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Research Appliction Summary

Sources and inheritance of resistance to Sesame Webworm in Uganda

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Abstract

Sesame (*Sesamum indicum* L.) is an important income security crop among smallholder farmers in Eastern and Northern Uganda. However, Sesame webworm (*Antigastra catalaunalis* Dup) causes high yield loses in Uganda. A few sesame genotypes resistant to the Webworm have been reported but these have not been studied in the Uganda context. Five genetically diverse parents were crossed in a half-diallel mating design (U1-7 and Ajimo A1-5, highly resistant), (SPSICR3-1-2-2-4, Runner 1-3-1-17-1, highly susceptible) and (Sesim2/5181, moderately resistant). The F_1 progeny and the five parents were planted in a Randomised Complete Block Design (RCBD) with three replications at NaSARRI (Serere) in eastern Uganda during the second rains of 2015. The results showed that resistance to sesame webworm is controlled by both additive and non-additive genetic effects with the additive being more important. Large negative GCA effects were recorded for percent leaf damage, severity, damaged plants per plot and number of larvae counts per plant in Ajimo A1-5 and U1-7 implying that these genotypes can be used as donors for resistance against the Sesame Webworm.

Key words: Agronomic traits, *Antigastra catalaunalis*, breeding, diallel, *Sesamum indicum*, Uganda

Résumé

Le sésame (*Sesamum indicum* L.) est une culture importante pour la sécurité du revenu des petits agriculteurs de l'Est et du Nord de l'Ouganda. Toutefois, la larve du Sésame (*Antigastra catalaunalis* Dup) provoque des pertes de rendement élevé en Ouganda. Quelques génotypes de sésame résistants à la vermine ont été signalés mais ils n'ont pas été étudiés dans le contexte ougandais. Cinq parents génétiquement différents ont été croisés dans un dispositif d'accouplement demi-diallèle (U1-7 et Ajimo A1-5, très résistant), (SPSICR3-1-2-2-4, Runner 1-3-1-17-1, hautement sensible) et (Sesim2 / 5181, modérément résistant). La progéniture F1 et les cinq parents ont été plantés dans un dispositif de blocs aléatoire complet (BAC) avec trois répétitions à NaSARRI (Serere) dans l'est de l'Ouganda pendant la deuxièmes saison de pluies de 2015. Les résultats ont montré que la résistance à la larve du sésame est contrôlée par les additifs et des effets génétiques non additifs avec l'additif étant plus importants. Des effets de GCA négatifs importants ont été enregistrés pour le pourcentage de lésions foliaires, la sévérité, les plantes endommagées par parcelle et le nombre de larves par plante dans Ajimo A1-5 et U1-7 ce qui implique que ces génotypes peuvent être utilisés comme fournisseurs de genes de résistance contre la larve du sésame.

Mots clés: Caractéristiques agronomiques, *Antigastra catalaunali*s, élevage, diallèle, *Sesamum indicum*, Ouganda

Background

Sesame (*Sesamum indicum* L.), which belongs to the family Pedaliaceae, is one of the oldest oilseed crops known to humans and is valued for its high quality seed (Ashri, 1998). It is perhaps one of the oldest crops cultivated by man, having been grown in the near east and Africa for over 5,000 years. Sesame is currently grown over an area of seven million hectares worldwide producing more than three million tons of seed annually (Faostat, 2016). Africa produces 15% of the world's sesame production with Uganda, Sudan and Nigeria being key producers. In Uganda, sesame is an important crop in the northern and eastern regions of the country, which produce 90% of the crop (Anyanga and Obung, 2001). Sesame is an integral part of the farming communities in these regions and is cultivated both as a cash and food crop. Presently sesame is one of the leading non-tradition oil export crops in Uganda. It is a highly tradable commodity in the domestic and international markets and farmers commonly refer to it as "white gold" (Munyua and Okwadi, 2013) because of its premium market. In addition to foreign exchange, sesame is rich in protein and contributes to a relatively balanced diet of people in northern and eastern Uganda (Anyanga and Obongo, 2001). However, a key challenge to the production of sesame in the country is the increased levels of damage by webworm (*Antigastra catalaunalis).* The objective of this study was to study the mode of inheritance of resistence to sesame webworm in Uganda.

