MANAGEMENT OF APHIDS AND APHID-TRANSMITTED VIRUSES IN STORED SEED POTATOES IN KENYA

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ABSTRACT

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This study was carried out in two storage seasons viz. May to August 2002 and November 2002 to February 2003 to determine effectiveness of insecticides (bifenthrin, dimethoate, mineral oil, pirimiphos-methyl plus permethrin) and commonly used indigenous technical knowledge (ITK) technologies (fresh blue gum leaves, dry grass and wood ash) to reduce aphid infestation and manage aphid-transmitted viruses in stored potato seed tuber sprouts during 2002 and 2003 at National Potato Research Center (NPRC), Tigoni, Kenya Agricultural Research Institute, Kenya. Three aphid species Aulacorthum solani, (Kalt) Myzus persicae (Sulzer) and Macrosiphum euphorbiae (Thomas) colonized the stored seed tubers. Aulacorthum solani was the most common followed by M. persicae then M. euphorbiae in both storage periods. Both bifenthrin and wood ash significantly ($P<0.05$) reduced aphid infestation. Two of the most economically important potato viruses such as potato leaf roll virus (PLRV) and potato virus Y (PVY) were serologically identified in all tubers infested by aphids with the latter having the lowest incidence in bifenthrin treated tubers while the former had its lowest incidence in DC Tron treated tubers. Both viruses had their highest incidence in untreated tubers. The presence of aphids and their related virus diseases on stored tubers affirms the importance of the storage phase pest management to assure quality seed tubers. This would reduce field losses associated with the aphids and the aphid-transmitted viruses. In addition, better quality seeds would assure farmers of improved productivity hence more family income.

Key words: Aphids, Aphid-vectored diseases, insecticides, indigenous technical knowledge

INTRODUCTION

Potato (Solanum tuberosum L.) is the most important tuber crop in Kenya and second after maize among all crops in the country (MOA, 2007). It is grown by small holder farmers as a food security crop and as the main source of family income. The production is constrained by lack of quality seeding material, usually the seed tubers. Most farmers use uncertified seed tubers from previous harvest, buy from the local market or acquire from their neighbors (Barton et al., 1997) oblivious of the latent infection status of these tubers. This is partly due to expensive certified seeds available in the market. In addition, there is poor availability of the certified seed tubers due to inadequate multiplication. Tuber-borne diseases such as bacterial wilt, caused by Ralstonia solanacearum (Smith) and those caused by viruses are major constraint to production of clean disease-free potato seed tubers as well as causing major yield losses of the crop in the field in Kenya (Kinyua et al., 1998). Therefore, the seed tuber storage is geared towards provision of optimum conditions to have viable and productive seed tubers at the time required for planting. Quality of seed potato tubers is the most important yield-determining factor and also a major constraint to potato production in many potato-growing developing countries (Struik and Wiersema, 1999). Storage management is therefore necessary to have viable seeds and establish a health crop not only in potato production but also for sustainable agricultural systems. In Kenya, aphids have been reported to infest stored seed tubers and have been known to disseminate severe viral diseases during the storage phase (Robertson and Wambugu, 1975). This is associated with the poor seed quality. For example, Booth (1984) found that degeneration of seed potato in stores occurs within short storage periods in unprotected seeds, due to virus infections. Pesticides have been shown to reduce aphid infestation in stores, leading to reduction of aphid-transmitted virus diseases. However, many farmers in Kenya use traditional technologies to manage storage pests of seed potatoes, e.g., use of wood ash (Kariuki, 1999). This study was done to evaluate the effectiveness of commercially available insecticides and commonly used traditional technologies for the management of aphids and aphid-vectored viruses in potato seed stores. The findings would assist in promoting the effective technology that would assure quality seeds for crop establishment. This would impact on the household food security and improve their family income.

MATERIALS AND METHODS

This study was carried out in two storage seasons (May to August 2002 and November 2002 to February 2003) at National Potato Research Center (NPRC), Tigoni, Kenya Agricultural Research Institute. One hundred certified sprouted potato tuber seeds (cv Desiree) were obtained from the centre, which is mandated tofgdru carryout national research on matters of potatoes and multiply clean seed potatoes for farmers. The seeds were put in wooden crates and stored in semi-diffuse light store. Each crate acted as a single plot. In the first storage season, six treatments were applied: neem extract spray (56 ml a.i /15 litre of water), neem extract dust (500g a.i /90 kg), brigade 250 EC (bifenthrin 2.4 l a.i /ha), Dimethoate 2.4 l a.i/ ha, Dc Tron 5.0 l a.i/ha (mineral oil) and tap water. These treatments were applied on seed tubers in the crates. In the second storage season, more treatments were included to reflect the farmers practice and traditional technologies. Those added were pirimiphos-methyl + permethrin 50g a.i/90 kg, wood ash 100g/90kg, malathion dust 50g a.i/90 kg, blue gum fresh leaves and dry grass. The blue gum leaves and grass were spread on each crate to form a physical barrier to aphids. Treatments were arranged in a completely randomized design (CRD) and replicated 3 times. A hand operated lever sprayer was used to apply the liquid treatments while dusts were sprinkled by protected hand. Treatments were applied once a month for 3 months.

