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UTILIZATION OF BORDER CROPS TO MANAGE APHID COLONIZATION AND PVY INCIDENCE ON POTATO (*Solanum tuberosum* L.)

FLORENCE OLUBAYO[1], JOHN NDERITU[1], ANDREW KIBARU[1], ROSE NJERU[1], DAMARISYOBERA[1] AND MUO KASINA[2a]

[1]Department of Plant Science and Crop Protection, University of Nairobi P.O Box 30197, 00100, Nairobi, Kenya, [2]Entomology Department, Kenya Agricultural Research Institute-NARL, P.O Box 14733-00800, Nairobi.

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ABSTRACT

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Sorghum (*Sorghum bicolor* L.), wheat (*Triticum aestivum* L.), maize (*Zea Mays* L.), common bean (*Phaseolus vulgaris* L.) and garden pea (*Pisum sativum* L.) were tested as border crops for their ability to reduce the number of colonizing aphids and Potato Virus Y (PVY) incidence in seed potatoes (*Solanum tuberosum* L.). The experiment was done at Tigoni, Central Kenya for two seasons, from 03 May 2002 and from 17 October 2002. Apterae aphids were monitored weekly by picking 15 leaves from 5 randomly selected plants per plot while alate aphids were collected using yellow sticky traps mounted 0.5 m from the ground level at the edge of border crops. Three aphid species were recorded: *Aphis gossypii* (Glover), *Macrosiphum euphorbiae* (Thomas) and *Myzus persicae* (Sulzer). PVY incidence in the inner rows of potatoes surrounded by fallow and the border crops was statistically insignificant (P>0.05) but outer rows in crop-bordered plots had significantly less PVY than outer rows of fallow-bordered plots. The DAS- ELISA test used to confirm presence of PVY showed that the disease had the highest and lowest incidence in fallow and wheat bordered plots, respectively. This study shows that the effective border-crops can be used to manage aphids and PVY disease in potatoes. In addition, since most Kenyan potato growers are low income earners, adoption of border cropping technology can improve immensely the production success of the crop.

Keywords: ***Aphid colonization, boarder crops, Solanum tuberosum***

INTRODUCTION

Potato virus Y (PVY), which is aphid transmitted in non-persistent mode causes economically important diseases of potato worldwide. At least 25 species of aphids (Hemiptera: Aphididae) are reported to transmit it. *Myzus persicae* (Sulzer), *Macrosiphum euphorbiae* (Thomas), *Aulacorthum solani* (Kalt) and *Aphis gossypii* Glover are major aphid species that infest potatoes and transmit these viruses in different parts of Kenya (Nderitu and Mueke, 1986; Were, 1996 unpublished MSc. Thesis, university of Nairobi-Kenya). The PVY acquisition and inoculation occurs in seconds, but infectivity is lost after one to several probes. By virtue of these transmission characteristics, PVY is more readily spread by alate aphids, which do not colonize the crop, than by apterae form of colonizing aphid species. Probing of non-host and starving of viruliferous aphids do not lead to loss of persistently transmitted viruses (Jones, 1993). Although insecticides applied to the crop can prevent build up of colonizing aphids, they cannot kill immigrating alate aphids quickly enough to prevent the spread of non-persistently transmitted viruses from sources outside the crop (Difonzo *et al.*, 1996). This nature of persistent viruses requires an efficient means of deterring aphids from landing on susceptible plants for a short time after acquisition of virus and this might result in decreased transmission. Difonzo *et al.* (1996) described use of soyabean, sorghum and winter wheat crop borders for management of PVY. Jones (1993) demonstrated use of oats and wheat borders in reduction of bean yellow mosaic virus (BYMV) in lupins. This present study tested the effectiveness of crop borders in reducing PVY spread and number of viruliferous aphids landing on seed potato crop.