Materials and Methods

Study site

The study was carried out at the National Semi–Arid Research Institute (NaSARRI) Serere. NaSSARRI is located in eastern Uganda at latitudes of $1^0$30 N and $33^0$33 E and altitude of 1,085 m above sea level, with average annual rain fall of 1000-1200 mm per year (Wamb*i et al.,* 2014).

Materials and methods

Five parents were crossed in half diallel mating design to generate 10 F_1 crosses. These crosses together with the five parents were evaluated in a Randomized Complete Block Design (RCBD) with three replications in NaSSARI. The treatments were allowed under natural webworm infestation. Data were taken on damaged leaves per plant, severity, number of larvae per genotype and damaged plants per genotype by selecting randomly 10 plants in every plot, on the second, third and fourth week after crop emergence. Agronomic data were recorded on days to 50% flowering while plant height, number of main branches, capsule length, number of seeds per capsule, and plant seed weight were taken at maturity by selecting five plants in every plot (Solanki *et al.*.2006).

Analysis was done according to Griffing (1956) Method 4. The estimates of GCA for the parents and the SCA effects for the crosses were calculated. The linear model for estimating the GCA effects for the parent and SCA effects for the crosses is as defined below;

$Y_{ijk} = \mu + GCA_i + SCA_{ij}$ Where; Y_{ij}= Observation of the cross, μ=Grand mean, GCA effects on I^{th} patents and SCA=SCA effects on I^{th} and j^{th} patent.

The variance components were calculated using the following formula

$$\sigma^2 GCA = \frac{MSGCA - MS\ ERROR}{P - 2}$$

$$\sigma^2 SCA = \frac{M\ S\ SCA - M\ S\ ERROR}{1}$$

where $\sigma^2 GCA$ = Variance of GCA
σ^2 SCA=Variance of SCA
MS ERROR= Mean square error
P= Parental number
Then Parents were considered to be a fixed factor, heritability was estimated as broad sense ccoefficient of genetic determination.

$$BS\ CGD = \frac{2\sigma^2 GCA + \sigma^2 SCA}{2\sigma^2 GCA + \sigma^2 SCA + EMS}$$

BS CGD= Broad sense of genetic determination.
Narrow-sense heritability of coefficient of genetic determination (The heritable portion was calculated by using the following formula.

$$NS\ CGD = \frac{2\sigma^2 GCA}{2\sigma^2 GCA + \sigma^2 SCA + EMS}$$

NS.CGD= Narrow sense of genetic determination.
Baker's ratio (Baker, 1978) was used to estimate the relative importance of GCA that reflects the additive gene action.

$$Baker's\ ratio = \frac{2\sigma^2 GCA}{2\sigma^2 GCA + \sigma^2 SCA}$$

Results and discussion

The analysis of variance (Table 1) showed a highly significant difference among the parents for all the eleven traits studied. The mean squares were also significant, implying that parents were genetically diverse. The baker's ratio and heritability indicated that reaction to webworm damage was mainly controlled by additive genetic effects, while number of larvae sustained was controlled by non-additive gene effects. Several studies on combining ability against sesame webworm done in different countries, has reported the pre dominance of non-additive genetic effects. For example a study done in

India by Gnanaskaran *et al.* (2010) indicated the predominance of non-additive genetic effects. Presence of both additive and non-additive effects for the combining ability against sesame webworm for the different traits taken during this study, might be contributed by the genotype and environmental interaction.

For the agronomic traits the number of capsules (NC) per plant and seed weight (kg/ha) were highly influenced by additive gene effects. Also studies done by Puspha *et al.* (2001) and Gnanasekaran *et al.* (2010) reported the presence of additive genes for number of capsule per plant and seed weight. Similarly a study in Uganda by Okello-Anyanga *et al.* (2013) also reported the presence of additive gene effects for number of capsules on main stem of sesame.

The other traits like days to 50% flowering, capsule length (CL), number of branches (NMB), plant height (PH), and seeds per capsule (S/C), were highly influenced by non-additive gene effects (Table 2). These results are in conformity with the study done in India by Solank and Gupta (2003), who reported the predominance of non-additive gene effects for days to 50% flowering and plant height. Similar gene effect for the number of branches per plant, capsule length, number of seeds per capsule were reported by Gnanasekaran *et al.* (2010).

