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Original Research

Efficacy of Push-Pull Strategies in Managing Cereal Stem Borers on Maize (*Zea mays* L.) in Western Ethiopia

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Abstract

Push-pull experiment was carried out at Boneya and Haru in 2012 and 2013. The trap plants used was napier grass (*Pennisetum purpureum*) and the repellent plants were green leaf desmodium (*Desmodium intortum*) and silver leaf desmodium (*Desmodium uncinatum*). The treatments were napier grass and desmodium intortum with maize; napier grass and desmodium uncinatum with maize and maize alone. The trail was laid in randomized complete block design in three replications. The parameters measured were borer density per plant, percent parasitism, percent infestation, stem damage and yield. The results demonstrated that push- pull strategy significantly reduced stem borer damage from maize and increased grain yield.

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INTRODUCTION

Maize, *Zea mays* L., is an important component of the farming systems in sub-Saharan Africa (SSA), where it is a staple for a large proportion of the population. In recent years maize is increasingly replacing indigenous cereal crops, such as sorghum and millet, as well as wild hosts insub-Saharan Africa; consequently, it has become the major host of insect pests (Chabi-olaye *et al*., 2005). The lepidopteran stem borers cause major yield losses in subsistence maize production throughout sub-Saharan Africa. The main method of stem borer control is use of chemical pesticides which is uneconomical and impractical to many resource-poor and small-scale farmers (Khan *et al*., 2003).

A habitat management (Push-pull) strategy for minimizing damage due to stem borers has been developed in maize-based farming systems for small and medium-scale African farmers (Khan *et al*., 2003). The function of push components of the push-pull strategy is to make the protected resource hard to locate, unattractive, or unsuitable to the pest. This is achieved through the use of stimuli that effect natural enemy avoidance behaviors and negatively influence host location and host acceptance (feeding and re-production). These stimuli may act over the long or short range and ultimately lead to the pest being repelled or deterred from the resource or not even approaching it. In pull components of push-pull strategies, attractive stimuli are used to divert pests from the protected resource to a trap or trap crop. The stimuli used to achieve this act mostly over a long distance. However, short-range stimuli can be useful additions to arrest and retain the pests in a predetermined place to facilitate the concentration of their populations and to prevent them from returning to the protected resource (Cook *et al*., 2007). Stem borers are repelled from the crops by repellent non host intercrops, particularly molasses grass (*Melinis minutiflora*), silver leaf desmodium (*Desmodium uncinatum*), or green-leaf desmodium (*D. intortum*) (Push), and are concentrated on attractive trap plants, primarily Napier grass (*Pennisetum purpureum*) or Sudan grass (*Sorghum vulgare* sudanense) (pull) (Cook *et al*., 2007; khan *et al*., 2003; Shelton and Badenes-Perez, 2006). So the study was designed to evaluate the efficacy of push pull strategy on maize in managing cereal stem borers.

MATERIAL AND METHODS

The studies were conducted in Haru agricultural research sub center and Boneya experimental station of agricultural office. Haru agricultural research sub center is found in west Wollega and is 464km away from Addis Ababa. Haru is found at 8^o58.992N and 35^o47.746E having an average elevation of 1672m. Boneya is found in east Wollega zone and is 320 km away from Addis Ababa. Boneya has coordinates of 8^o58.614N and 36^o40.206E and an altitude of 1680m. The experimental station is found in the middle of farmer field producing maize.

The experiment was conducted during the rainy season of the year 2012 and 2013 from May to

September. The trap plants used in the experiment was napier grass (*Pennisetum purpureum)* and the repellent plants were green leaf desmodium (*Desmodium intortum*) and silver leaf desmodium (*Desmodium uncinatum*). Both the trap and repellent plants were received from Bako Agricultural Research center. The maize variety used was shone at Boneya and Morka at Haru, which were selected based on the preference of the farmers in the area.

The treatments were napier grass and desmodium intortum with maize; napier grass and desmodium uncinatum with maize and maize alone. These were laid using randomized complete block design in three replications. The Plot size was 4.8m x 7m (33.6m^2) with a space between blocks and plots 2m and 1m, respectively.

