (Evan *et al*., 2005). It is unknown what precipitated its domestication because the edible portion of the wild variety is too small and hard to obtain to be eaten directly, as each kernel is enclosed in a very hard bi-valve shell. However, it was demonstrated that the kernels of teosinte are readily "popped" for human consumption like modern popcorn. Some have argued that it would have taken too many generations of selective breeding in order to produce large compressed ears for efficient cultivation. However, studies of the hybrids readily made by intercrossing teosinte and modern maize suggest that this objection is not well founded (Evan *et al*., 2005). Maize belongs to the family graminae, and probably originated from Mexico in Central America (Anon, 1994). The cultivation of maize spread from Mexico, northward to Canada and southward to Argentina (Anon, 1992). Maize is widely cultivated throughout the world, and a greater weight of maize is produced each year than any other grain. The United States produces 40% of the world's harvest; other top producing countries include China, Brazil, Mexico, Indonesia, India, France and Argentina (FAO, 2009). Worldwide production was 817 million tonnes in 2009—more than rice (678 million tonnes) or wheat (682 million tonnes) (FAO, 2009). In 2009, over 159 million hectares of maize were planted worldwide, with a yield of over 5 tonnes/hectare. Production can be significantly higher in certain regions of the world. There is conflicting evidence to support a report by food and agriculture organization (FAO) that maize yield potential has increased over the past few decades (FAO, 2009). United States of America was the highest producer accounting for about half the world's total (43.1%) followed by Asia (32%), Latin America and Caribbean (16.3%). Africa produced 4.1% of the world's total with Nigeria producing 7.53 million tones or 1.1% of the world's figure (FAO, 2009). The world average yield was 4255kg per hectare. Average yield in USA was 8600 kg per hectare, while in Sub-Saharan Africa it was 1316 kg per hectare (Anon, 1992). Maize is one of the most important food crops worldwide and grown between latitude 58^o N and 49^o S of the equator. Varying latitudes have an effect on number of days to flowering and maturity. This is as a result of higher temperatures at lower altitudes, which accelerate growth while the lower prevailing temperatures at higher altitudes retard growth and extend time to mature (Seed Co., 1999). Maize is the most important cereal in the United States occupying double the area of all others crops. Some parts of Africa particularly South Africa, Malawi, Zimbabwe, Kenya, Tanzania, Ghana, Nigeria and Egypt are suitable for growing maize and it is fast replacing traditional staple foodstuffs.

Sulfur requirement and metabolism in plants are closely related to N nutrition (Reuveny *et al*., 1980), and N metabolism is also strongly affected by the S status of the plant (Janzen and Bettany, 1984; Duke and Reisenauer, 1986). A deficiency in S supply has been shown to depress the uptake of nitrate and the activity of nitrate reductase in maize and spinach (Friedrich and Schrader, 1978; Prosser *et al*., 2001), and to result in transient or steady-state nitrate accumulation in maize, wheat, and oilseed rape (McGrath and Zhao, 1996; Gilbert *et al*., 1997). Fismes *et al*. (2000) have shown using field-grown oilseed rape that S deficiency can reduce nitrogen use efficiency (NUE: ratio of harvested N to N fertilization) and that N deficiency can also reduce sulphur use efficiency (SUE). This study was therefore designed to observe whether interaction between maize variety and sulfur rate will affect uptake of N and S by QPM maize.

