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Evaluating Border Cropping System for Management of Aphids (Hemiptera: Aphididae) Infesting Okra (Malvaceae) in Kenya

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Abstract: A field experiment was carried out in 2003 and 2004 to evaluate border-cropping system as a strategy for management of aphids infesting okra (*Abelmoschus esculentus* (L.) Moench). Four crops used as border crops; maize (*Zea mays* L.), Sorghum (*Sorghum bicolour* (L.) Moench) pigeon peas (*Cajanus cajan* (L.) Milisp.) and millet (*Pennissetum glaucum* (L.) R. Br.) were planted 14 days prior to okra sowing, providing a protection perimeter around the whole plot. The number of live and parasitized aphids was monitored *in situ* on randomly selected leaves of okra in each plot for ten weeks. This was also done weekly on pods of randomly selected okra plants per plot for seven weeks after their formation. The number of aphids in okra leaves was significantly ($p<0.05$) different among the treatments during the two seasons. The plots bordered by pigeon peas and maize had lowest and highest mean aphid population among the border crops respectively. However, maize bordered plots recorded the highest number of parasitized aphids in both seasons. In all the treatments, there was no significant difference ($p>0.05$) in the yield of okra. This study concludes that some border crops have potential use in aphid management in okra crop and can be used in combination with border spraying in an integrated pest management strategy to maintain the pest below economic damage. In addition, such a system would lower insecticide sprays in a season, reduce cost of production and improve farm profits. The strategy is also friendly to the environment.

Key words: Aphids, border crops, okra, yield, perimeter protection

INTRODUCTION

Okra has a wide range of pests, some of them such as aphids (Hemiptera:Aphididae) occur through out the year. Aphids have been identified as the most economically important pests of okra in Kenya (Seif, 2002). Like all other export crops, okra has to meet certain quality standards that include maximum residue levels of pesticides used in its production. The year round production of okra ensures continuous presence of pests, among them being aphids. Usually, it is the alate aphids that are greatly affected by barriers such as hedges, trees and farm buildings. These barriers prevent the fastness of the pest in colonizing the crop. If well managed, such barriers can offer better control option of aphids and other pests that occur all year round. Although cultural management of aphids is encouraged, chemical pesticides remain the most sought tool for controlling aphids in okra. However, very few have been registered in Kenya for use in okra production (Pest Control and Products Board, 2004), making cultural control methods more attractive for the pest management. Trap crops are utilized as a cultural strategy to attract pests from the more economically important crop and hence

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protect it (Hokkanen, 1991). To succeed, the management of trap cropping system is crucial and relies considerably on the bionomics of the target pest. For example, pests can be prevented from infesting the main crop or be managed within the field. Therefore, trap crops could be planted as companion or border crops depending on the choice of the farmer, the target pest and crop. They can also be manipulated in time or/and space to attract the pests at the critical development stage of the pest/crop. The population of the trap crop can also be manipulated to provide the desired results. Perimeter trap cropping, a form of trap cropping where the trap crop forms a perimeter around the whole main crop, has been studied in Kenya. Crops planted around the borders of the main crop to prevent pest colonization have been reported to influence aphid populations by either repelling or attracting them from the main crop. For example, Kibaru (2004) reported lower aphid (*Aphis gossypii* (Glover)) infestation in potatoes bordered by wheat (*Triticum aestivum* L.), sorghum (*Sorghum bicolour* L.) and maize (*Zea mays* L.) compared with those surrounded by fallow land. This border cropping can enhance populations of natural enemies, which would regulate the pest populations. There is growing interest in use of trap crops for pest management (Brewer and Schimdt, 1995; Aluja *et al*., 1997; Mitchell *et al*., 2000; Boucher and Ashley, 2001; Boucher *et al*., 2003). Some current reports of effectiveness of trap crops have been practiced on wide range of crops, e.g., control of Colorado potato beetle (Michanec, 2003) and pepper and cucurbit pests (Boucher, 2003; Boucher and Durgy, 2003) Although pesticides are the first choice of farmers in controlling insect pests of okra, their use is accompanied by several drawbacks such as development of resistance by the pests due to continuous exposure (Yu, 1993). Effective cultural methods against aphids in okra can overcome this problem as well as reduce environmental pollution, pesticide residues in the produce, pesticide poisoning, pest resurgence and reduction of the associated costs. This study was conducted to assess the effectiveness of border cropping for the management of aphids pests of okra in Kenya. An effective border crop would be attractive to the farmer hence easier to adopt it in their farming systems.