Napier grass was planted surrounding the plots in two rows with 1m distance between the rows of napier grass and 50cm between the napier plants three weeks prior to the planting of maize. The repellent crop was planted with maize at the same time in between the rows of maize. Maize mono crop was planted 15m away from the push pull plot. Maize was planted with the spacing of 70cm x 30cm. Two seeds were planted per hill which was later thinned to one after two weeks of emergence.

At planting maize DAP was applied at the rate of 100kg/ha and UREA at the same rate was applied when maize was at knee height. Cultural practices like weeding were done according to the farmers practice.

The number of plants showing any damage symptom by stem borers was recorded at seedling, vegetative, tasselling, silking and maturity stage to determine percent infestation in relation to the total plant. In addition, at vegetative, tasselling, silking and maturity stage three plants were randomly selected and cut at ground level. They were inspected for any external symptoms and dissected vertically to check for any stage of stem borers and parasitoids. At harvest all dried leaves were removed from the stem and carefully observed for holes made by larvae for entrance or adult emergence. The number of plant with stem damage was counted and divided by total stand count and multiplied by 100 to get percent stem tunnel. The larvae recovered from the dissected plant was kept in glass vials and given fresh maize every three day till pupation and the pupae and parasitoid cocoons was kept in separate glass vials till adult emerge. Yield data was taken from predetermined sub plot with the area of 2.53m^2. The cobs was dehusked and dried in oven dry to the moisture level of 12-13%.

Data Analysis

Analysis of variance and mean comparison test was done using SAS software and Tukey's studentized range (HSD) test was used for mean separation. Insect counts were transformed using square root and the percentage data were transformed using arcsine before analysis.

RESULTS

Stem Borer Density and Parasitism

The difference between maize mono crop and push pull plot was significant at both locations in both years for stem borer density. The highest number of borer per plant was recorded on mono crop maize at both locations and both years. In the push- pull plot, the difference between maize planted with *D. uncinatum* and *D. intortum* was not significant for borer density per plant. The lowest number of borer density per plant was recorded from maize planted with *D. uncinatum* (0.88) at Haru in 2013 (Table 1).Three species of stem borers were recorded and they were *B. fusca*, *C. partellus* and *S. calamistis*. The dominant species was *B. fusca*.

Two species of parasitoid were recorded which include the larval parasitoid *C. flavipes* and the pupal parasitoid *D. busseolae*. Parasitism percentage was higher on maize planted in the push- pull plot than the sole maize for both locations and years. The average parasitism percentage from both years were 14.7, 17.4 and 9.6 at Boneya and 20.1, 19.4 and 12.3 at Haru for maize planted with *D. unicinatum*, *D. intortum* and sole maize, respectively.

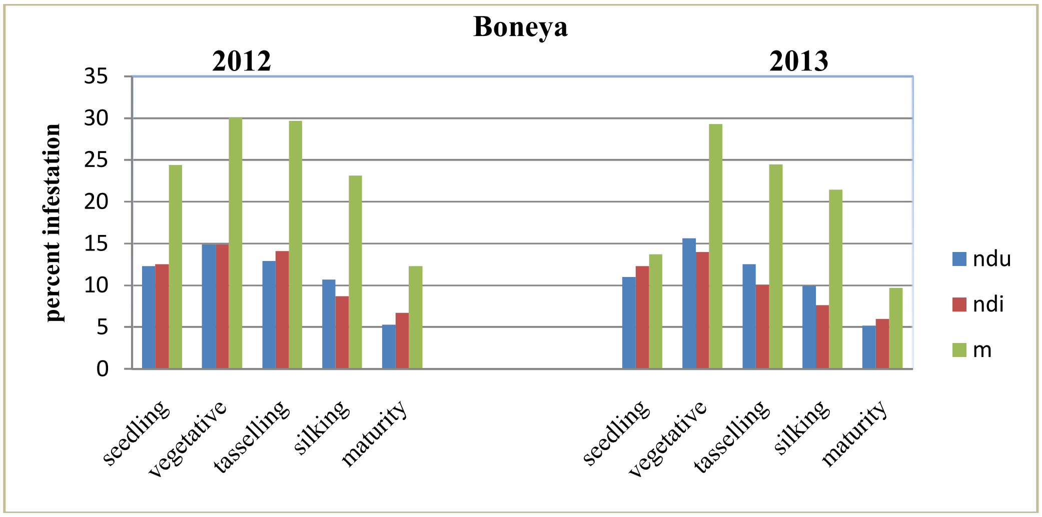
Table 1: Mean stem borer density per plant from maize mono crop and push pull plots