For the parents AJIMO A1-5 and U1-7, negative GCA effects were recorded for % leaf damage, severity, number of damaged plant per plot, and number of larvae counts per plant. This suggests that these genotypes can be used in the introgression of the gene for resistance against sesame webworm. In the case of RANNER1-3-1-17-1 and SPCUCR 3-1-2-4, positive GCA effects were recorded on % Leaf damage, severity and number of larvae. These parents may be considered as poor combiners for resistance against sesame webworm.

Sesim 2/5181 showed relatively high positive GCA effects for seed yield compared to the rest of the parents, indicating that this genotype can be used in breeding for high yielding sesame plants in Uganda. A study by Okello-Anyanga *et al.* (2013) also showed that Sesim 2/5181 had no positive or negative effects for the traits studied but had good yield. Negative GCA effects for 50% flowering were recorded for RUNNER1-3-1-17-1 indicating that this parent can be used for breeding for early maturing sesame genotypes.

AJIMO A1-5*RUNNER 1-3-1-17-1 and RUNNER 1-3-1-17-1*SPCUCR3-1-2-2-4 negative significant SCA effects for 50% flowering and Plant height were recorded. On the hand AJIMO A1-5* SPCUCR3-1-2-2-4 and SESIM2//5181* RUNNER 1-3-1-17-1 had positive SCA effects for capsule length, number of branches, plant height, seeds per capsule and seed weight (Table 3). The above four crosses can be used as good hybrids for yield performance since days to 50% flowering, capsule length, number of branches, seeds per capsule and seed weight were positively correlated to yield (Okello-Anyanga *et al.,* 2013). A study done in Uganda on the inheritance of resistance to Sesame gall midge (Ubor *et al.,* 2015) observed that combining good parents did not necessarily result in anticipated SCA effects.

Table 1: ANOVA for combining ability (GCA and SCA) and coefficient of genetic determination

SOV	d.f.	50% FLW	SEV	NV	DPP	%LD	Sd. kg/ha	CL	NC,P	NMB	PH	SC
Total	8	58.77***	2.36***	0.61**	7.02***	61.52***	13031***	0.12***	26.65ns	0.86***	451.3***	70.9***
GCA	4	31.70***	4.44***	0.55*	11.8***	114.2***	19784***	0.07***	45.45ns	0.90***	509.7***	37.5***
SCA	4	85.84***	0.29ns	0.68**	2.20ns	8.81***	6277***	0.17***	7.85ns	0.82***	392.8***	104.3***
Error	23	0.50	0.23	0.13	1.31	1.02	453.33	0.00	19.94	0.01	13.94	1.15
VcGCA		17.33	2.34	2.36	5.85	62.89	10739.26	0.04	14.17	0.50	20.31	20.19
VcSCA		85.34	0.06	5.27	0.89	7.79	5823.67	0.16	0.00	0.81	28.17	103.15
BR		0.17	0.98	0.31	0.87	0.89	0.65	0.18	1.00	0.38	0.42	0.16
CGD NS		0.17	0.89	0.31	0.73	0.88	0.63	0.17	0.72	0.38	0.42	0.16
CGD BS		1.00	0.91	0.98	0.84	0.99	0.97	0.98	0.72	0.99	0.78	0.99

Values marked *,**, *** are significantly different at probability level 0.05, 0.01, 0.001 respectively.50% FLW=Days to 50% Flowering,SEV=Severity,NV=Number of Larvie, DPP=Damaged plant per plot,% LD =Percentage leaf damage (Incidence),Sd. Kg/ha=Seed weight in Kg/ha, CL=Capsule length. NC,P=Number of capsules per plant,NMB=Number of branches,PH= Plant height,SC = Number of seeds per capsule, VcGCA=Variance component GCA, Vc SCA=Variance component SCA, BR=Bakers ratio,CGD NS= Coefficient of genetic determination Narrow sense and CGD BS=Broad sense.

Table 2: General combing ability relative estimates for the five parents.

