Evaluation of relative resistance of four cowpea (*Vigna unguiculata* (L.) Walp) varieties to the black cowpea aphid (*Aphis craccivora*) in southeastern Botswana

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ABSTRACT:
Cowpea (*Vigna unguiculata* (L.) Walp) is an important food legume in many tropical countries, but its production is seriously constrained by insect pests. *Aphis craccivora* is one of the major pests of cowpea worldwide. Abundance of the pest was assessed on four cowpea varieties, Black eye, B359, IT18 and Tswana in field cages in order to determine their relative resistance to the pest in southeastern Botswana. The data was analysed using MSTAT-C programme package. Aphid abundance varied significantly between varieties ($P < 0.05$). Overall abundance was greatest (95.4 aphids per plant) on Black eye and least (17.7 aphids per plant) on IT18 plants. Therefore cowpea variety IT18 was 5.3 times more resistant to the black cowpea aphid than variety Black eye. Using relative resistance to *A. craccivora*, the varieties were ranked in the order: IT18 ≥ B359 ≥ Tswana > Black eye. A relatively higher proportion (53%) of alates than apterae was produced on variety IT18. Variety IT18 showed a combination of antibiosis and antixenosis mechanisms of resistance against the pest. This variety would be the most suitable for use in breeding programmes aimed at developing more resistant cultivars to the cowpea aphid.
Keywords: *Aphis craccivora*, Botswana, cowpea, resistant cultivars, resistance mechanisms,

INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp) is an important food legume that is widely grown in many African countries including Botswana (Karikari and Molatakgosi, 1999). One of the main advantages of growing cowpea is that it is able to fix nitrogen and therefore can grow well in soils with relatively low nitrogen content (Singh and Rachie, 1985). Its leaves and immature pods are used as vegetables while dry seeds are prepared as relish to accompany main dishes. Its seeds contain about 23 to 30% protein (Bressani, 1985) and are relatively cheaper than meat and fish. As a result, cowpea is an important source of dietary protein for the rural and urban poor who cannot afford meat or fish. However, although it is an important crop for resource poor farmers, cowpea production is greatly constrained by pests in all growing areas (Sing *et al.* 1990, Singh and Jakai, 1985).

Major pests of cowpea in Africa include: the cowpea aphid (*Aphis craccivora*), legume pod borer (*Maruca testularis*), legume bud thrip (*Megalurothrips sjostedti*), coreid bugs (*Anoplocnemis curvipes, Riptortus dentipes, Clavigralla tomentosicolis, C. shadabi* and *C. elongata*) and cowpea storage weevils (*Callosobruchus maculatus* and *C. chinensis*) (Singh, 1990, Singh and Rachie, 1985). Insect pests are the main cause of failure to obtain the potential yield of 1,500 kg per hectare in most growing areas (Omitogun *et al.*, 1999). They can cause 100% cowpea yield losses on susceptible cultivars, if they are not controlled (Singh and Jakai, 1985). The black cowpea aphid is a common pest of cowpea in all cowpea growing areas of the world (Singh *et al.* 1990). It is one of the few aphid species that are considered to be major pests of cowpea in the tropics (Pettersson, 1998, Blackman and Eastop, 2000). The black cowpea aphid has been reported as a major pest of cowpea in Botswana (Ingram *et al.*, 1973, Obopile, 2006), and other Africa countries (Isubikalu *et al.*, 1999 Karungi *et al.*, 1999, Javaid *et al.* 2005). In Uganda, Nampala *et al.* (1999) and Karungi *et al.* (1999) found that the only satisfactory method of controlling cowpea aphids under field conditions was the use of a combination of pest control methods including host plant resistance, intercropping, seed dressing and minimum use of insecticide sprays applied at critical periods of crop development in an integrated manner. The need for development and identification of cowpea varieties that can be used in integrated pest management programmes against the cowpea aphid has been advanced by other researchers in Botswana (Obopile and Ositile, 2009, Obopile 2006) and elsewhere (Isubikulu *et al.*, 1999, Javaid *et al.*, 2005, Nampala *et al.*, 1999, Omitogum *et al.*, 1999, Singh *et al.* 2006). Javaid *et al.* (2005) reported that cowpea varieties that were observed to be resistant to *A. craccivora* in Africa were not resistant to the aphid populations in Georgia (USA), demonstrating the importance of evaluating local germplasm for host plant resistance to this species. The aim of this study was to screen available cowpea germplasm for resistance to *Aphis craccivora* that can be used in integrated pest management strategies in Botswana.