MATERIALS AND METHODS

The study was carried out at Kibwezi Irrigation Project Field Station at Kibwezi, Eastern Kenya in two seasons (November 2003-February 2004 and February-June 2004). Okra plots (7.0×6.3 m) were surrounded by two rows of different border crops as treatments. These were arranged in a randomized complete block design and replicated four times. An alley of 5 and 1.5 m was maintained between blocks and plots, respectively. The inter-row spacing of border crops was 60 cm but intra-row spacing depended on the border crop. Maize (*Zea mays* L., var. DHO1) had 30 cm, pigeon peas (*Cajanus cajan* L., var. KAT 60/8) 40 cm, sorghum (*Sorghum bicolor* L., var. Seredo) 20 cm and millet (*Pennisetum glaucun* L., var. ICCV 221) 15 cm intra-row spacing. Control plots of okra were bordered by fallow land, which was kept weed free throughout the season. Fourteen days after planting of the border crops, okra seeds (var. Pusa Sawani) were sown at 40 cm inter-row and 30 cm intra-row spacing. A 30 cm gap was maintained between outer okra row and inner row of the border crop. Basal fertilizer was mixed well with the soil before sowing using locally recommended rate of 125 kg di-ammonium phosphate ha^{-1}. Top dressing was done 4 weeks after okra sowing at a local rate of 70 kg calcium ammonium nitrate ha^{-1} and repeated four weeks later. Drip irrigation was used to supplement rains. The drip lines were laid at a spacing of 40 cm apart along the rows. Plots as well as areas between plots and blocks were kept weed free manually through out the season.

The counting of live and parasitized (mummified) aphids was done *in situ*. On leaves, sampling started 4th week after okra sowing and continued weekly for ten weeks. From each plot, ten okra plants were randomly selected during each sampling period and from each plant three leaves (a leaf from top, middle and bottom plant canopy) randomly selected. On pods, aphid sampling started after pods reached commercial maturity and continued once a week for seven weeks. Ten plants from each plot were randomly selected and from each plant one pod selected and the number of aphids counted. The two outer rows of okra were not sampled.

Eight plants from each border crop were randomly selected and from each plant three leaves (a leaf from top, middle and bottom plant canopy) were randomly selected and the number of aphids counted.

All commercially mature okra pods were harvested four times a week for seven weeks. The harvested pods were separated to three grades; export, local market and unmarketable. The unmarketable grade was further separated into two; aphid-contaminated and non-aphid contaminated. Export-graded pods were 10-15 cm long, dark green and not discoloured, bruised or pimpled. The local market-graded pods had some defects, were overgrown but acceptable in the local market. Aphid-contaminated pods had honeydew, sooty moulds, aphids or their cast skins while non-aphid contaminated pods were damaged by non aphids pests.

All the data were subjected to Analysis of Variance (ANOVA) using GENSTAT statistical software ver. 8. The data were transformed ($(x+0.5)^{0.5}$) prior to analysis to satisfy the assumption of normality for ANOVA if there was need to. The means were separated by least significant differences of means (LSD) at 95% level.

RESULTS

There were significant ($p<0.05$) differences among treatments on the observed live aphids infesting okra leaves (Table 1). In both seasons, the aphid number on leaves was lowest in okra plots bordered by pigeon peas while maize bordered plots recorded the highest live aphids among the border crops. Generally there was a lower mean aphid infestation in all treatments in the second season. Using the LSD value at 95% level, only pigeon pea border crop had significantly lower aphid counts. The other border crops had no significant difference but in the second season plots bordered by fallow land had significantly higher aphids count. The population of live aphids on the leaves peaked between 7th and 8th week after okra sowing then declined up to the end of the harvesting period in the first season (Fig. 1a). This trend was generally similar in all the treatments. The aphids' population peaked in the 11th week after okra sowing in the second season and though their population declined thereafter, it was still high by the end of the season (Fig. 1b).

