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Factors Causing Yield Reduction in Snake Cucumber (*Cucumis melo var. flexuosus*) During Summer and Winter Seasons in Central Sudan

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ABSTRACT

Two trials were conducted at Geneid sugar cane farm, the first in the summer season of 2007 and 2010. The snake melon variety Silca was planted in a randomized complete block design with four replications and four treatments. The objective was to study the effect of the plant growth regulator ethrel and manual pollination on sex expression, vegetative growth and yield in the summer months. The second trial was executed in the winter season of the year 2007 and 2010 to test the new Powdery Mildew Resistant (PMR) line of snake cucumber compared with the local variety (Silca), for powdery mildew resistance, earliness of flowering, yield, number of fruits, number of primary and secondary branches and the number of unmarketable fruits per plant. The results showed that spraying ethrel at a concentration of 250 ppm at the 2nd leaf stage significantly reduced the male to female flower ratio and enhanced the yield. The study confirmed the role of ethrel in flower sex modification and lowering the sex ratio by suppressing the production of male flowers. The treated plants recorded a sex ratio of 42:1 compared to the control (93:1), and increased the branches after the first node. No significant difference in fruits, aborted flowers and aborted fruits perplant were observed.

In the second trial, significant differences were found in favour of the PMR line over silca in earliness of flowering, yield, number of secondary branches and powdery mildew resistance but no significant differences were shown in the number of fruits, primary branches or unmarketable fruits per plant

Keywords: Yield reduction; Snake cucumber (Cucumis melo var. flexuosus); Summer and winter seasons; Central Sudan

Introduction

The snake melon Cucumis melo var flexuosus is an important vegetable crop having a wide biodiversity of races in the Sudan. Different races have been domesticated and grown as farmers cultivars, such as the cultivar (silca) which is characterized by straight, slender, light green fruits having shallow grooves.

The main breeding objectives for snake melon are disease and insect resistance, and better fruit quality. Breeding for resistance is a top priority because the fruit is often consumed fresh, making it hazardous to use chemicals, especially where pesticide restrictions are not observed. Breeding for quality aims at producing cultivars with slender, tender and good colored fruit for the fresh consumption in green salads [1]. Many local land races are not resistant to diseases and insects. One of the most important diseases is the powdery mildew caused by the fungus (Sphaerotheca fuliginea). Which limits the production of the cucumber in winter season and causes great reduction in fruit yield if not controlled. Scheduled spraying programs with fungicides are recommended to avoid crop losses. These are very expensive for the farmers and hazardous to consumers. The snake cucumber PMR inbred line is homozygously

resistant to powdery mildew caused by the fungus (Sphaerotheca fuliginea) (race,1-2). The gene that conferred this resistance was transferred from the line P1 124112 by back-crossing to affixed snake cucumber line (silca). At the end of the breeding program, the resistance of this line was confirmed by incubation in controlled conditions at INRA (France). Now this line will be tested to be released as an open pollinated variety.

It is also noticed that the yield of snake cucumber is reduced during the summer season, especially when planted in the months of April and May. This may be due to the reduction of bee activity which, in turn, is affected by climatic conditions. The bees become inactive when wind speed is more than 24 km/hr, and the temperature is higher than 30ºC. Another factor could be that high temperature causes a reduction of the female flowers.

Therefore, the objectives of this study were to study the effect of the growth regulator ethrel on flower sex ratio and the effect of manual pollination on snake cucumber yield in summer and also to evaluate the inbred line (PMR) for powdery mildew resistance and horticultural characters in winter.

Materials and Methods

The work reported here was carried out at Geneid sugar factory farm (Latitude 14 15′, longitude 33º 38 E, altitude 500 m above sea level), Sudan. The soil belonged to the heavy central cracking clay plains. Two experiments were conducted during the period of the study, repeated in two seasons.

The summer experiment

This experiment started during May 2007 and repeated in May 2010. The purpose of this experiment was to evaluate snake melon performance during the summer months. The randomized complete block design with four replications and four treatments labeled as follows:

HP+ E, which indicated the plots in which the plants were hand pollinated and treated with ethrel, HP, which indicated the plots in which the plants were hand pollinated but not treated with ethrel, E: Indicated the plots in which the plants were left for natural pollination and treated with ethrel, Cont.: Which indicated the plots in which the plants were used as a control *i.e.* without hand pollination or growth regulator treatment.

The prepared land was divided into three meters wide, five meters long flats in east west direction. Using the local Silka variety, two to four seeds were planted in each hole with 50 cm between holes and thinned to one plant per hole 15 days after sowing. Two doses of urea (46% N) were applied 21 and 45 days after sowing at the rate of 100 kg/Ha per each dose. The crop was irrigated regularly. Hand weeding was done as well as chemical control of insects and diseases.