MATERIALS AND METHODS

Experimental site

Four cowpea (*Vigna unguiculata* (L.) Walp) varieties: Black eye, B359, IT18 and Tswana were evaluated for resistance to the black cowpea aphid (*Aphis craccivora*) in cage experiments conducted in the field at the Botswana College of Agriculture, Gaborone, Botswana (Longitude 25^0 54' E, Latitude 24^0 33' S).

Experimental design and crop management

The experimental design was a completely randomized design with three replicates. Two cowpea seeds of each variety were sown in black polythene pots of 10 cm diameter and 20 cm depth, filled with potting soil. The seeds were planted on the 7th of February 2005 and the seedlings were thinned to one per pot 14 days after emergence. Each plant was placed in a separate labeled cage (30 cm long, 30 cm wide and 45 cm high), 21 days after emergence. The cage was covered with fine mosquito netting to prevent aphids from escaping or from invading the plant. Each cultivar was replicated three times. A completely randomized design was used. One mature aphid was placed on each plant and left to produce nymphs for 24 hours and then removed. All except one of the nymphs were then removed from each plant in order to start the experiment with the same number of aphids that were of the same age. The remaining nymph was left to develop to maturity and to breed.

Dependent variables determined

The abundance of aphids on each plant was assessed using direct counts, once every five days, on 10 assessment dates (1st March, 6th March, 11th March, 16th March, 21st March, 26th March, 31st March, 5th April, 10th April and 15th April 2005) following the initial infestation. Relative susceptibilities of the different cowpea varieties were assessed by comparing average abundances of aphids on the plants. The number of apterous aphids and alates produced on the different varieties was also used to determine relative susceptibilities of the varieties. Rainfall was recorded on each assessment date. The experiment was terminated after the last assessment date when the plants had deteriorated.

Data analysis

Data collected was subjected to analysis of variance using the MSTAT-C programme package. Where significant F-test was observed, treatment means were separated using the Honest Significant Differences (HSD) of Tukey's test at P = 0.05. Appropriate regression and correlation models were used to determine the relationships between rainfall and pest abundance.

RESULTS

The average number of cowpea aphids per plant varied significantly (P < 0.05) between dates and variety (Figure 1). The interactions between dates and varieties were also significant (Figure 1). The greatest number of aphids (261.3 aphids per plant) occurred on Black eye plants assessed 31 days after initial infestation while the smallest (0.8 – 0.9 aphids per plant) were on all varieties 20, 25 and 35 days after initial infestation. The overall assessment date averages showed that cowpea aphids were most abundant on cowpea plants 30 days after initial infestation and least abundant 20, 25 and 35 days after initial infestation. The overall varietal averages were greatest (94.5 aphids per plant) on Black eye plants and lowest (17.7 aphids per plant) on IT18 plants.