The number of parasitized aphids observed on okra leaves was significantly ($p<0.05$) different among the treatments (Table 2). There were more parasitized aphids in the second season than in the first. In both seasons, plots bordered by maize crop recorded the highest mean number of parasitized aphids compared with all other treatments. The parasitized aphid population in all treatments increased rapidly in the first season, reaching a peak on the 8th week after sowing. It then declined till the end of the season but with slight increases between the 11th and 12th weeks in maize, pigeon peas and sorghum bordered plots and between 12th and 13th weeks in millet bordered plots (Fig. 2a). Maize-bordered plots had higher population of parasitized aphids between the 5th and 10th weeks

Table 1: Mean number of live aphids on leaves of okra under different border cropping system during two seasons at Kibwezi, Eastern Kenya

Border cropping	Season 1 (2003-2004)	Season 2 (2004)
Pigeon peas	2530.0a	2032.0a
Sorghum	2691.0ab	2258.0ab
Millet	2830.0bc	2310.0bc
Maize	2870.0bc	2323.0bc
Fallow	2624.0ab	2516.0c
LSD (p = 0.05)	264.0	238.1

Means of 30 leaves, 10 samplings; Values with similar letter(s) in the same column are not significantly different at 95% level

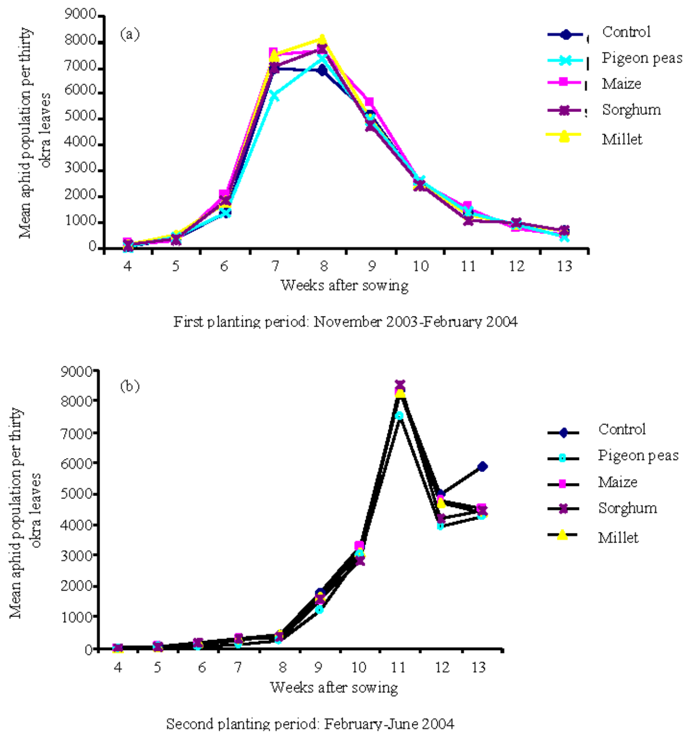


Fig. 1: (a, b) Mean live aphid population trend in okra plots surrounded by different border crops during two seasons, 2003-2004 at Kibwezi, Eastern Kenya

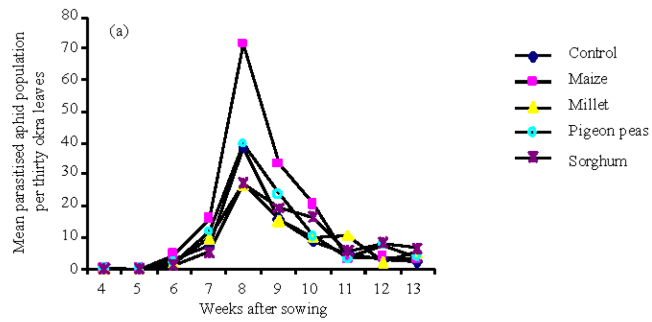
Table 2: Mean number of parasitized aphids in leaves of okra under different border cropping system in two seasons, 2003-2004 at Kibwezi, Eastern Kenya