MATERIALS AND METHODS

Plots of 4 x 4 m were planted with certified seed potato var. Desiree at National potato Research Center (NPRC), Tigoni, on 03 May 2002 and repeated on 17 October 2002 for the long and short rains respectively. An inter- and intra-row spacing of 75 by 35 cm was used, respectively. In each potato seed-hole, 10 g of Diammonium Phosphate (DAP) was applied and thoroughly mixed before placing the seed tuber. Two outer rows of each potato plot served as guard rows, while the inner four were used for sampling. Maize (*Zea mays* L.), wheat (*Triticum aestivum* L.), sorghum (*Sorghum bicolor* L), common bean (*Phaseolus vulgaris* L.) and garden pea (*Pisum sativum* L.) were planted in a 0.5 m border space at the same time with potato crop, with fallow ground acting as a control. Maize was spaced at 30 cm within and 90 cm between rows. Wheat and sorghum were drilled into three rows each 15 cm apart. Common beans were planted in two rows at spacing of 15 cm within and 30cm between rows. Garden peas were planted in double rows 60cm apart and 10 cm within a row. The experiment was laid in a randomized complete block design (RCBD) with 4 replications. The plots were 1 m apart within a block, while a gap of 2 m separated the blocks. Weeding in the plots (border and potato) was done on weeks 3, 5 and 8, while ridging was done on week 5 after emergence of the potatoes. The fallow borders were cultivated every week to remove weeds and any volunteer potato plants. Late blight was

[a] Corresponding author: Muo Kasina, jkasina@yahoo.com, P.O Box 14733-00800, Nairobi; Tel. +254204444144; Fax +254204443926

controlled by three spray applications of Mancozeb (a protective fungicide) and two spray applications of Metalaxyl (curative fungicide) in each season. Sorghum and wheat were tested because they are known to be hosts of several aphid vectors of PVY but cannot become infected with PVY. Maize, common bean and garden pea were evaluated because most farmers in Kenya rotate, intercrop or grow them adjacent to potato fields.

Aphid populations monitoring

Alate aphids and ladybirds were monitored using yellow painted sticky metal plate traps. The traps were mounted when 40% of potato tubers had emerged in all the plots. Clear polyethylene sheet was mounted on the yellow metal plate. On this polyethylene sheet sticky glue was applied to form a thin layer. The clear polyethylene was used so that the yellow color on the metal plate was not concealed and thus affect aphid landing on the trap. The traps were mounted about 0.5 m from the ground level and at the edge of every experimental plot. Every week the polyethylene sheet was carefully removed off from the metal plate and put in a labeled brown paper. Aphids were carefully removed from the polyethylene sheet using a dissecting needle and placed in a universal bottle half filled with 70% alcohol for preservation awaiting counting and identification. Ladybirds were also removed from the sticky yellow traps and counted. When 40% of the potato plants had emerged in each plot, five potato plants per treatment were randomly selected every week and three leaves clipped from bottom, middle and top part of each plant. Alate and apterae aphids were brushed from the leaves using a fine camel brush and placed into a universal bottle half-filled with 70% alcohol.

Visual and serological virus incidence assessments

During the long rains season, after 6 weeks of crop emergence, 12 plants from guard rows and 12 from sampling rows were randomly selected from each plot and three leaflets clipped from bottom, middle and top part of each plant. At the same period in the short rains season, 8 plants in the guard rows and 8 from the inner rows per treatment were randomly selected. From these plants three leaflets were clipped from bottom, middle and top of each plant. The leaflets were processed for PLRV and PVY indexing using Double Antibody Sandwich Enzyme Linked Immunosorbent Assay (DAS-ELISA) as described by Clark and Adams (1977). The ELISA results were expressed as a percentage of number of the plants that tested positive per sample/plot and this is the serological incidence. Visual viral incidence was estimated every week by identifying plants within a plot that showed viral symptoms. Diseased plant numbers were then expressed as a percentage of the total plant populations within a plot to give the visual disease incidence.

Data Analysis

Data were subjected to Analysis of Variance (ANOVA) and where it showed skewness, it was transformed by square root function [$(x+ 0.5)^{0.5}$]. Genstat statistical software Discovery edition (Anonymous, 2007) was used to aid in the analyses.

RESULTS

Aphid population assessment

Aphis gossypii was the most abundant, while *M. persicae* was the least abundant throughout the two seasons. There was significant (P<0.05) difference of aphid population in potatoes surrounded by different treatments in both seasons (Table 1). The lowest and highest aphid population was recorded in potatoes bordered by wheat and fallow, respectively. *Aphis gossypii* count was significantly (P<0.05) different in plots bordered by wheat, sorghum and maize in both seasons. However, there was no significant difference on infestation of potatoes by *M. euphorbiae* and *M. persicae* in plots surrounded by maize and sorghum crops during the two seasons. In comparison, plots surrounded by common beans had higher aphid population than those surrounded by garden peas in the two seasons. Only the count of *M. persicae* was higher on garden pea bordered plots than on common bean bordered plots in the long rains.

