THE ROLE OF SILICA AND NITROGEN IN RESISTANCE OF MAIZE TO STEM BORER ATTACK

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ABSTRACT

The silica and nitrogen contents of the dry weights of five maize varieties Obaatanpa, Abeleehi, Okomasa, Ewifompe and Abutui were determined using the gravimetric method and Kjedahl's method respectively to determine how these affect the level of stemborer infestation in maize. The experiment was conducted in the major and minor planting seasons. In the minor season, the silica content of the stem ranged from 0.44% dry weight in Obaatanpa to 0.53% in Abutui. The differences were statistically not significant ($P > 0.05$). Higher percent silica was recorded for the different maize varieties in the major season. This ranged from 1.19% in Aheleehi to 1.58% in Abutui. The differences in the percent silica was statistically not significant ($P > 0.05$). There was a high negative correlation between the percent silica and the number of infested plants as well as the number of larvae/pupae per infested plant. In the minor season the introgen content ranged from 0.30% in Abutui to 0.68% in Ewifompe whilst in the major season it ranged from 0.40% in Abutui to 0.90% in Ewifompe. Stem borer infestation appeared to correlate with nitrogen content of the stem.

Key words: *Maize, silica content, nitrogen content, stem borer damage*

INTRODUCTION

Maize, *Zea mays* (L.) is attacked by a number of pests both on the field and in storage. Across Africa, the most important field pests of maize plants are a complex of lepidopterous stem and cob borers belonging to the families Noctuidae, Pyralidae (Appert, 1970; Harris, 1968; Atkinson, 1980; van Rensberg, *et al.*, 1978) Crambidae and Tortricidae. However, the stemborers are more important as pests of maize than the cob borers. This is because stem borers cause more devastating damage to maize plants than the cob borers. Five stemborer species are known to cause significant yield losses in maize. These are the noctuid moths *Busseola fusca* (Fuller), *Sesamia nonagrioides botanephaga* (Tams and Bowden) and the pink stalk borer *Sesamia calamistis* (Hampson), the pyralid *Eldana saccharina* (Walker) and the crambid *Chilo alenielius* (Strand).

The development of phytophagous insects often depends on the physical conditions of the plant. The mineral contents of the soil influences the health and therefore the quality of plants as food for herbivorous insects, the extent of feeding and hence the level of damage caused to the plants. Plants grown on soil containing all the nutrients necessary for plant growth often influences the longevity, fecundity and damage caused by insect pests (National Academy of Sciences, 1969). Taylor *et al.*, (1952) recorded a higher survival and growth rates of the European cornborer *Ostrinia nubilalis* (Hübner) reared on maize plants growing on complete nutrient diet than on NPK stressed plants. The resistance status of different plants to an insect pest is determined by its suitability to sustain the population of the insect pest. Several features of the Gramineae make them relatively difficult to chew and silica content of the plant is one of these features (Bernays and Berbehenn, 1987). Silica increases the hardness of plant tissues and interferes with larval boring and feeding (Djamin and Pathak, 1967). Other effects of silica on borers

such as small body size and slower rate of growth have been reported for *Chilo suppressalis* feeding on rice plants (Ukwungwu and Odebiyi 1985; Ukwungwu, 1990).

The use of fertilizers to enhance plant nutrition often enhances the longevity, fecundity and damage caused by insects (National Academy of Sciences, 1969). Cannon and Ortega (1969) related nitrogen fertilizer to borer survival on corn.

The objective of the study was to assess the levels of silica and nitrogen contents of the stems of five maize varieties and how these influence the level of stem borer infestation.

MATERIALS AND METHODS

Five maize varieties, Obaatanpa, Abeleehi, Okomasa, Ewifompe and Abutui were planted as monocrops. Obaatanpa, Abeleehi and Okomasa were chosen because they are improved varieties, with high yields and of better nutritional qualities. Ewifompe and Abutui on the other hand store better. Some farmers therefore prefer them to the improved varieties. Each plot measured 3m x 3m, with five rows 75cm apart and 30cm between the maize stands with a total of 50 hills per plot. There were five replicates for each maize variety. The experiment was therefore arranged in a Latin square design. Fertilizer was not applied to any of the treatments. After germination, each plant on each plot was carefully examined fortnightly for signs of stem borer attack such as frass, "deadhearts" and exit holes. The number of plants showing "deadhearts" in each variety were noted and the means calculated. Frass was looked out for two weeks after germination and exit holes were looked for 8 weeks after germination. At harvest (14 weeks after emergence, (WAE) the total number of plants infested by stem borers for each variety was noted by counting. The mean number of larvae/pupae per infested plant were also calculated for each variety. Data were collected in both the major and minor seasons.

The stem of each maize variety was analysed for silica and nitrogen content 42 days after germination. Pieces of maize stem were cut from five plants randomly selected from each plot of each of the maize varieties, put into labelled envelopes and dried in an oven at 80°C for 48 hrs. Percentage nitrogen content of the stem pieces was determined using Kjedahl's method. Silica content analyses were done using the Gravimetric method. Correlation coefficients were calculated to establish the relationship between the percent silica and nitrogen content of the stem and the levels of stem borer infestation.

RESULTS AND DISCUSSION

The stem borer species that attacked the maize plants during the study period were *Sesamia calamistis* , *S. nonagrioides botanephaga Eldana saccharina and Chilo aleniellus*. The abundance of each species depended on the season in which maize was sown and the weather conditions prevailing during the growth of the plant. With the exception of *C. aleniellus*, all the stem borer species attacked the maize plants during both the major and minor planting seasons. *C. aleniellus* however attacked the maize plants only during the season major planting season.