Treatments	Season 1	Season 2
Pigeon peas	10.3a	59.1a
Millet	8.3a	72.5a
Sorghum	9.1a	60.9a
Maize	15.6b	79.3b
Fallow	8.4a	54.3a
LSD (p = 0.05)	5.1	24.9

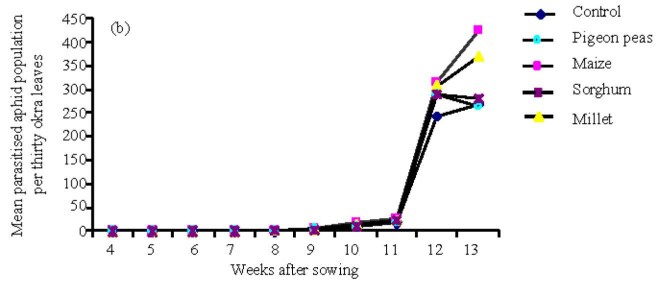
Means of 30 leaves, 10 samplings; Values with similar letter(s) in the same column are not significantly different at 95% level

whereas sorghum bordered plots had the lowest number between the 6th and 8th weeks (Fig. 2a). In contrast to first season, parasitized aphid-population increased gradually in all treatments during second season, attaining a peak on the 12th week after sowing for pigeon peas and sorghum-bordered plots and 13th week after sowing for millet, maize and fallow (control)-bordered plots (Fig. 2b). The mean parasitized aphids was slightly higher in the second season than in first season but the distribution over the growing period was more even in first season. The trend of parasitized aphids over the growing period in both seasons was relatively similar to that of live aphids.

There was no significant ($p<0.05$) differences on the number of aphids counted on okra pods among the different treatments in the two seasons. The number of aphids on pods was relatively lower in the second season (Table 3). Maize-bordered plots had the lowest number of aphids counted on the pods while Fallow (control)-bordered plans recorded the highest count.



First planting period: November 2003-February 2004



Second planting period: February-June 2004

Fig. 2: (a, b) Mean parasitized aphid population trend in okra plots surrounded by different border cropping system in two seasons, 2003-20004 at Kibwezi, Eastern Kenya

Table 3: Mean number of aphids in okra pods from plants under different border cropping system during two seasons, 2003-2004 at Kibwezi, Eastern Kenya

Border cropping treatments	Season 1 Nov 2003-Feb 2004	Feb-June 2004
Maize	249.0	221.0
Millet	260.0	237.0
Pigeon peas	270.0	242.0
Sorghum	247.0	241.0
Fallow	260.0	254.0
LSD (p = 0.05)	28.0	35.0

Means of aphids in 10 pods, 7 samplings

Table 4: Mean weight (kg) of okra pods from plants under different border cropping regime in the first season, November 2003-February 2004 at Kibwezi, Eastern Kenya

Border cropping treatments	Marketable grade		Un-marketable grade	
	Export	Local	Aphid-contaminated	Non-aphid contaminated
Maize	7.00	1.20	2.30	2.2
Millet	7.10	1.00	2.30	2.2
Pigeon peas	6.90	1.40	2.40	2.3
Sorghum	7.20	1.10	2.40	2.4
Fallow	7.20	1.10	2.20	2.3
LSD (p = 0.05)	0.77	0.46	0.48	0.3

Means in the same column are not significantly different (p>0.05)

Only sorghum-border crops were infested with aphids but these aphids were different species from those observed in okra. These include *Aphis sorghi* Theobald and *Melanaphis sacchari* (Zehnter), which are different from *A. gossypii*, the aphid species that infested okra plants. There was no significant (p>0.05) differences on the okra pod yield among the treatments in both seasons. The second season recorded slightly higher yield of export grade (Table 4, 5).