PARENTS	50% FLW	%LD	CL	DPP	NC,P	NMB	NV	PH	SC	SEV	Sd wt kg/ha
AJIMO_A1_5	1.58***	-8.04***	0.00***	-2.38**	3.31ns	0.45***	-0.59**	14.51***	5.71***	-1.27***	2.91ns
RANNER1_3_1_17_1	-4.79***	5.84***	-0.13**	2.34**	-4.77*	-0.57***	0.44*	-7.42***	-0.13***	0.97***	-22.79*
SESIM2_5181	4.95***	2.51***	0.28***	0.40ns	0.53ns	0.77***	0.34ns	7.98**	-1.54*	-0.22ns	155.21***
SPSUCR3_1_2_2_4	-0.61ns	4.44***	-0.17***	1.21ns	-2.96ns	-0.56***	0.10ns	-19.12***	-4.02***	1.48***	-68.39***
U1-7	0.14ns	-5.51***	0.12**	-1.95**	5.35ns	0.12*	-0.26ns	8.07**	-0.54ns	-1.37***	-37.49**

Values marked *,**, *** are significantly different at probability level 0.05, 0.01, 0.001 respectively. 50% FLW=Days to 50% Flowering, SEV=Severity, NV=Number of Larvie, DPP=Damaged plant per plot, % LD=Percentage leaf damage (Incidence), Sd. Kg/ha=Seed weight in Kg/ha, CL=Capsule length. NC,P=Number of capsules per plant, NMB=Number of branches, PH=Plant height, SC=Number of seeds per capsule

Table 3: Specific combining ability of sesame crosses for resistence to webworm in Uganda

Crosses	50%FLW	%LD	CL	DPP	NC-P	NMB	NV	PH	SC	SEV	Sd_wt_ kg_ha
AJIMO A1-5*RANNER 1-3-1-17-1	-2.37***	0.37ns	-0.49***	0.31ns	-1.44ns	-0.99***	0.46ns	-14.37***	-13.25***	0.66ns	-73.17***
AJIMO A1-5*SESIM2//5181	-11.11***	-2.61**	-0.06ns	-1.43ns	-0.41ns	-0.33***	-0.87**	-15.44***	1.481ns	-0.15ns	23.90ns
AJIMO A1-5*SPSUCR3-1-2-2-4	6.44***	0.42ns	0.22***	0.54ns	3.07ns	1.00***	0.36ns	20.33***	5.96***	- 0.18ns	65.93***
SESIM2//5181*RANNER 1-3-1-17-1	7.37***	3.50***	0.22***	1.79*	2.88ns	0.66***	0.77**	21.92***	5.31***	-0.27ns	70.90***
SESIM2//5181*SPSUCR3-1-2-2-4	3.74***	-0.89ns	-0.16***	-0.35ns	-2.47ns	-0.32***	0.10ns	-6.48*	-6.79***	0.42ns	-94.80***
SPSUCR3-1-2-2-4*RANNER 1-3-1-17-1	-4.07***	-0.78ns	0.27***	-0.85ns	-1.64ns	-0.01ns	-0.82**	-5.96*	7.29***	-0.48ns	7.23***
U1-7*AJIMO A1-5	7.04***	1.82ns	0.33***	0.58ns	-1.23ns	0.32***	0.05ns	9.48**	5.81***	-0.33ns	-16.67ns
U1-7*RANNER 1-3-1-17-1	-0.93ns	-3.09***	-0.002ns	-1.24ns	0.19ns	0.34***	-0.42ns	-1.59ns	0.64***	0.09ns	-4.97ns
U1-7*SPSUCR3-1-2-2-4	-6.11***	1.26ns	-0.33***	0.66ns	1.04ns	-0.67***	0.36ns	-7.89**	-6.46***	0.24ns	21.63ns

Values marked *,**, *** are significantly different at probability level 0.05, 0.01, 0.001 respectively. 50% FLW=Days to 50% Flowering,SEV=Severity,NV=Number of Larvie, DPP=Damaged plant per plot, % LD =Percentage leaf damage (Incidence), Sd. Kg/ha=Seed weight in Kg/ha, CL=Capsule length. NC,P=Number of capsules per plant, NMB=Number of branches,PH=Plant height, SC=Number of seeds per capsule

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