Journal of Academia and Industrial Research (JAIR)
Volume 3, Issue 11 April 2015

ISSN: 2278-5213

RESEARCH ARTICLE

Effects of Improved Fallow with Tephrosia on Lepidopterous Borer Attacks on Maize and Yield Parameters in a Mid Altitude Area of North West Cameroon

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Abstract

Field trials were run in Njinikom (North West Cameroon) during the second planting season of 2005 and first planting season of 2006, to investigate the effects of rotating maize with Tephrosia on the infestation by borers on maize yield parameters. A continuous maize production system was compared with crop sequence system in which maize followed Tephrosia or a natural bush fallow. The experimental design used was randomized complete block with 8 treatments i.e. four maize, with two receiving fertilizer (NPK and Urea); two Tephrosia; and two bush fallow. In one of each pair of treatments, the insecticide carbofuran was applied. In both seasons, plots with fertilizer had the highest number of borers. There were significant differences between treatments for basal stem diameter and total plant height during both seasons. In the first season of 2006, plots with fertilizers had the tallest and biggest plants for the no insecticide group while for the insecticide group, the Tephrosia/maize plots and plots with fertilizer had the tallest and biggest plants. No significant treatment differences were observed for stem tunneling and cob damage in both seasons. Furthermore, in the first season of 2006, for the no insecticide group, plots with fertilizer had the biggest cobs while for the insecticide group, cobs from the Tephrosia/maize plots were biggest.

Keywords: Maize, Tephrosia, Lepidopterous borers, yield parameters, insecticide, plant height.

Introduction

According to estimate, traditional sector in the whole of Cameroon, produced a total of 466,000 tons in 1990-1991; the North West region of Cameroon accounting for about 45% of this (Ayuk-Takem and Atayi, 1991). Maize is increasingly gaining importance as cash crop following the large decrease in price of some cash crop such as coffee. Many farmers in Cameroon in general and the North West region in particular, now diversify their crop production because of the new trend in market forces as a result of local demand for maize to satisfy the need of the growing urban population, animal feed mills and other maize processing industries (Ndemah, 1999; Neba, 2006). This relative new trend has also been encouraged by large scale buyers such as MAISCAM (Maiseries du Cameroun), SCTM (Societe Camerounaise de Transformation de Cereal) etc. (Conte and Fussillier, 1993). Furthermore, in Cameroon, maize has a wide range of uses namely: in the fresh state, it can be roasted and boiled; in the dry state (about 15% of water), the grains can be ground to produce flour that can use for the production of ''fufu'', for the production of pap for children and also biscuits. For a typical man from the North West region of Cameroon, will generally not hesitate to admit that he feels he has not eaten at all if he has not had a Maize meal at least once a day. Industrially, the grains of dry maize can be used for the production of beer and starch (Ndemah, 1999; Aroga, 2007).

The decline in soil fertility has been described as a major constraint to maize production in the North West Region of Cameroon. A large proportion of soils in the region present a variety of constraints to maize production such as nutrient deficiency, low soil organic matter and high erosion potentials since the North West region of Cameroon is an upland area (Ndemah, 1999). The input of soil nutrients through fertilizers by smallholder farmers in the North West region of Cameroon has resulted to mining of agricultural soils; most of the fertilizers used are nitrate based that leads to rapid acidification of soil and hence, a drastic decline in soil fertility (Ndemah, 1999). Agroforestry practices such as rotating maize with shrub like nitrogen fixation plants such as Tephrosia can be seen as an alternative to the used of fertilizers, especially in sub-Saharan Africa and the North West region of Cameroon in particular where fertilizers are not always available and when available, the cost usually limit their use by smallholder farmers (Barrios *et al.*, 1998). Furthermore, in addition to soil fertility problems, another constraint to maize production in the region is the problems of pest with the Lepidopterous stem and ear borers being the most problematic (Cardwell *et al.*, 1997; Schulthess *et al.*, 1997; Ndemah, 1999; Borgemeister, 2002; Aroga, 2007). Lepidopteran larvae feed on the aboveground parts of the maize causing economically important yield losses to the crops.

Table 1. Treatments per block.