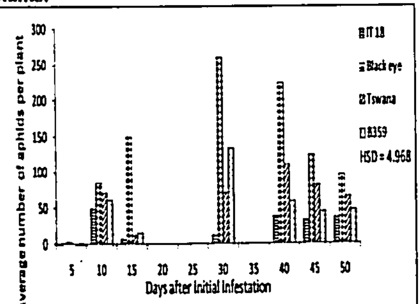

Figure 1: Average number of cowpea aphids per plant (alates and apterae) on four cowpea varieties on different days after initial infestation

Rainfall significantly affected abundance of cowpea aphids (Figure 2). Figure 2 shows that periods of low cowpea aphid abundance either coincided with or occurred during periods that followed considerable amounts of rainfall in the study site. Cowpea aphid abundance was negligible at 20, 25 and 35 days after initial infestation following 7, 22, 35 and 7mm of rainfall that fell at 15, 20, 25 and 30 days after initial pest infestation. The highest amount of rainfall (34 mm) received in the study area occurred 25 days after initial pest infestation while the least occurred at 10, 35, 40, 45 and 50 days after initial infestation.

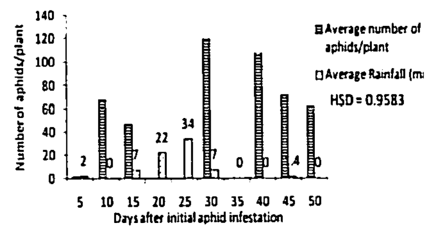

Figure 2: Showing relationship between overall average number of cowpea aphids across varieties per plant and average rainfall

Apart from the pest density that occurred 30 days after initial infestation, aphid abundance on cowpea plants was high during the days when rainfall in the study site was minimal. However, in general rainfall amount is negatively correlated to aphid number per plant (Figure 3). High rainfall significantly (P = 0.05) lowered the number of aphids per plant (Figure 3).

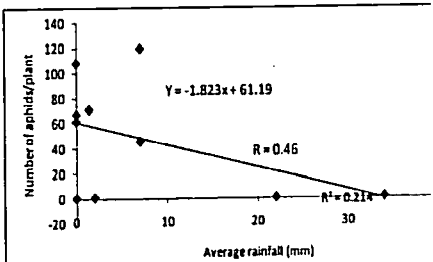

Figure 3: Relationship between overall average number of aphids per plant and rainfall

The overall average number of cowpea aphids was greatest (94.5 aphids per plant) on Black eye plants and lowest (17.7 aphids per plant) on IT18 plants (Figure 4). However, the overall average number of aphids on cowpea variety IT18 was not significantly different from the numbers found on varieties B359 and Tswana.

The proportion of alates (winged forms) produced differed significantly (P = 0.05) among the varieties. Figure 4 shows that while the ratio of winged to apterae (wingless forms) produced was not significantly different on IT18, and Tswana varieties, significantly (P = 0.05) more winged forms than wingless forms were produced on B359 and Black eye plants.

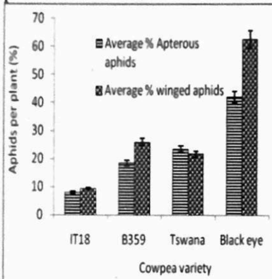

Figure 4: Overall percentage of apterous and alate forms of cowpea aphids produced on different cowpea varieties

DISCUSSION

The results showed that average abundance of cowpea aphids was significantly affected by the cowpea variety on which they were reared and the date on which the populations were assessed. Rainfall was a major mortality factor against cowpea aphid populations on all cowpea varieties. Aphid abundance was lowest during periods of high rainfall and greatest during periods of low rainfall. The results also showed that while 2 mm of rainfall that fell 5 days after initial pest infestation was not followed by a decline in cowpea aphid abundance, 7 mm of rainfall that fell 15 days after initial pest infestation caused the overall average aphid abundance to decline from 46 to almost zero aphids per plant on plants assessed 5 days later. Similarly, 7 mm of rainfall that fell 30 days after initial pest infestation was followed by a decline in the overall pest abundance from 119 to almost zero aphids per plant on plants assessed 35 days after initial infestation. This pattern suggests that the amount and intensity of rainfall required to effect an almost total wash-off of aphids from cowpea plants under field conditions is as little as 7 mm. These results can have practical value in the effective control of the cowpea aphid in cropping systems where sprinkler irrigation systems are used. The negative linear relationship (r = - 0.46) between the total rainfall and the overall number of aphids per plant suggests that rainfall plays an important role in the control of *A. craccivora* on cowpea in the field during the growing season. Similar results were found in studies on the control of *Aphis gossypii* on okra in Botswana (Munthali and Mmapetla, 2008).