The growth regulator ethrel (250 ppm) was applied, sprayed at two true leaf stage. Twelve plants from each plot were taken randomly to study the flower sex ratio by tagging and counting both male and female flowers. The same plants were taken to study the number of branches per plant after the first node. All plants within the plot were taken to study the yield and yield components *i.e.* fruit number, fruit yield, aborted flowers and aborted fruits per plant.

The winter experiment

This was conducted during November 2007 and repeated during November 2010 to evaluate the Powdery Mildew Resistant (PMR) line compared with the local variety silka for powdery mildew resistance and fruit characters.

The design used, land preparation and cultural practices were the same as in the summer experiment. The local variety silka and PMR line were planted. The control of diseases was not performed to avoid the interference of the study of powdery mildew resistance. Artificial contamination was done by spraying spores of powdery mildew disease from infected plants to all the plants in the experiment.

Twelve plants from each plot were taken randomly to study the number of primary branches, secondary branches, powdery mildew resistance. All the plants in the plot were used to study earliness, yield, marketable fruit number, unmarketable number and weight of fruits.

Earliness was estimated by recording the period from the time of planting to the appearance of the first female flower. Also the number of primary branches originating from the first node on the plant stem, secondary branches originat-

ing from other nodes on the main stem or on the other primary branches of the plant and total yield per plant were recorded. Number of fruits, weight of unmarketable fruits, weight of deformed and unacceptable fruits, and number of unmarketable fruits per plant were counted.

Screening of powdery mildew disease

Evaluation for resistance to powdery mildew disease was done using the disease rating scale of 3-9 where:

3-Severe infection: Manifested by a whitish powder which covered the upper and lower leaves surfaces and the stem as well.

5-Moderate infection: Shown by the appearance of whitish powder which covered the lower side of the leaves.

7-Mild infection: Described the presence of small whitish powdery spots on the lower side of the leaves.

9-Resistant: Where no symptoms were observed on the leaves.

Twelve plants from each replication were used to calculate the mean disease score.

The mean disease score was calculated by adding the number of infected plants in each scale divided by the total number of tested plants. Infection percentage calculated by dividing the number of infected plants by the total number of tested plants multiplied by 100.

Results and Discussion

Effect of ethrel on growth parameters and yield

According to Tables 1 and 2, a high significant difference was observed in the number of branches after the first node in season two (P=0.01), when ethrel was applied with manual pollination or without. This agrees with Elkholy and Hafeez; Alikhan et al. and Rafeekher et al., who observed that the application of ethrel was found to be effective in obtaining a higher number of branches per vine compared to control in watermelon and cucumber. Reduction of apical dominance by ethylene may have resulted in more number of branches [2].

Treatment	Yield (g/plant)		Aborted female flowers		Branches after first node		Aborted fruits	
	S1	S2	S1	S2	S1	S2	S1	S2
HP+Ehrel	147a	375a	5.3a	2.3a	9.0a	9.0ab	0.9a	1.3a
Ethrel	86a	195b	4.2a	1.3a	7.5a	11.0a	0.8a	1.2a
HP	93a	183b	3.6a	1.9a	7.7a	5.0c	0.8a	1.6a
Control	83a	96b	2.7a	1.7a	8.9a	7.0bc	0.5a	1.1a
Lsd	65.5	133	2.8	1.4	2.3	3.3	0.5	0.9

Table 1: Effect of hand pollination and ethrel treatment on yield and yield components of snake melon (Cucumis melo var. flexuosus.) in summer months, means of season one (May 2007) and season two (May 2010). Means followed by the same letter (s) in the columns are not significantly different according to Duncan's multiple range test. S1: Seasonone; S2: Season two; HP: Hand Pollination.

The growth regulator ethrel increased the fruit yield significantly at P=0.001 during the summer months, at least in season two (Table 1). Hand pollinated and ethrel- treated plants exhibited the highest yield per plant compared to control. There was no significant difference in the yield in season one when the plants were manually pollinated and treated with ethrel, although there was a trend of increasing yield in all the treatments. Probably this was due to the decrease in temperature during the crop season (mean 28°C) which lead to more bee activity which carried out the pollination process in plots that were not manually pollinated. In the combined data (Tables 2 and 3), there was a high significant difference in the yield per plant at (P=0.001) of treated (hand pollinated and ethrel) over the yield in the treatments (natural pollination with ethrel), (hand pollination without ethrel) and control (natural pollination without ethrel). In summer season in Egypt, similar results were observed by El-Kholy and Hafez, 1982 on the application

Source of variation	♂/♀ flowers	Yield/plant	No. fruits/plant	Aborted ♀ fowers/plant	Branches/plant	Aborted fruits/ plant
Season(S)	* *	Ns	Ns	* *	Ns	* *
Replication(R)	Ns	Ns	Ns	Ns	Ns	Ns
Treatment (T)	Ns	**	Ns	Ns	**	Ns
S x T	Ns	**	Ns	Ns	**	Ns