MATERIALS & METHODS

The study was conducted at the Institute for Agriculture Research (IAR) Farm, Samaru, Zaria (11^o $11^/$ N; 07^o $38^/$ E and 686 meters above sea level), located in the northern Guinea Savanna ecology. The experiment was carried out for three wet seasons, 2006, 2007 and 2008. The treatments consisted of two (2) open pollinated QPM varieties (Obatampa and EV – 99), four rates each of nitrogen (0, 60, 120 and 180 kg N/ha) using urea and sulfur (0, 5, 10, and 15 kg S/ha) using potassium sulfate. The experiment was laid out in split plot design with nitrogen and variety in the main plot and sulfur in the subplot. The experiment was replicated three times, each replication comprised of thirty-two plots. Borders between plots within a replication were separated by one meter spacing and between replications by spacing of 1.5m. Gross plot size was 6 ridges *i.e.* 4.5m by 2.5m, giving an area of 11.25m^2, while net plot size was 4 ridges *i.e.* 3.0m by 1.5m with an area of 4.5m^2. Plots were demarcated after ridging with well-formed borders between plots and replications to minimize nutrient seepage. Sowing was done by hand in the month of June after rainfall has been established to provide moisture for better germination. Two seeds were planted per hole at the spacing of 25cm between holes, and then the seedlings were later thinned to one plant per stand at two weeks after sowing. The nutrients applied were N, P, K and S. However, P and K were equally applied to all the plots while N and S were as the treatment indicated. N was applied in two equal doses, at 3 and 6 weeks after sowing when the whole of P, K, S and half of N were applied at 3 weeks after sowing, then the remaining half of N at 6 weeks after sowing. Weeding was done by hoe to control weeds at 3 and 6 weeks after sowing. This was followed by remolding immediately after the second weeding and at the time of second dose of N fertilizer application. Stem borer infestation was observed, which was controlled by spraying with a broad spectrum insecticide called best Action at the rate of 1 litre per hectare. No disease was observed throughout the period of the trial. Ear and flag leaves from five plants in each plot were collected at 50% tasselling, oven dried and ground into powder using electrical grinder. Grains were also randomly selected from each plot sun dried and ground into powder using electrical grinder. The powder was then sieved using 1mm-mesh sieve and one gram was used for laboratory analysis for N and S. One gram of the sieved sample was digested using sulfuric acid and perchloric acid with copper and sodium sulfate acting as catalysts. The digest was then used to determine N and S content of the leaves and grains. Part of the digest was distilled into boric acid and the distillate was then titrated against a standard hydrochloric acid (HCl) and the percent N and S contents were determined from the titre using Macro – Kjedhal (Bremner, 1965; IITA, 1975).

RESULTS

Ear Leaf S up-take (mg/kg) in 2006

Interaction of Obatanpa variety and 0kg S/ha produced higher ear leaf S content though at par with 5kg S/ha in 2006. When interaction of EV-99 variety was observed, significantly higher S content was given by its interaction with 5kg S/ha than the other sulfur rates which were statistically similar.

Ear Leaf S up-take (mg/kg) in 2007

Variety and Sulfur interaction in 2007 revealed that interaction of Obatanpa variety and 10kg S/ha produced significantly higher ear leaf S content than the other Sulfur rates which were statistically similar. While the interaction of EV-99 variety with 10kg S/ha produced significantly lower ear leaf S content than the other sulfur rates which were statistically similar.

Flag Leaf S up-take (mg/litre) in 2007

Laboratory tissue analysis revealed that interaction of Obatanpa variety and 0kg S/ha produced significantly higher flag leaf S content than its interaction with other Sulfur rates which were statistically similar. Whereas significantly lower flag leaf S content was produced by the interaction of EV-99 variety and 5kg S/ha than its interaction with other rates which were statistically similar.

Flag Leaf S up-take (mg/kg) in 2008

Analysis of flag leaf S content in 2008 revealed that both varieties (Obatanpa and EV-99) produced statistically similar flag leaf S content from their interaction with all the Sulfur rates except the interaction of Obatanpa variety and 5kg S/ha which produced lower flag leaf S content.

Flag Leaf N up-take (g/kg) in 2006

Interaction of Obatanpa variety and 10kg S/ha produced higher flag leaf N content in 2006, but statistically at par with its interaction with 0kg S/ha and 5kg S/ha. Nitrogen content of flag leaf in 2006 was not affected by the interaction of EV-99 variety and all the Sulfur rates.

Flag Leaf N up-take (g/kg) in 2008

Interaction of Obatanpa variety with 10 and 15kg S/ha produced similar but significantly higher flag leaf N content than its interaction with other S rates which were statistically similar. Higher flag leaf N content was observed when EV-99 variety interacted with 0kg S/ha than the other S rates though at par with its interaction with 5kg S/ha.

Ear Leaf N up-take (g/kg) in 2008

Uptake of N was not affected by interaction between Obatanpa variety in 2008, whereas variety and sulfur fertilizer interaction influenced uptake of N fertilizer by EV-99 variety where its interaction with 0kg S/ha and 5kg S/ha significantly enhanced higher N uptake than 10kg S/ha and 15kg S/ha which were statistically similar.