Treatments	Description	Code
1	Maize followed by maize and treated with carbofuran	MMI
2	Maize followed by maize without insecticide (carbofuran)	MM
3	Maize followed by maize and treated with carbofuran and fertilization	MMI-NPK-N
4	Maize followed by maize without carbofuran and with fertilization	MM-NPK-N
5	Tephrosia followed by maize and treated with carbofuran	TMI
6	Tephrosia followed by maize and without carbofuran	TM
7	Bush fallow followed by maize and treated with carbofuran	BfaMI
8	Bush fallow followed by maize and without carbofuran	BfaM

Feeding and tunneling by Lepidopterous larvae can result in the destruction of the growing point (resulting in dead hearts), interference with nutrients and metabolite translocation, resulting in the malformation of grains, stem breakage, plant stunting and direct damage to ears (Unnithan, 1987; Harris and Nwanze, 1992; Kfir *et al.,* 2002). Tunneling in host plant can predispose host plant to infections (Van Ransburg and Flett, 2008; Kendall *et al.,* 2014). Keeping the above facts in view, this study was aimed with the following objectives:

1. To investigate the effects of rotating maize with Tephrosia on Lepidopterous maize stem and ear borer incidence and damage caused on maize.
2. To investigate the effects of rotating maize with Tephrosia on maize growth and yield parameters.

Materials and methods

Study site: The study site was Njinikom in the North West region of Cameroon. Njinikom is located in the mid altitude Ecozone, at about latitude 06^{0} 12.628' N and longitude 10^{0} 17.540' E with an elevation of about 1100 ma.s.l. Njinikom is characterized with heavy rainfall, with a rainy season that extends from March to mid November (every year), while the dry season covers the rest of the months. The soil is humus, sandy and loamy in nature. Maize is planted twice a year. The first planting season extends from March to July while the second season extends from August to December.

*Experimental design and layout: E*xperimental design used was randomized complete block design (RCB) with four replications, using different farmer's plots as replicates or blocks. The blocks were separated from each other by 300-800 m. Each block was divided into 8 plots. A plot consisted of 10 eight metre ridges, spaced at 75 cm from each other. Each treatment was randomly assigned to a plot. There were four maize, two Tephrosia and two natural fallowed treatments. The crops were planted during the last week of August in the second maize cropping season of 2005 (August to December). Two of the maize plots were the control, one with carbofuran applied, while the other insecticide was not applied. For the other two plots, NPK (20-10-10) at the rate of 200 kg/ha of compound fertilizer and urea (40 kg/ha) were applied. Like in the control, the insecticide carbofuran was applied in one of the plots that received fertilizer. The treatments were separated from each other by 1.5 m. The maize variety used was the 150 days open pollinated Kasai and this was planted at the rate of four grains per stand, with the stands spaced at 50 cm within ridge. The maize crops were thinned to two plants per stand, 14 days after planting (DAP). The Tephrosia was planted at the rate of two grains per stand, with the stands spaced at 50 cm from each other. The NPK fertilizer was applied as side dressing 7 DAP; while the nitrogen treatment was applied at 28 DAP. Carbofuran was applied as granules in whorl leaves at the dose of 1.5 kg of active ingredient per hectare, at 21 and again 42 DAP. All crop plots were weeded as required.

Sampling and data collection: Beginning 21 DAP, each maize plot was divided into four quadrants and four plants randomly sampled per quadrant, making a total of 16 plants per treatment. Each plant was dissected and observed for borer eggs, larvae and pupae numbers, identified according to pest species. The observations were done bi-weekly till green harvest. Additionally the basal stem diameter as well as the total plant height, percentage stem tunneled, cob fill, damage and cob width, length and weight were measured. In February 2006, all the maize plots were ridged afresh. The bush fallow plots were slashed and ridged as well. In the first week of March 2006, the Tephrosia was cut down and the biomass allowed for three weeks. The ridges were softened in the last week of March 2006 and all 8 plots planted with maize (Kasai variety). All the maize plots were treated like the second season 2005 trials and the agronomic practices were the same as in the 2005 trials. A summary of the 8 different treatments per block is given in Table 1.

Statistical analysis: Analysis of variance (ANOVA) of plant, pest and damage and yield variables was carried out using the mixed model of SAS statistical analysis package (SAS institution, 2002). Treatment was considered as fixed effects while plants and quadrants were used as random effects and the whole analyses done in repeated measures over sampling dates. For most variables except total plant height during the first season of 2006, the interaction effects between insecticide and fertilizers was not significant, so the analyses were done as for a simple experiment, even though the treatments were factorial in arrangement.