Varietal resistance can play an important role in the control of the cowpea aphid, *Aphis craccivora* on cowpea. Significant differences in the average number of aphids that occurred on the different cowpea varieties suggest that the pest status of this species varied depending on the variety planted. A variety such as Black eye, on which the highest number of aphids were produced can be considered to be the most susceptible while that on which the lowest number were produced can be regarded as the least susceptible and therefore the most resistant. It can, be concluded that variety IT18, which had the lowest average number of aphids per plant was the most resistant to the pest while variety Black eye which had the highest number was the most susceptible of the four varieties evaluated in the study. The average pest density on Black eye plants was 5.3 times that on IT18. This shows that, on the basis of aphid abundance, variety IT18 was 5.3 times more resistant to the black cowpea aphid than Black eye.

Similarly, varieties B359 and Tswana were 2.6 and 2.3 times more resistant than the Black eye variety. Low abundance of pest individuals on a resistant variety could be a result of reduction in reproductive capacity of the pest or reduction in its development on the plants. This could explain the low average numbers of aphids that occurred on IT 18 plants. A cowpea variety that affects the biology of the pest through reduction of its reproductive capacity or development uses the antibiosis mechanism of resistance (Dent 2000; Russel 1978). This may suggest that IT18 uses the antibiosis mechanism of resistance against the cowpea aphid.

The results found in this study showed that a high proportion of aphids produced on IT18 plants (53%) were alates. Since IT18 variety showed resistance to the cowpea aphid, the production of winged forms was probably induced to enable the species to escape from the plants. When insects leave unsuitable cultivars (by switching to the alate form) it is regarded as a measure of antixenosis (Dent 2000). Aphids are known to produce alates on resistant varieties to escape from the unsuitable hosts (Dent, 2000). The production of a higher proportion of winged forms of aphids than apterous forms on the relatively resistant cowpea varieties IT18 and B359 compared to the Tswana variety could be a result of antixenotic action of the variety against the pest. This suggests that cowpea variety IT18 uses a combination of antibiosis and antixenosis against *A. craccivora.* The use of a combination of antibiotic and antixenotic factors has been found to explain aphid resistance in grain legumes elsewhere (Edwards 2001). The results in the present study are similar to those by Annan *et al.* (1996) in which cowpea variety ICV-12 that was developed by the International Institute of Tropical Agriculture (IITA) exhibited both antibiotic and antixenosis resistance to *A, craccivora.*

The results of the current study also showed that a high proportion of alates was produced on the relatively susceptible cowpea variety, Black eye. Aphids can also produce alates on highly susceptible host plants for dispersal purposes when their populations become too high to be sustained on the infested host plant (Pettersson *et al.*, 1998). In this case production of alates is an indication that the host plant has deteriorated in quality and is no longer a suitable host. A high population of alates would be an indication that the host plant is becoming overcrowded and, therefore, unsuitable for the pest (Pettersson *et al.*, 1998). The significantly high proportion of winged forms that was found on the highly susceptible cowpea variety, Black eye, could be explained by overcrowding. The production of large numbers of winged forms may result in rapid spreading of the pest to other plants in a crop.

CONCLUSIONS AND RECOMMENDATIONS

The results of this study showed that plant resistance can play an important role in the development of cowpea varieties that are more tolerant to cowpea aphid infestations. The cowpea variety IT18 was the most resistant against *A. craccivora* among the varieties evaluated. Its use in breeding programmes aimed at developing cowpea cultivars with greater resistance to cowpea aphids is recommended

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