TABLE 1: Interaction of Variety and Sulfur fertilizers on Tissue N & S content

Treatment	**0kg S/ha**	**5kg S/ha**	**10kg S/ha**	**15kg S/ha**	**0kg S/ha**	**5kg S/ha**	**10kg S/ha**	**15kg S/ha**
	Ear Leaf S up-take (mg/kg) in 2006				**Ear Leaf S up-take (mg/kg) in 2007**			
Obatampa (V1)	696.25 a	451.25 abc	397.5 bc	397.5 bc	173.5863 b	201.57 b	292.4475 a	216.9925 b
EV – 99 (V2)	316.25 cd	557.5 ab	152.5 d	272.5 cd	300.0175 a	335.8388 a	203.6888 b	290.64 a
S.E.±	57.1436				19.446			
	Flag Leaf S up-take (mg/litre) in 2007				**Flag Leaf S up-take (mg/kg) in 2008**			
Obatampa (V1)	292.7575 a	201.9113 bc	171.725 c	169.9063 c	18112.5 a	17350 b	18037.5 ab	18175 a
EV – 99 (V2)	237.7125 b	149.0625 c	235.9 b	226.3913 b	18037.5 ab	18512.5 a	18037.5 ab	17912.5 ab
S.E.±	16.916				222.73			
	Flag Leaf N up-take (g/kg) in 2006				**Flag Leaf N up-take (g/kg) in 2008**			
Obatampa (V1)	18.66875 abc	18.7875 abc	20.13875 a	17.56875 bc	20.41875 bc	19.42 c	23.11375 a	22.6025 a
EV – 99 (V2)	18.96875 abc	18.57125 abc	16.9425 c	18.8225 abc	21.9325 ab	20.1 bc	19.52625 c	18.7375 c
S.E.±	0.5927				0.7198			
	Ear Leaf N up-take (g/kg) in 2008				**Maize Grain S up-take (mg/kg) in 2006**			
Obatampa (V1)	17.3175 b	15.82 b	16.1675 b	17.735 ab	900 b	875 b	962.5 b	750 c
EV – 99 (V2)	19.2075 a	19.24875 a	16.95625 b	17.01375 b	975 b	937.5 b	950 b	1087.5 a
S.E.±	0.6046				38.046			
	Maize Grain S up-take (mg/kg) in 2007							
Obatampa (V1)	850.2338 d	1000.324 bc	1100.146 ab	937.7725 cd				
EV – 99 (V2)	1037.653 abc	1112.698 a	1025.198 abc	937.6538 cd				
S.E.±	33.385							

Means followed by the same letter(s) within a treatment group are not significantly different at 5 percent level of significance using DMRT

Maize Grain S up-take (mg/kg) in 2006

Variety and sulfur fertilizer interaction significantly influenced maize grain S content in 2006. Interaction between Obatanpa variety and sulfur fertilizer rate of 15kg S/ha significantly produced higher maize grain S content than its interaction with other S rates which were statistically similar. However, Interaction of EV-99 variety with 15kg S/ha produced significantly higher maize grain S content than other S rates which were statistically similar.

Maize Grain S up-take (mg/kg) in 2007

Interaction of Obatanpa variety and sulfur rate of 10kg S/ha produced higher maize grain S content in 2007 though at par with its interaction with 5kg S/ha. When EV-99 interacted with 5kg S/ha higher maize grain S content was produced though at par with its interaction with 0kg S/ha, and 10kg S/ha.

DISCUSSION

Effect of interaction between maize variety and sulfur fertilizer on ear leaf, flag leaf and maize grain nitrogen and sulfur content was shown to be inconsistent; meaning higher uptake of these nutrients varies between different interactions and years of the trial (Table 1). This is an indication that among the various factors affecting nutrient uptake, interaction between variety and sulfur rate has little influence. This was supported by a report by Clain Jones **(**2011) that all plants require the same mineral elements; however, the quantity, rate and timing of uptake vary with crop, variety, climate, soil characteristics and management. These combined factors influence the nutritional need, nutrient content, and overall yield of a crop. Even though this interaction was shown to be significant from the analysis of variance (ANOVA) tables, but effect of the various interactions for each variety and different sulfur rates have weak influence on uptake of N and S nutrients. This could be due to the fact that uptake of nutrient does not depends on variety of a crop alone but combination of factors. When the two varieties were compared Obatanpa variety showed better uptake of S than EV-99 variety. This was agreed with earlier report by Grant and Rowell (1976, 1978) in a work concluded in Zimbabwe that S uptake was dependent on site and variety grown. All nutrient uptake rates are dependent on the specific interactions of hybrids with their environment and management factors like plant density and soil nutrient availability (Vyn and Ciampitti, 2014).

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