Table 2. Insect pest count during the second maize planting season of 2005.

Treatments	*Busseola fusca*	*Sesamia calamistis*	*Mussidia nigrivenella*	*Cryptophlebia leucotreta*	*Chilo partellus*
No insecticide group					
MM	0.06^{aA}	0.01^{aA}	0.0001^{aA}	0.001^{aA}	0.000
MM-NPK-N	0.08^{aA}	0.02^{aA}	0.001^{aA}	0.001^{aA}	0.064^{aA}
Insecticide group					
MMI	0.02^{aA}	0.05^{aA}	0.01^{aA}	0.01^{aA}	0.000
MMI-NPK-N	0.03^{aB}	0.004^{aA}	0.004^{aA}	0.001^{aA}	0.003^{aA}

Values are those of the least square means (LSM) (the values are back transformed), Means followed by the same upper case and lower case letters in the same column are not significantly different.

Table 3. *Busseola fusca* count during the first maize planting season of 2006.

No insecticide group		Insecticide group	
MM	0.02^{aA}	MMI	0.01^{aA}
BFaM	0.04^{aA}	BFaMI	0.01^{aB}
MM-NPK-N	0.04^{aA}	MMI-NPK-N	0.02^{aB}
TM	0.01^{aA}	TMI	0.01^{aA}

Table 4. Maize plant growth and yield parameters during the second maize planting season of 2005.

Treatments	Yield parameters					
No insecticide group	Stem dia (cm)	Total plant height (cm)	Cob width (cm)	Cob length (cm)	Cob weight (g)	Cob filled (%)
MM	1.58^{aA}	142.26^{aA}	4.31^{aA}	11.06^{aA}	0.15^{aA}	0.97^{aA}
MM-NPK-N	1.92^{bcA}	156.77^{bA}	4.60^{bA}	12.94^{aA}	0.18^{aA}	0.94^{aA}
Insecticide group						
MMI	1.68^{aA}	149.33^{aA}	4.27^{aA}	11.48^{aA}	0.24^{aA}	0.95^{aA}
MMI-NPK-N	1.99^{bA}	164.52^{bA}	4.57^{bA}	12.95^{aA}	0.18^{aA}	0.98^{aA}

However, for meaningful comparison to separate treatment means, these were done separately for sets of treatment with or without insecticide and in a pair wise manner.

Results

Effect of treatments on pest number: Five borer species were encountered namely*: Busseola fusca* (Fuller) (Lepidoptera: Noctuidae), *Sesamia calamistis* (Hampson) (Lepidoptera: Noctuidae), *Mussidia nigrivenella* (Ragonot) (Lepidoptera: Pyralidae), *Cryptophlebia leucotreta* (Meyrick) (Lepidoptera: Trotricidae) and the spotted stem borer *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae). *Busseola fusca* was the most abundant species. In both seasons there were significant treatment effects on *B. fusca* (DF=7, 4801; F=6.08; P<0.0001 for second season (S2) of 2005 and DF=15, 4330; F=2.38; P<0.0001 for first season (S1) of 2006); while for the other species, no significant treatment differences were observed. Plots with fertilizers applied had the highest number of borers (Table 2 and 3).

Effect of treatments on plant and yield variables: In both maize planting seasons, there was significant treatment difference for both the basal diameter (DF=7, 981; F=13.6; P<0.0001 for S2 of 2005 and DF=7, 1030; F=4.81; P<0.0001 for S1 of 2006) and total plant height (DF=7, 981; F=9.24, P<0.0001 for S2 of 2005 and DF=7, 1030; F=4.81; P<0.0001 for S1 of 2006).

In the second season (S2) of 2005, there were significant differences among treatments for cob width (DF=7, 998; F=5.57; P<0.0001) while in S1 of 2006, there were no significant difference (DF=15, 1026; F=1.34; P=0.1700). In contrast, there were significant treatment difference for cob weight only during S1 of 2006 (DF=15, 1026; F=4.11; P<0.0001 for S1 of 2006, and DF=7, 986; F=1.05; P=0.3974 for S2 of 2005). No significant treatment difference was observed for both the cob length (DF=7, 989; F= 1.23; P=0.02829 for S2 of 2005 and DF=15 1026; F= 1.51; P= 0.0958 for S1 of 2006) and percentage cob filled in both seasons. In S2 of 2005, basal stem diameter, total plant height and cob width were significantly more for plots that received both chemical fertilizers in both the no insecticide and insecticide treatments (Table 4). In S1 of 2006 and for the no insecticide treatment, basal stem diameter was biggest for the maize continuous treatment by chemical fertilizers. The plot with chemical fertilizers had the tallest plant and the widest cobs in the no insecticide group. For the insecticide plots, Tephrosia/maize rotation and plots with chemical fertilizers treatment had the biggest and tallest plants; however the plants in the Tephrosia/maize rotation were significantly taller and wider than in plants with chemical fertilizers (Table 5).