Table 1. Mean number of aphids on leaves of potatoes grown under different treatments in 2002 at Tigoni, Central Kenya

Treatment	**Long rains**			**Short rains**		
	Aphis gossypii	*Macrosiphum euphorbiae*	*Myzus persicae*	*Aphis gossypii*	*Macrosiphum euphorbiae*	*Myzus persicae*
Fallow	45.2	27.0	12.8	39.6	15.4	11.7
Bean	24.9	15.8	7.7	26.4	10.7	7.7
Garden pea	22.3	17.0	8.3	15.6	7.4	5.2
Maize	16.8	10.0	5.9	15.4	5.2	4.4
Sorghum	15.3	9.6	5.9	12.8	6.0	4.1
Wheat	9.7	6.3	3.8	8.8	3.7	2.8
P= 0.05	< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001
LSD	**0.9**	**0.6**	**0.5**	**0.8**	**0.5**	**0.4**

Alate aphid and ladybird catches on the yellow sticky traps

In the sticky traps, *M. euphorbiae* was the most caught aphid species while *M. persicae* was the least caught (Table 2). More alate aphids were trapped during the short rains than the long rains. Both sorghum and maize-borders recorded the highest number of trapped aphids. Although traps in the maize borders had lower count than traps in sorghum borders, they were not significantly (P>0.05) different from each other. The sticky traps placed in the fallow borders had the lowest aphid counts. Among the plant borders, traps in the bean treatment had the lowest count in all aphid species but *M. euphorbiae*, which was least-caught on wheat borders. The ladybird beetle, a main aphid predator, was caught in all traps but with no significance difference (P>0.05) across the treatments in both seasons. However, the beetles were highest in sorghum borders and lowest in bean borders.

Table 2. Alate aphids and ladybirds count per sticky trap placed at the edge of border crops during the long and short rains

Treatments	**Long rains**				**Short rains**			
	Aphis gossypii	*Macrosiphum euphorbiae*	*Myzus persicae*	ladybird beetles	*Aphis gossypii*	*Macrosiphum euphorbiae*	*Myzus persicae*	ladybird beetles
Beans	20.5	23.7	9.0	5.5	20.3	23.6	10.0	5.6
Wheat	19.2	22.2	9.8	6.4	19.3	22.5	11.1	6.5
Garden pea	17.9	23.9	10.2	6.0	17.8	24.1	10.3	5.8
Maize	30.7	35.3	10.9	6.6	30.7	35.9	12.4	6.9
Sorghum	33.5	38.6	15.3	6.5	33.6	40.5	15.9	6.5
Fallow-border	11.9	13.6	5.5	5.6	13.0	14.4	6.8	6.0
P= 0.05	<0.001	<0.001	<0.001	0.058	<0.001	<0.001	<0.001	0.052
LSD	**3.4**	**1.9**	**2.2**	**0.8**	**3.4**	**3.5**	**2.6**	**0.9**

In the long-rain season, aphid population increased in all the treatments for three weeks, and then declined except in bean bordered plots, before rising to peak at week 7 (Figure 1a). After this period, aphids declined towards the end of the season. In the short-rain season, aphid population peaked once in week 4 after crop emergence although there was a small peak at weak 6 (Figure 1b). The population of all aphid species had similar trend throughout the season.

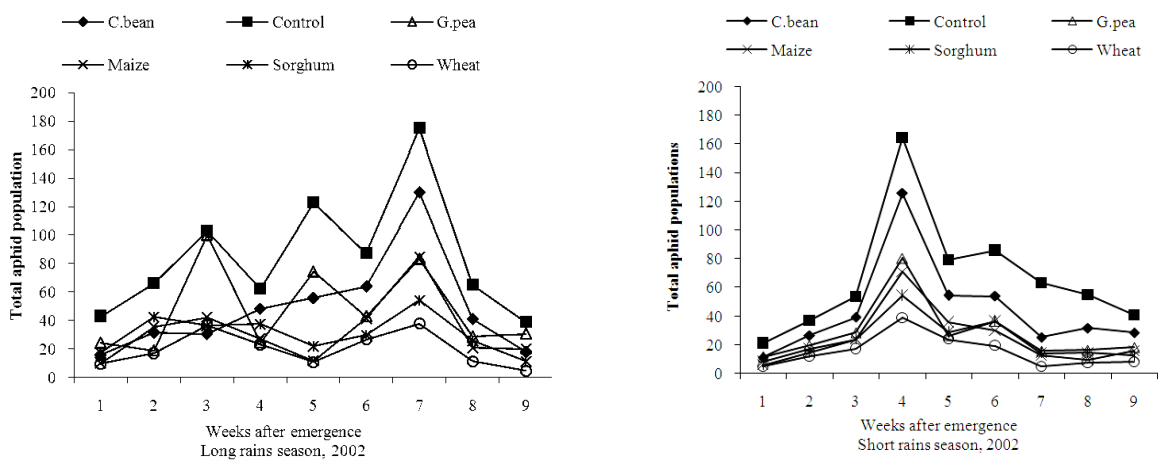

Figure 1 (a and b). Total aphid population in potato plots surrounded by border crops during the long and short rains