Treatments	Boneya		Haru	
	2012	2013	2012	2013
Ng+Du + Maize	0.98± 0.14 ^{b}	1.23± 0.06 ^{b}	1.03 ± 0.06 ^{b}	0.88± 0.02 ^{b}
Ng+Di + Maize	0.92± 0.05 ^{b}	0.91± 0.05 ^{b}	1.05± 0.1 ^{b}	0.98±0.05 ^{b}
Sole Maize	1.51± 0.17 ^{a}	1.86± 0.08 ^{a}	1.36± 0.02 ^{a}	1.32± 0.06 ^{a}

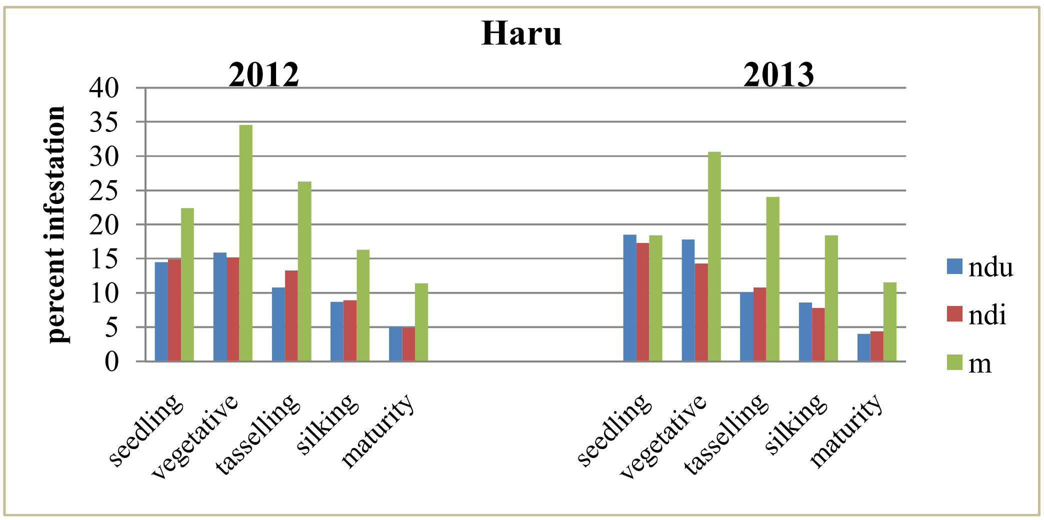
Means in the same column followed by same letter are not significantly different at P≤0.05 according to Tukey studentized range test. Data pulled together from vegetative, tasseling, silking and maturity.
Ng= napier grass, Du= *Desmodium uncinatum*, Di= *Desmodium intortum*

Percent Infestation

The percent infestation was high in maize mono crop when compared with the push pull plot at seedling, vegetative, tasselling, silking and maturity stage of maize. Percent infestation was low at seedling stage and reached pick at vegetative stage and start declining thereafter. The trends shown in both places of experiment and years were almost similar. The results are shown on Figure 1. The percent infestation ranged from 5.3 at maturity stage for maize in push pull plot to 30.1 at vegetative stage for sole maize in Boneya during 2012. During 2013, the percent infestation followed similar trend with the previous year of the experiment. At Haru the result is almost similar with the trend at Boneya except for the year 2013 in which the maize under push pull plot and sole culture have almost similar percent infestation at seedling stage.



(a)



(b)

ndu=napier grass + *Desmodium uncinatum* + maize, ndu= napier grass + *Desmodium intortum* + maize, m= maize

Figure 1: Mean percent infestation from mono crop maize and push pull plot at Boneya (a) and Haru (b) in 2012 and 2013

Percent Stem Tunnel

The percentage of stem tunneled differed significantly between maize mono crop and push pull plots at both locations for both years except for 2013 at Haru. The highest number of stem was damaged in maize planted alone when compared with maize in push pull plot. The two repellent crops didn't differ significantly; however, the lowest percent of maize stem was tunneled in maize planted with *D. intortum* in push pull plot at Boneya in 2012 and 2013. In Haru, the same trend happened for the year 2012 but in 2013 the lowest stem tunnel percentage was recorded from maize planted with *D. unicinatum* (Table 2).