Aphid infestations

Seven seed tubers were randomly selected from each crate just before treatment application and repeated at an interval of two weeks for three months to assess the level of aphid infestation. Aphids were brushed off from the sprouts with a camel brush onto a petri- dish. The aphids were later transferred into a universal bottle half filled with 70% ethyl alcohol for identification and counting in the laboratory. During sampling period, climatic data, particularly the prevailing temperatures, were recorded.

Virus disease assessment

To measure viral disease presence on the seed tubers from the different treatments, ten tubers were randomly selected from each plot in the store after 12 weeks of establishment and planted (in plastic pots) in an aphid proof screen house. The treatments were arranged in a CRD and replicated three times. Forty–five days after emergence, four potato plants were randomly selected from each plot and three leaflets were clipped from bottom, middle and top part of the potato seedling. The leaflets were processed for potato leaf roll virus (PLRV) and potato virus Y (PVY) indexing using DAS-ELISA as described by Clark and Adams (1977).

Data analysis

Analysis of variance (ANOVA) was done for all the collected data and means separated by least significant difference (LSD). Data were square-root $((x+0.5)^{0.5})$ transformed if not normally distributed to fit the requirements of ANOVA. GENSTAT ver. 7.0 statistical software was used to carry out the analysis.

RESULTS AND DISCUSSION

Aphid infestations

Three aphid species were recorded infesting the potato seed tubers: Foxglove aphid, Aulacorthum solani (Kalt), Green peach aphid, Myzus persicae (Sulzer) and Potato aphid, Macrosiphum euphorbiae (Thomas). Aulacorthum solani had the highest number among the three aphid species in the first storage season. However, as temperature decreased, its numbers decreased by about 10%. In contrast, the numbers of M. persicae and M. euphorbiae increased by 50% and 20%, respectively, at the same period (Table 1). In the second season, temperature increase of 3% resulted to increased number of aphids, three times M. persicae and four times for M. euphorbiae. Likewise, the numbers of A. solani increased by 9% due to increase of temperatures by 1°C, which similarly resulted to increase M. persicae by 22%. Generally in both seasons, the number of A. solani was about 5 and 2 times more than that of M. euphorbiae and M. persicae, respectively (Table 1). The aphid infestation was higher in the second storage season. There was significant ($P<0.05$) difference in aphid infestation among all the treatments in both seasons. Seed tubers in plots treated with brigade were least infested while those in untreated plots had the highest infestation by all the different aphid species. Tubers in plots treated with dry grass, blue gum fresh leaves and neem dust were not significantly ($P>0.05$) different in reducing infestations by A. solani and M. persicae. The wood ash treatment had similar effects to DC Tron and neem spray in reducing infestations of M. euphorbiae and M. persicae.

In the first storage period, A. solani had higher infestations at start of experiment but this decreased as the storage period progressed although there were some population peaks at week 6 to 8 and week 10 to 12 (Figure 1). The number of the other aphid species, M. euphorbiae and M. persicae progressively increased to peak at week 2 of storage but then declined thereafter throughout the remaining storage period. In the second storage period, the number of the entire three aphid species increased steadily towards week 2 of storage then followed by slight population decline.

Serological incidence assessment of PLRV and PVY

There was higher virus (both PLRV and PVY) incidence on seed potato tubers in the second storage season compared with the first season although not significant (Table 3). In terms of response, there was significant