Visual and Serological incidence

In both seasons, the PVY visual incidence was significantly (P<0.05) different on potatoes under the different treatments (Table 3). In the long-rain season, potatoes surrounded by a fallow border had the highest visual incidence of PVY while those surrounded by beans had the lowest incidence. However, in the short-rain season, it is those potatoes surrounded by beans that had the highest visual incidence of PVY while fallow-bordered plots had the lowest. The intensity of the PVY incidence was different when serological analyses were performed (Table 3). The incidences were lower compared to visual incidence. In addition, fallow bordered plots recorded higher incidences compared to any other treatment. The serological incidence was higher on the outer rows compared with the inner rows in all the treatments. There was significant (P<0.05) difference among the different plots on the serological incidence of PVY except in the inner rows during the short-rain season. Also, plots bordered with garden peas had higher serological incidence especially on the outer rows compared with the other treatments. It is also noteworthy that the serological PVY incidence in the outer rows was more than double than in the inner rows in all the treatments.

Table 3. PVY serological incidence and visual incidence in potato plots surrounded by border crops during the long and short rains

Treatment	Short rains 2002			Long rains 2002		
	Serological incidence		Visual incidence	Serological incidence		Visual incidence
	Inner rows	Outer rows	Inner rows	Inner rows	Outer rows	Inner rows
Wheat	6.2	12.5	25.6	4.2	6.3	6.5
Common bean	15.6	31.2	18.7	10.4	22.9	16.8
Garden pea	12.5	40.6	18.8	12.5	27.1	17.4
Sorghum	12.5	25.0	15.4	4.1	16.7	11.5
Maize	12.5	31.2	15.0	12.5	16.7	12.8
Fallow-border	21.9	50.0	12.0	20.8	33.3	31.8
F= 0.05	0.451	<0.001	0.009	<0.001	<0.001	<0.001
LSD	15.38	12.52	7.26	5.885	6.029	7.5

In both seasons, there was progressive increment of the PVY visual incidence in potatoes across all the treatments (Figure 2a and b). However, this was more pronounced in the long-rain season compared with the short-rain season especially the first 4 weeks after crop emergence. Potatoes in plots surrounded by fallow had higher magnitude of the PVY visual incidence while those surrounded by wheat had the lowest.

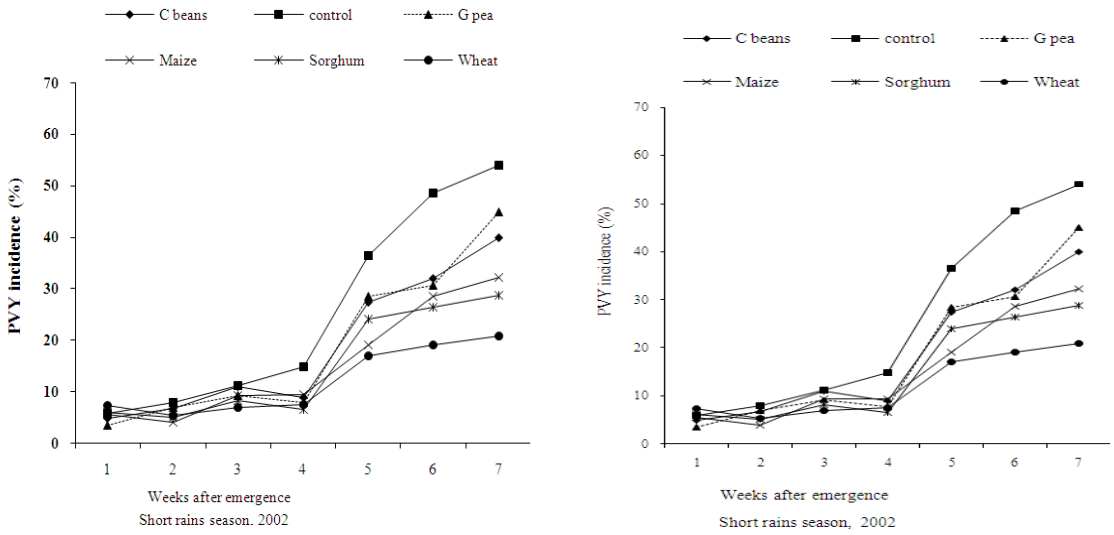

Figure 2 (a and b). PVY disease progress curves in potato plots surrounded by border crops during the long rains and short rains