Table 5: Mean weight (kg) of okra pods harvested from plants under different border cropping systems in the second season, February-June 2004 at Kibwezi, Eastern Kenya

Border cropping treatments	Marketable grade: Export	Marketable grade: Local	Un-marketable grade: Aphid-contaminated	Un-marketable grade: Non-aphid contaminated
Maize	7.90	1.00	2.10	2.20
Millet	8.20	1.20	2.00	2.20
Pigeon peas	8.10	1.30	1.90	2.20
Sorghum	8.00	1.30	2.20	2.20
Fallow	8.00	1.10	2.20	2.30
LSD (p = 0.05)	0.41	0.39	0.26	0.23

Means in the same column are not significantly different (p>0.05)

Generally in all the treatments, about 56% of all pod-yield was of export quality in the first season while in the second season it was about 60%.

DISCUSSION

This present study shows that border cropping, a form of trap cropping system, could be used as a management strategy for aphids infesting okra in Kenya. Use of pigeon pea border crop showed good effects in reducing aphid's population on leaves, but there was no particular border crop that was better than others in checking the pest infestations on the pods. The study did not investigate further the mechanism that enabled the different border crops to reduce pest infestations. However, it is possible that the system created barriers, provided alternate hosts of natural enemies or/and repelled the pest from the main crop or acted as an attractant for the insect pest from the main crop (Hooks and Fereres, 2006; Shelton and Badenes-Perez, 2006). The role of border crops as providers of good habitat for natural enemies was confirmed in this study by the higher parasitisation of aphids by *Aphidius* spp. on okra crops bordered by different crops compared with those bordered by fallow area. There is an indication that pigeon pea, a legume, could be a better border crop especially considering the high rate of parasitisation and lower aphids population observed in the main crop compared with observations from okra surrounded by other border crops. This is a welcome finding since in the research area, pigeon pea is a traditionally considered as a food security crop (Anonymous, 2007). It would be easier to advocate use of this crop in the region as a border crop since farmers have experience in its production. It is suggested that under border cropping system, pesticides can be used to lower the pest population especially when the infestation is severe. It seems the effectiveness of a border crop against the aphids depends also on the main crop. For example, Kibaru (2004) reported effectiveness of maize and sorghum border crops against *A. gossypii* infesting Irish potatoes compared with the fallow border. Since these crops were not effective in this study, it could imply that okra may be a more preferred host. Presence of higher parasitisation of aphids in the maize-bordered plots is in conformity with Wang *et al*. (1998) whereby the parasitisation of aphids by *Aphidius* was found to increase by 23.9-29.9% in fields inter-planted and mixed-sowed with maize and soybeans. Parasitisation usually reduces the pest population as observed in this study implying that if well managed, the parasitoids can effectively reduce the pest population in okra fields. In other studies, intercropping has been found to increase predation, e.g., the number of *A. gossypii* predators such as Coccinellids, Chrysopids and spiders in maize and chilli intercrop increased significantly (Idris *et al*., 1999). The effectiveness of a control strategy against any pest should be reflected on the yields, i.e., better yields should be reported on the control option which records lower infestation. In this study, pigeon peas bordered plots had lower pest population compared with maize bordered plots. However, the pest parasitism in the latter was higher than in other treatments. This lead to lower crop damage, as reflected on the yield of okra from the maize-bordered plots. Indeed the different mechanism of the border cropping was well reflected on this kind of findings. Since there were no significant differences in the yield of the okra crop under different border cropping systems, this study cannot sufficiently suggest any particular border crop for aphids' management based on the pest population alone. However, the border crops that show potentiality, i.e. pigeon peas and maize, should be studied further to determine their influence on the pest population and crop yield under different spatial and temporal arrangements in a season. Such study would also provide the suitability of these border crops in an integrated management of aphids infesting okra. Since in this current study there is evidence of some border crops reducing pest infestation, their combination with pesticides, sprayed on these border crops could drastically reduce the pest problem as well as lower sprays. This has been successfully used in other areas, e.g., in an improved system where border cropping was combined with border sprays, squash farmers in USA reported improved crop yield as well as 93% decrease in insecticide sprays against cucumber beetles in a season (Boucher and Durgy, 2004). Therefore, a sound trap cropping technology has future and crucial benefits in pest management in agricultural fields.

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