($P<0.05$) difference among all the treatments on the viral incidence in the seed potato tubers in both seasons. The incidence of PLRV in season 1 was lowest in seed tubers treated with brigade and dimethoate although the two were significantly ($P<0.05$) different with the former having the lowest count. The incidence of this virus was highest in seed tubers under control. In contrast, PVY incidence was significantly ($P<0.05$) lower in DC Tron treated tubers and highest in seed tubers under control. Similarly in the second season, seed tubers treated with brigade and dimethoate recorded the lowest ($P<0.05$) PLRV incidence while those treated with DC Tron and brigade the lowest ($P<0.05$) PVY incidence. All the treatments performed differently in terms of reducing the viral incidence when compared with the control. The PLRV was the most responsive to the different treatments compared with PVY. For example, DC Tron, which was the most effective against PVY reduced the incidence by 41% and 45% in the first and second season, respectively compared with the control. In contrast, brigade, which was the most effective against PLRV lowered the incidence by 54% and 58% in the first and second season, respectively, compared with the control. Brigade was the second most effective treatment for PVY, reducing its incidence by 37% and 31% in the first and second season, respectively. Likewise Dimethoate was the second most effective treatment against PLRV, reducing its incidence by 51% and 57% in the first and second season, respectively. The neem based treatments performed poorly compared with the synthetic insecticides. However, among the two neem treatments, seed tubers under the spray treatment had significantly ($P<0.05$) lower viral incidence than the dust treated tubers. In addition, PLRV was more responsive compared with PVY in both seasons. Wood ash was effective as brigade and dimethoate, and better than malathion and actellic super in reducing the incidence of PVY but it was less effective against PLRV when compared with these other insecticides. Actellic super was the third most effective treatment against PLRV but was comparable to most synthetic treatments against PVY.

(a)

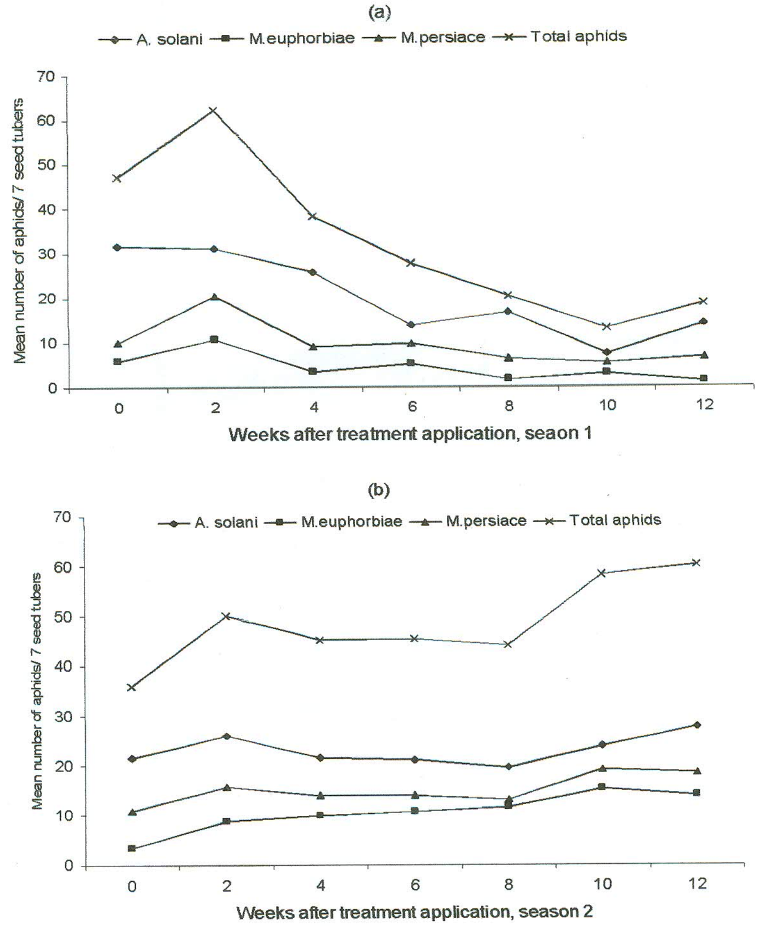

Figure 1 a and b: Mean number of different aphid species infesting seed potato tubers in two storage seasons (2002-2003) at National Potato Research Center, Tigoni

Table 1. Mean aphid numbers infesting seed potato tubers at different storage temperatures in two seasons

Months	Temperature (°c)	M. persicae	A. solani	M. euphorbiae
May 2002	15.1	9.7	31.7	5.9
June 2002	14	14.6	28.4	7.1
July 2002	14	9.4	15.3	3.4
August 2002	14	2.5	11.6	2.5
November 2002	16	5.5	11.5	2
December 2002	16.5	14.8	23.6	9.3
January 2003	18	13	20.2	11.1
February 2003	17.4	18	25.7	14.6

Table 2. Mean number of aphids infesting seed potato tubers in two storage seasons

Treatments	First season (May-August 2002)			Second season (November 2002- February 2003		
	A. solani	M. persicae	M. euphorbiae	A. solani	M. persicae	M. euphorbiae
Control	69.3	22.5	14.2	47.2	33.3	24.5
Dry grass	NA	NA	NA	31.1	19.5	15.5
Blue gum	NA	NA	NA	30.8	20.0	14.8
Wood ash	NA	NA	NA	20.8	14.8	10.0
Brigade	1.3	2.0	1	10.0	5.1	2.6
Malathion dust	NA	NA	NA	14.6	9.4	5.0
Actellic super	NA	NA	NA	11.9	8.3	4.8
DC Tron	12.3	5.3	2.5	21.8	14.7	10.5
Dimethoate	2.4	3.0	2.0	10.6	6.3	4.0
Neem dust	10.7	5.8	2. 4	29.6	18.5	12.7
Neem spray	24.6	13.8	7.4	23.7	15.5	11.2
P (95%)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
LSD	0.9	0.8	0.6	5.9	4.3	0.6