DISCUSSION

In the field, Irish potato is mainly colonized by *A. gossypii*, *M. euphorbiae* and *M. persicae* (Nderitu and Mueke, 1986; Rongai *et al.*, 1998), which was confirmed in this study. The population trend of the aphids found colonizing the potatoes can be used to aid in decision making for their management, e.g., timing of insecticide application. In this study, trap catches could have played a role in terms of checking aphid colonization and abundance of the three aphid species on potatoes. For example, more *M. euphorbiae* were trapped compared with *A. gossypii*, which had higher numbers on the potato crop. Therefore, it would be safe to say that the yellow sticky trap could be used effectively to manage aphid infestation especially as part of a well planned integrated management strategy. This would work in terms of reducing the level of infestation of the pest onto the crop particularly if a large population of the aphids is trapped. However, the choice of color of the sticky trap would depend on the target aphids. For example, in this study, the yellow trap was more effective on *M. euphorbiae* compared with the other aphid species. Since the yellow color traps were found not to alter the general aphid trends over time, the catches could be used to predict aphid infestations on the crop and possible peaks. This would support decision making on which and when to apply a certain control measure. Other than traps, this study reports that aphid infestation on Irish potato was influenced by the border crops. Some border crops were effective in reducing the pest infestation on the potatoes. Among the cereals, maize allowed more alate aphids into the potatoes compared with wheat and sorghum border crops. This could be due to the growth pattern as well as the spacing of the crop. Maize is large and usually widely spaced compared with the others. Wheat requires the least spacing and can provide a better 'wall' compared with the other two, as reflected on the low number of aphids that colonized potatoes in plots it surrounded.

Lower populations of apterae aphids on potatoes in both seasons could be due to the delay of aphid movement by the border crops. That delay has effect on the ability of aphids to transmit viruses. For example, Jayasena and Randles (1985) reported barley-borders to reduce short-range spread of bean yellow mosaic by apterae aphids. Berger *et al.* (1987) reported that most aphid species can retain PVY on their mouth-parts for up to 6-8 h if denied feeding, simulating long distance dispersal. Several studies have confirmed the role of border crops in reducing virus spread on the main crop. Difonzo *et al.* (1997) found that borders of soybean and potato effectively displaced the crop fallow interface, protecting the interior seed plot from PVY. In other crops, Jones (1993) demonstrated that approximately 8 m border of oats surrounding lupins resulted in 13% plants infection and greater than 97% in unprotected lupins seeds plots. In the present study, the low percentage infection of the protected plots was attributed to loss of PVY by incoming viruliferous alates as they probed on non-host (the oats border) before moving to the lupins. Although cereal border crops have been reported as more effective than legume borders (Jones, 1993), this study did not show any of this. Thresh (1982) attributed the benefits of border crop with a non- host to increased separation between susceptible plants, provision of a barrier to movement of inoculum by the non-host, and possibly also as a source of natural enemies of the vector, which seem to reflect the findings from this study.

Crop borders appear to be an effective and practical method for reducing PVY incidence. In plots with fallow borders, PVY incidence was significantly higher than in other treatments. These results are consistent with the many reports of higher incidence of transmitted virus infections on the crop edges (outer rows) (Raccah *et al.*, 1985; Difonzo *et al.*, 1996). It can be interpreted from the findings that border crops effectively displaces the crop fallow interface to the border margin, significantly reducing PVY incidence in the protected (bordered) seed potato plots. Border crops did mechanically block alate aphid landings, as noticed of the low apterae aphid populations recorded in cereal-bordered crops, i.e., wheat, sorghum and maize.

Since most of the bordered crops used in this study have a market value in terms of their yield, careful selection of these crops can enable farmers to obtain maximum benefit of clean seed tubers and added income from sale of border crops. Therefore, keenness in selection of border crops in combination with other aphid and virus management strategies, e.g., seed lot inspection and certification, chemical control, rouging and ELISA testing can be used as part of an overall aphids and PVY management in seed potato production.

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