Table 2: Mean stem tunnel percentage from maize mono crop and push pull plots

Treatment	Boneya		Haru	
	2012	2013	2012	2013
Ng+Du + Maize	13.7± 0.49 b	14.6± 0.84 b	16.7 ± 1.13 b	14.5± 1.02 a
Ng+Di + Maize	12.7± 0.68 b	14.27± 1.14 b	16.4±0.06 b	15±1.74 a
Sole Maize	17.87±0.87 a	20.5± 0.1 a	26.5± 0.81 a	19.4± 0.96 a

Means in the same column followed by same letter are not significantly different at P≤0.05 according to Tukey studentized range test. Ng= napier grass, Du= Desmodium unicinatum, Di= Desmodium intortum

Grain Yield

Grain yield were significantly different between maize mono crop and maize in push pull plots in both locations for both years except for Boneya in 2013. The results are presented on Table 3. The highest grain yield was recorded from maize in push plot and the lowest from mono crop maize at both locations in both years. The difference between the two repellent crops was not significant. In Boneya, maize planted with *D. unicinatum* and napier grass has the highest (4.23±0.09) yield in the year 2012 and in 2013, maize planted with *D. intortum* and napier grass had the highest (4.13± 0.19) yield. In Haru, the same trend happened with Boneya at both years.

Table 3: Average maize grain yield from maize mono crop and push pull plots

Treatment	Boneya		Haru	
	2012	2013	2012	2013
Ng+Du + Maize	4.23±0.09 [a]	3.93± 0.03 [a]	5.76 ± 0.15 [a]	5.87± 0.03 [a]
Ng+Di + Maize	4.1± 0.06 [a]	4.13± 0.19 [a]	5.5± 0.5 [ab]	6±0.6 [a]
Sole Maize	3.53±0.12 [b]	3.49± 0.2 [a]	4.27± 0.15 [b]	4.5± 0.09 [b]

Means in the same column followed by same letter are not significantly different at $P \leq 0.05$ according to Tukey studentized range test. Ng= napier grass, Du= *Desmodium unicinatum*, Di= *Desmodium intortum*

DISCUSSION

The current study showed that the push-pull strategy was effective in controlling stem borer and increased yield at mentioned locations in both years. These results in line with the study conducted by Khan *et al*. (2008) in Kenya in which push pull effectively controlled stem borer and increased yield in farmers managed field across different agro ecologies. Dilnesaw *et al*. (2008) have also recorded significantly higher number of stem borer density per plant, higher mean percentage of stem tunneled and higher mean percentage of foliar damage on maize planted alone compared to maize surrounded by five wild hosts in Ethiopia.

The reduction of stem borer damage to maize and increase in yield in push pull strategy is due to both the attractant and repellent crops. The attractant crop, napier grass, is known to attract stem borer. The female moth prefers napier grass for oviposition much better than maize. However, very few stem borer larvae survive on napier grass. When the eggs hatch and the small larvae bore into Napier grass stems, the plant produces a sticky substance like glue which traps and kills them (Khan *et al*., 2007).

The repellent crops, *D. uncinatum* and *D. intortum* produce volatiles during damage to plants by herbivorous insects. They release nonatriene 11 and ocimene 7 which repels ovipositing female moth (Khan *et al*., 2000). Therefore, the combination of the two crops highly reduces the chance of female moth to reach maize in the push pull plot than the maize planted alone. The trap and repellent plants also provide high quality feed for livestock, thereby increasing their productivity in terms of meat and milk (Khan *et al*., 2007).

CONCLUSIONS

It was possible to prove that the push-pull strategy can be applicable to the mentioned sites. Since the repellent and attractants plants used in the study are known by the farmers in the area it could be possible and easy to introduce the system to the farmers. They can be benefited it two ways, reduction of pest pressure and getting more feed for their live stocks, especially nowadays when the land for grazing is getting smaller and cultivated land is expanding. The repellent plant can also be useful in controlling erosion.

Conflict of Interest

None declared.

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