Effects of treatment on plant damage: In both seasons, there were significant treatment differences for stem bored (DF-7,986; F=6.89; P<0.0001 for S2 of 2005 and DF=15, 1030; F=2.10; P<0.0001 for S1 of 2006).

Table 5. Maize plant growth and yield parameters during the second maize planting season of 2005.

Treatments	Yield parameters					
No insecticide group	Stem dia (cm)	Total plant height (cm)	Cob width (cm)	Cob length (cm)	Cob weight (g)	Cob filled (%)
MM	1.33^{aA}	144.33^{aA}	4.20^{aA}	12.07^{aA}	185.48^{bcA}	0.95^{aA}
BFaM	1.33^{aA}	127.54^{aA}	3.78^{aA}	10.07^{aA}	132.55^{aA}	0.88^{aA}
MM-NPK-N	1.66^{bcA}	146.21^{bA}	4.60^{aA}	11.73^{aA}	190.93^{abA}	0.95^{aA}
TM	1.45^{abA}	130.64^{aA}	3.94^{aA}	10.23^{aA}	135.46^{abA}	0.90^{aA}
Insecticide group						
MMI	1.37^{aB}	131.39^{aA}	4.49^{aA}	10.17^{aA}	148.29^{abA}	0.88^{aA}
BFaMI	1.36^{aA}	130.98^{aA}	3.89^{aA}	10.11^{aA}	151.46^{abA}	0.85^{aA}
MMI-NPK-N	1.57^{bA}	148.39^{bcB}	4.23^{aA}	13.55^{aA}	178.60^{bcA}	0.95^{aA}
TMI	1.64^{bcB}	148.76^{bcB}	4.38^{aA}	12.76^{aA}	209.29^{bcdA}	0.98^{aA}

Table 6. Stem bored and cob damage during the second season of 2005.

Treatments	Parameters	
No insecticide group	Stem bored (cm)	Cod damage (cm)
MM	0.03^{aA}	0.04^{aA}
MM-NPK-N	0.06^{aA}	0.03^{aA}
Insecticide group		
MMI	0.02^{aA}	0.03^{aA}
MMI-NPK-N	0.03^{aB}	0.02^{aA}

Table 7. Stem bored and cob damage during the first season of 2006.

Treatments	Parameters		
No insecticide group	Cob filled (%)	Stem bored (cm)	Cod damage (cm)
MM	0.95^{aA}	0.02^{aA}	0.01^{aA}
BFaM	0.88^{aA}	0.02^{aA}	0.04^{bA}
MM-NPK-N	0.95^{aA}	0.02^{abA}	0.02^{aA}
TM	0.90^{aA}	0.01^{aA}	0.01^{aA}
Insecticide group			
MMI	0.88^{aA}	0.01^{aA}	0.01^{aA}
BFaMI	0.85^{aA}	0.01^{aA}	0.02^{aA}
MMI-NPK-N	0.95^{aA}	0.010^{aB}	0.01^{aA}
TMI	1.04^{aA}	0.003^{aB}	0.01^{aA}

In both seasons, for the insecticide group, plots with N and P, and the Tephrosia/maize plot had the highest level of stem bored, while for the no insecticide group, the highest level was observed only in 2005 in the plots that received N and P (Table 6). No significant treatment differences were observed for cob damage in both seasons (DF=7, 993; F=0.81; P=0.5821 for S2 of 2005 and DF=15, 1026; F=1.28; P=0.2049 for S1 of 2006) (Table 7). In S1 of 2006, though the treatment effect was not significant for cob damage, the bush fallow followed by maize in the no insecticide group, had the highest percentage of damage.