Table 3. Incidence (%) of PLRV and PVY in seed potato tubers in two storage seasons

Treatment	Season 1		Season 2	
	PVY	PLRV	PVY	PLRV
Control	53.0	56.3	70.0	72.0
Dry grass	NA	NA	66.0	59.3
Blue gum	NA	NA	60.0	56.7
Wood ash	NA	NA	48.3	37.0
Brigade	19.7	2.0	39.3	11.7
Malathion	NA	NA	43.0	20.3
Actellic super	NA	NA	42.0	15.3
DC Tron	11.0	23.0	25	46.0
Dimethoate	25.0	5.0	41.0	12.7
Neem dust	40.7	45.0	57.7	54.3
Neem spray	36.3	38.3	56.3	47.3
P (95%)	<0.001	<0.001	<0.001	<0.001
LSD	3.9	3.6	3.2	3.8

The presence of aphids in the seed potato tubers showed their importance as storage pests of this crop. Other than the physical damage, they are also key vectors of the viral diseases, PVY and PLRV that were screened in the infested tubers. All the three aphid species recorded are reported as main vectors of various viruses on potatoes in Kenya (Farrell et al., 1995). However, an additional species, Aphis gossypii, a known potato pest in Kenya, was not recorded in the stored seed tubers. This could imply that this pest does not affect potatoes in store although it is a main field pest. Myzus persicae is a main vector of PLRV (Päts, 1985; Stötzer and Kanyagia, 1980) but it was easily controllable using brigade, resulting to low PLRV incidence in brigade treated plots.

The high incidences of PLRV and PVY could be associated with the presence of A. solani and M. persicae in the stores, which have been confirmed as efficient vectors of the two important potato viruses (Robertson and Wambugu, 1972). The high aphid populations observed on stored potatoes during the November-February storage period emphasize the significance of temperature in aphid flight and colonization. Radcliffe (1982) observed that low temperature (below 17.7 °C) reduces flight of alate aphids. From the study it can be inferred that November-February storage period is accompanied by increased PLRV and PVY build up in the stores. Booth (1984) and Robertson and Wambugu (1975) reported that total number of aphids infesting sprouts increases at the same rate in different light and dark stores, but that more winged aphids are evident on tubers stored in darkness. Since aphid population increased throughout the storage phase stringent aphid and viruses control measures need to be put in place to reduce seed degeneration.

Results from this study indicate that the use of bifenthrin, dimethoate, and actellic dust during the storage phase reduces aphid infestation and thus PLRV and PVY incidence. Booth (1984) demonstrated that spraying the stored tubers every fifteen days with insecticides controlled aphids build up and dissemination of the aphid transmitted PLRV and PVY (CIP, 1976; Nderitu, 1991)). Parker et al. (1983) found that spraying stored tubers with insecticide Monitor controlled aphid build-up and thus indirect control of aphid-transmitted viruses. He further reported that failure to control aphids on sprouts in either dark or well-lit stores was accompanied by increased PLRV and PVY incidences increase in subsequent plantings. Hanafi (2000) and Bradley et al. (1966) reported that mineral oils form a thin film on tuber surface thus impeding transmission of stylet borne viruses like PVY (Bradley et al. 1962). The results reported here agree with the above finding since all DC Tron treated tubers had low PVY incidences. Wood ash emerged as a promising strategy for aphid and aphid-vectored virus control and this is in agreement with the reports of Kariuki (1999).

The high levels of virus infection in this study where no pesticide was applied clearly shows that unprotected seed can be completely infected by viruses within a short period. At the beginning of this study certified seed was used, but by the end of storage periods the unprotected seed had about 71% PLRV and 53% PVY infection. This results are consistent to those of Booth (1984) who reported that the incidence of PVY and PLRV, increased from a base level of 3% to 72.5% and 89.7% in one clone stored unprotected for six months, respectively. This information confirms the importance of the storage phase in maintaining the health standards of seed tubers. Thus, if attention is not paid to the risk of transmission of viruses by aphids during storage, the expensive results of several years of seed multiplication may be lost in just a few weeks. Additionally, the potential for virus build-up during the storage period may help explain common reports of considerable reduction in virus health standards from one crop season to the next and which have previously been attributed to late season aphid activity in the field.

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