Stem silica content

The silica content of the maize stem in all the varieties were lower in the minor than in the major planting season. In the minor season, percent silica ranged from 0.44 in Obaatanpa to 0.53 in Abutui but the differences were statistically not significant ($P > 0.05$). In the major season, even though the silica content of the maize varieties were relatively greater than those of the minor season, (Tables 1 and 2) the differences were statistically not significant ($F = 1.67$; $P > 0.05$). Maize varieties that contained greater amounts of silica recorded lower stem borer infestations. There was a high negative correlation between percent silica and the number of plants infested with stem borers in the different maize varieties ($r = -0.84$). It is therefore apparent that if there is a large stem silica content it will render the plant less susceptible to the stem borers leading to a reduction in attack. The percent infested plants and the number of living larvae per stem were positively correlated ($r = 0.89$) implying that the larger the number of living larvae, the greater the percent deadhearts.

The variation in the silica content between the major and minor seasons could be due to the different growing conditions of the plant in the two seasons.

In the major season, because of the abundance of water available to the plants they were better able to absorb the mineral resources in the soil. However,in the minor season, because of limited water, the maize plants could not absorb the available minerals, including silica from the soil. Although the difference in stem silica was not significant, it must be emphasised that differences in stem silica however small, can influence the level of stem borer attack. Abutui, which recorded the largest stem silica content in both planting seasons also recorded the least percent infested plants (Tables 1and 2). Maize varieties that contained lower percent stem silica had relatively larger numbers of infested plants. At harvest, in the minor season, Ewifompe, with the least percent silica, harboured a mean of 2.6 larvae/pupae per infested plant whilst Abutui, with the largest stem silica recorded half the infestation of Ewifompe. In the major season, at harvest, Ewifompe contained 2.1 larvae/pupae per infested plant whilst Abelechi contained only a third of that infestation.

High stem silica may have negatively affected larval penetration and as a result reduced infestation in the maize varieties with high silica content. The silica content of plants has been considered to impart resistance to pests and diseases. Sasamoto (1961) recorded an increase in total percentage silica in rice plants grown in a soil treated with silica gel and a decrease in rice borer susceptibility. High silica content has been found to interfere with larval feeding. Djamin and Pathak (1967) observed that the mandibles of larvae feeding on rice varieties with high silica content were severely worn, whereas those of larvae feeding on low silica varieties were normal.

Table 1. Nitrogen and silica content of maize stem and the level of stem borer infestation in the minor season, Cape Coast, 1994.

Maize Variety	% Silica	% Nitrogen	% Plants Infested
Obaatanpa	0.44	0.61	36.8
Okomasa	0.47	0.52	27.0
Abelechi	0.48	0.55	37.2
Ewifompe	0.45	0.65	50.2
Abutui	0.53	0.30	20.8

Table 2. Nitrogen and silica content of maize stem and the level of stem borer infestation in the major season, Cape Coast,1995.

Maize Variety	% Silica	% Nitrogen	% Plant Infested
Obaatanpa	1.49	0.82	20.5
Okomasa	1.28	0.77	20.5
Abelechi	1.19	0.59	15.3
Ewifompe	1.21	0.90	23.0
Abutui	1.58	0.40	13.5

Percent nitrogen

In the minor season the nitrogen content of the maize varieties ranged from 0.30% in Abutui to 0.90% in Ewifompe (Table 1). The difference in nitrogen content was statistically not significant ($F = 3.0$; $P > 0.05$). In the major season, relatively greater nitrogen contents were recorded for all the maize varieties compared with the minor season. This ranged from 0.40% in Abutui to 0.90% in Ewifompe (Table 2). Statistically the difference was significant ($F = 5.0$; $P<0.05$). The greater nitrogen content of the stem of Ewifompe and Obaatanpa resulted in the greater stem borer infestation in these varieties. Similarly, Abutui, which had the least percentage nitrogen in both seasons, also suffered the least infestation in both seasons (Tables 1 and 2). There was a positive correlation between percentage nitrogen and percent infested plant ($r = 0.80$). These results indicate that higher nitrogen and for that matter, higher protein contents of maize plants positively influences the level of stem borer infestation.

The greater nitrogen content increased the nutritional quality of the plant making it more attractive for stem borer attack. Singh and Singh (1969) reported similar results for *Chilo partellus* feeding on maize plants fertilized with nitrogen fertilizer. Higher nitrogen levels lead to the tilting of the balance of C/N (Carbon/Nitrogen) in favour of nitrogen. As a result a greater nitrogen supply may increase protein production and decrease the carbohydrate content, resulting in the formation of thin cells and softer more succulent tissues which make the plant more acceptable to insect attack and feeding. The addition of nitrogen – containing fertilizer creates a healthier plant and increased leaf area to receive an increased stem borer population and oviposition.

CONCLUSION

Stem borer attack on maize is a serious drawback to increased maize production in Africa and a higher silica content of the plant can reduce stem borer populations. However, from the present study it looks as if for silica to play a significant role in the control of stem borers, there must be a relatively higher percentage of it in the plant than obtained from the different maize varieties.

It was evident that higher nitrogen levels lead to an increase in stem borer infestation. The increased use of nitrogen containing fertilizer to improve maize production would as a consequence lead to an increased stem borer attack. High stem silica coupled with reduced use of nitrogen fertilizer could reduce stem borer attack.

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