Table 2: Analysis of variances of the combined data of the two summer experiments (May 2007-May 2010). * and **, significant at the (P=0.05) and (0.01) respectively. Ns: Not significant.

of 100 ppm ethrel at the two and four leaf stage in snake cucumber. The results also agree with those of Matlob and Basher, who observed that the application of ethrel (300 ppm) at two to three leaf stages was found to be effective to bring about the maximum fruit yield over the control in summer squash [3]. They also agree with Singh and Singh; Sitaram et al., in cucumber. Susila et al. showed that the application of ethrel at 100, 200 and 300 ppm increased the production of female flowers and suppressed the production of male flowers and this resulted in increasing the yield of the cucumber crop. Sure et al. in Iran found that spraying of ethrel at 100, 200 and 300 mgl^{-1} on pumpkin, significantly enhanced the yield by increasing the female flowers and decreasing the sex ratio [4].

The honey bees are the only insects that are realistic pollinators for snake cucumber. The average requirement is 12 insect visits to each flower during a one day period. Otherwise, this will result in aborted or misshapen fruit. In this experiment hand pollination was used to insure pollination because of the reduced number of bees during the summer months. This was confirmed by Hassan, who reported that the bees are inactive when the temperature is above 30°C. Hand pollination had no influence on the number of aborted flowers, number of fruits per plant but had an effect on the yield (Table 3). The results of increased yield agree with Musiiko [5]. Hassan reported that good pollination increased the yield of cucumber, but did not increase fruit size. In this experiment, manual pollination increased the yield of snake cucumber through the increase in fruit size. It is well known that the size and shape of fruit is usually related to the number of seeds produced by pollination. Poor pollination is one of the main causes of fruit abortion, misshapen fruit, or poor fruit set in cucumber, although other factors may be involved [6].

Treatment	Yield per plant (g)	Aborted fruits per plant	No. of branches after first node	No. aborted fruits
Ehrel+HP	261a	3.8a	9.4a	1.1a
Ethrel	141b	2.8a	9,1a	1.0a
HP	138b	2.7a	7.9ab	1.0a
Control	90b	2.2a	6.6b	1.0a
Lsd	91	2	2.7	0.8

Table 3: Effect of hand pollination and ethrel treatment on yield and yield components of snake melon (Cucumis melo var. flexuosus) in summer months, means of combined data of two seasons (May 2007- 2010). Means followed by the same letter(s) in the columns are not significantly different according to Duncan's multiple range test

Effect of the growth regulator ethrel on flower sex ratio

In season two (Table 4), the growth regulator ethrel significantly influenced the ratio of male to female flowers per plant. The minimum number of male flowers was recorded with ethrel at (250 ppm) during the summer experiment, leading to a significant narrow sex ratio (42:1) compared with untreated plots which recorded (93:1) male to female flowers. On the other hand, there was no significant difference in sex ratio in season one (Table 4).

Treatment	Season 1	Season 2
Ethrel treated	25.0a	42.0a
Without ethrel	24.5a	93.0b

Table 4: Effect of ethrel treatment on the ratio of male to female flowers in the snake melon (Cucumis melo var. flexousus) in the summer months. Means followed by the same letter(s) in the columns are not significant different according to Duncan's multiple range test.

The suppression of male flowers by ethrel is probably due to the reduction in the endogenous production or proportion of gibberellins to auxins and cytokinins, which generally induce suppression of male flowering [7]. Exogenous application of ethrel probably has increased the endogenous auxins level in the plants which hastened the female flowering. This result was in line with the finding of El-kholy and Hafeez who recorded less number of male flowers compared with the control with the spray of etherl in concentration of 100 ppm at two and four leaf stage in snake cucumber. The findings are also in agreement with Verma et al. in bitter gourd and with Sitaram et al.; Jutamanee et al. [8] and Kshirasagar et al. in cucumber.

Table 2 shows a high significant difference between the two seasons in sex ratio (P=0.01), aborted female flowers number (P= 0.01) and the aborted fruits (P=0.01). This variation among the seasons may be due to the decrease in temperature in season one which lead to a favourable lower sex ratio. This agrees with Hassan, who showed that decrease in temperature increased the number of female flowers. Miao et al. showed that low temperature alters the sex epression of cucumbers (C. sativus L.). It was found that plant femaleness is highest at low night temperatures [9]. The high number of aborted female flowers and aborted fruits in season two in this work probably was due to the high atmospheric humidity and soil moisture (average rainfall was 114 mm). This agrees with Wood (2008), who showed too much moisture in the soil for long periods can shut down the pumpkin plants roots, debilitate the plants and cause flower and fruit abortion.