Discussion

The following five borer species were collected, namely: *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae), *Sesamia calamistis* (Hampson) (Lepidoptera: Noctuidae), *Mussidia nigrivenella* (Ragonot) (Lepidoptera: Pyralidae), *Cryptophlebia leucotreta* (Meyrick) (Lepidoptera: Noctuidae) and *Chilo* spp. (Swinhoe) (Lepidoptera: Crambidae).

Though the stem borer species composition was slightly different from those in the forest zone of Cameroon, overall the results are in line with previous results encountered in Cameroon. According to Ndemah *et al.* (1995), Borgemeister (2002), five borer species were encountered on maize in the forest zone of Cameroon, namely: *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae), *Sesamia calamistis* (Hampson) (Lepidoptera: Noctuidae), *Mussidia nigrivenella* (Ragonot) (Lepidoptera: Pyralidae), *Cryptophlebia leucotreta* (Meyrick) (Lepidoptera: Noctuidae) and *Eldana saccharina* (Walker) (Lepidoptera: Pyralidae). In this study, *E. saccharina* was not encountered but instead *Chilo* spp. *Busseola fusca* was the most abundant species, corroborating result by Cardwell *et al*. (1997), Ndemah *et al.* (2001) and Ndemah *et al.* (2002). Plots with both N and P applied had the highest number of borer which is in agreement with previous findings by Pimental (1970) who pointed out that, well nourished plants are more susceptible to attack by insect and other pests.

Setamou *et al.* (1993) found out that nutrient, nitrogen in particular had a positive effect on both plant growth variables and the development and survival of stem borers. In the same light, Ndemah *et al*. (2006), found out that stem borer infestation on maize were higher in plots that received fertilizers. They noted that the most important factor related with stem borer abundance, plant damage and yield is plant nutrients. They also stated that, individual mineral nutrients do not only affect plant growth but they have a positive or negative effect on stem borer bionomics. Similarly, Setamou and Schulthess (1995) in a survey in maize fields in Benin found a positive correlation between soil nitrogen and egg laid per plant by *Sesamia calamistis.* Some studies shows that, the female moth prefer to oviposit on host plant augmented with nutrients (Wolfson, 1980; Myer, 1985). Singler *et al.* (1988) showed that, oviposition preference and larval performance may be correlated, such that the females prefer plant species on which their larvae have the greatest chance of surviving during the first 10 days of growth. In the same line, Jansen (1993) and Muhammad *et al.* (2013) noted that, the development and survival of larvae were lowest in treatment with zero nitrogen and larvae survived for a long time in plots with higher nitrogen doses. They stated that, the greater the nitrogen supply would amplify protein production and reduce the carbohydrate contents consequential in development of thinner cell wall and softening the tissues, which ultimately attract insects and damage by insects amplifies. In both seasons, there were significant treatment differences for basal diameter and total plant height. In first season of 2006, maize plants in the Tephrosia/Maize/insecticide plots had the tallest and widest plants and in addition, the widest cobs. This was followed by plots that receive chemical N and P. Though the nutritional analyses for treatments were not done, it can be hypothesized that Tephrosia greatly contributed an optimum amount of nutrients to the succeeding maize resulting in increased plant vigor and consequently increased in cob weight. Chabi-Olaye *et al.* (2005) stated that an increased nutritional state of plants enhance both borer fitness and plant vigor (increased stem diameter, increased total height) but with an increased net benefit of the plant i.e. cob length, cob width and cob weight. In first season of 2006, in the no insecticide group, the bush fallow followed by maize plot had the highest percentage of cob damage. It is possible that plants especially elephant grass (*Pennesetum purpureum*) which was among the different grasses and plants in the bush fallow plot acted as reservoir for stem borers. Schulthess *et al*. (1997) pointed out that wild grasses are believed to be reservoirs for stem borers and are responsible for pest out break on crops.

Conclusion

The findings of this study shows that, improved fallow (rotating) with Tephrosia, appears to be a better management practice than a continuous maize system, with more or less similar effect on borer incidence and maize yield parameters. Sequencing with Tephrosia is more economically beneficial to farmers, especially poor farmers. Fertilizers are often very expensive for some farmers to buy; hence a decrease in yield may be noticed.

Acknowledgements

Authors want to acknowledge the relentless support given to me by the people of Baichi (Njinikom), during the preparation of fields for this trial; for always keeping the experimental blocks weed free and above all, their assistance during the collection of data.

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