The winter experiment

Earliness of flowering: Earliness of flowering is considered as the number of days elapsed from the time of planting to the appearance of the first female flower. The earliness period should be as short as possible to minimize the cost during the vegetative phase. Table 5 shows that the Powdery Mildew Resistant (PMR) line scored the best earliness period over the local variety Silca. This result is a matter of genetic inheritance, because the two varieties had the same cultural practices.

Number of primary and secondary branches: When the plant has a high number of branches that indicates there is a vigorous growth and consequently the plants produce more flowers, and high yield. Table 6 shows no significant difference in the number of primary and secondary branches in season one, but was found in the number of secondary branches and the combined data in season two in favor of the variety PMR line over the local variety silca (Table 5).

	Earliness (DAP)			No. primary branches			No. secondary branches		
Season variety	S1	S2	S1+S2	S1	S2	S1+S2	S1	S2	S1+S2
Silca	35a	35a	35a	10.4a	8.6a	9.5a	6.1a	6.7b	4.4b
PMR	28b	34a	31b	9.5a	8.5a	8.9a	6.2a	12.3a	9.2a
Lsd	3.8	5.6	1.1	2.1	0.5	2.2	4.1	2.4	2.6

Table 5: Vegetative characters of two varieties (PMR line and local variety silca), means of season one winter experiment (November, 2007) and season two (November 2010). Means followed by the same letter(s) in the columns are not significantly different according to Duncan's multiple range test. DAP: Days After Planting.

Yield and fruit characters

PMR line produced a significantly higher yield in both seasons and in the combined data (Table 6). No significant difference was found in the number of produced fruits and in the combined data, in the weight of unmarketable fruits or the unmarketable fruits.

Powdery mildew screening

Powdery mildew of field grown snake cucumber caused by (Sphaerotheca fuliginea) is a critical factor that limits its production in the winter season in the Sudan. It can be controlled by using partially resistant cultivars. All aerial plant parts are mostly affected by the disease (e.g leaves, stem and fruits). This leads to a considerable reduction of quantity

and quality of cucumber fruits. Severe infection results in discoloring and loss of leaves, with the reduction in the number and size of the fruit. The disease usually causes a great reduction in fruit yield if it is not controlled. Currently, the use of fungicides is the only method available to control this serious disease in the Sudan, but the fungicides are very expensive and very dangerous to consumers.

Parameters	Yield (gm/plant)			# of fruits			Unmarketable fruits (g/ plant)			# Un-marketable fruits		
Season	S1	S2	S1+S2	S1	S2	S1+S2	S1	S2	S1+S2	S1	S2	S1+S2
Silca	705b	675b	690b	3.5a	3.6a	3.5a	1.8a	0.3b	1.1a	0.5a	0.5a	0.5a
PMR	1045a	900a	970a	4.6a	4.4a	4.5a	1.7a	0.4a	1.0a	0.4a	0.3a	0.4a
Lsd	264	149	196	1.3	1.2	1.3	0.7	0.1	0.7	0.3	0.2	0.5

Table 6: Yield and yield characters of two varieties (PMR line and local variety silca). Means of season one (Winter experiment, November 2007) and season two (November 2010) and the combined data of the two seasons. Means followed by the same letter (s) in the columns are not significantly different according to Duncan's multiple range test.

In the present experiments (Table 7), PMR line proved to be resistant to powdery mildew, with zero infection. Whereas, the locally-grown Silca variety had the highest infection percentage (90.7%). Mean disease score explains the level of infection in the two varieties. PMR line scored zero, whereas, Silca variety scored 1.2. PMR line has almost a full resistance against the powdery mildew. At the same time the fruit characters of the PMR line are better than the local variety silca. We can say that this line can partially solve the problem of yield reduction in winter season if other factors like viral diseases are considered.

Mean disease score	Infection percentage	Varity
Silca	90.70%	1.2
PMR line	Zero	Zero

Table 7: Screening of two varieties of snake melon for powdery mildew resistance, winter experiment (November, 2007 -2010).

Conclusion

The application of 250 ppm of the growth regulator ethrel at the second leaf stage significantly improved the vegetative growth and lowered the sex ratio of male to female flowers in Cucumis melo var flexuosus.

The application of ethrel together with manual pollination significantly increased the yield per plant. No significant difference was found in the number of aborted flowers and aborted fruits. The interaction between seasons and treatments showed a high significant difference in yield and number of branches after the first node.

The PMR line showed complete resistance to the powdery mildew disease caused by the fungus Sphaerotheca fluiginea. It also showed a significantly better earliness in flowering, more secondary branches, and better yield per plant compared with the local variety (Silka), but no significant difference was noticed in the number of primary branches.

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