Performance of Long- and Short-duration Rosette-resistant Groundnut Genotypes in Malawi

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Abstract

Selected long- and short-duration rosette resistant groundnut genotypes, ICGV-SM 93535, ICGV-SM 93561, ICG 12991 and ICG 12988, were evaluated at several sites for yield and adaptability, with JL 24, a rosette-susceptible variety, as a control. The treatments were laid out in a Randomized Complete Block Design (RCBD) in three replications. The experiments were conducted both on-station and on-farm during summer and winter months (under residual moisture) in the 1998/99 and 1999/00 crop seasons. ICG 12991 and ICG 12988 gave similar yields to the control variety at most sites. However, in areas where rosette pressure was high, ICG 12991 and ICG 12988 significantly ($P \leq 0.05$) out-yielded the recommended variety JL 24. In another experiment, selected Virginia groundnut genotypes, C581/7 and D27/3, from the National Groundnut Breeding Programme, and two other genotypes, P49-6 and ICGV-SM 89709, from the ICRISAT Groundnut Project, were evaluated together with CG 7 as a control variety in a Randomized Complete Block Design (RCBD) in four replications. The experiment was conducted on-station at Chitedze, Chitala, Mbawa, and Makoka Research Stations in the 1998/99 crop season; and at Chitedze and Chitala Research Stations in the 1999/00 crop seasons. The objective of the experiment was to identify the highest yielding genotype with acceptable grain characteristics. P49-6 and C851/7 gave similar seed yields to CG 7 at all the experimental sites during the two years of study. However, the yield of C851/7 was lower than P49-6 and CG 7, the red-seeded types. Nevertheless, C851/7 has desirable and favourable seed characteristics for confectionery purposes, such as good pod filling, tan seed coat and a good roasted flavour that is similar to that of Chalimbana.

Keywords: genotypes, rosette-tolerant, long- and short-duration, Malawi

Introduction

Groundnut (*Arachis hypogea* L.) is a very important crop in Malawi, both as a food crop and as a source of income. When grown in rotation with cereals, such as maize, groundnut improves soil fertility (Brown, 1958). The crop is produced over a wide range of environments, ranging from the lakeshore (100 m asl) to plateau areas of Lilongwe-Kasungu-Mchinji (1,500 m asl), where 70% of the crop is produced during the summer months. Off-season (winter) groundnut is also produced in some parts of Nkhata Bay and Karonga districts (Subrahmanyam and Nyirenda, 1993).

Although improved cultivars and management practices have been developed and recommended to farmers, groundnut yields in Malawi are still very low, ranging from 250 to

700 kg ha^{-1}, in marked contrast to yields of over 4,000 kg ha^{-1} obtained at research stations (Chiyembekeza et al., 1988). The reasons for low groundnut productivity are many and varied. These include: recurrent droughts, low producer prices, low soil fertility, poor cultural practices, lack of improved seed of acceptable quality and insect pests and diseases among many others. Among the many groundnut diseases, groundnut rosette is the most serious virus disease in Malawi. Yield losses of up to 90% are common in epidemic years. Groundnut rosette is transmitted by aphids (*Aphis cracivora* Koch) (Okusanga and Watson, 1966). This disease can be controlled by the use of insecticides and cultural practices. Management of groundnut rosette by insecticidal control of the vectors has been known since the mid-1960s (Davies, 1975a; 1975b). However, chemical control, besides being unfriendly to the environment, is not economically feasible to smallholder farmers in Malawi. Several researchers have demonstrated that groundnut rosette can be reduced when the crop is sown early in the season, and at optimum plant population densities (Subrahmanyam et al., 1992; Subrahmanyam and Hildebrand, 1994; Naidu et al., 1999). Due to differential crop priorities, many farmers in Malawi plant their groundnut crop late. Apparently, the most feasible way to combat groundnut rosette is perhaps the development of resistant genotypes.

A medium- to long-duration Virginia type of groundnut (ICGV-SM 90704), which is also resistant to rosette, has recently been released for commercial production in Malawi (Chiyembekeza et al., 2000). However, progress to develop high-yielding, short-duration rosette-resistant groundnut genotypes has remained slow, until recently when such genotypes were developed and/or identified by the SADC/ICRISAT Groundnut Project. This major break-through continues to furnish the National Groundnut Breeding Programme with materials for evaluation and adaptation in areas characterized with low rainfall and prone to rosette attack. The selected materials that had shown promise in the preliminary evaluations (Chiyembekeza and Subrahmanyam, 1996; Chiyembekeza et al., 1997), were advanced to on-farm testing during summer and winter months (under residual moisture) for two cropping seasons across the country.

In a parallel programme, a number of long-duration groundnut genotypes selected from various breeding programmes were evaluated in a series of trials conducted under on-station and on-farm conditions. Two genotypes, C851/7 (with Chalimbana background) and D27/3 gave high yields that were similar to those of CG7 over the three-year study period (Chiyembekeza, 1998; 1999). During the same time, two other genotypes, ICGV-SM 89709 and P49-6, were identified from the SADC/ICRISAT Groundnut Project as having better or similar yield levels to CG 7. It was, therefore, decided that these genotypes should also be evaluated in one experiment to ascertain their yield potential in various agro-ecological zones of Malawi, with the overall aim of identifying superior genotypes that can be recommended to farmers for commercial production.

Materials and Methods

Genotypes

Tables 1 and 2 present the pedigree, description and selection criteria for the entries used in for two experiments: (a) Evaluation of short-duration (90-120 days) and rosette-resistant groundnut genotypes (Spanish bunch types), and (b) Evaluation of promising long-duration (120-140 days) groundnut genotypes (Virginia bunch types).

Table 1: Description of genotypes used in the short-duration (90-120 days), rosette-resistant groundnut evaluation trial (a)

Genotype	Pedigree	Colour	Selection criteria
CGV-SM 93535	ICGM 522 x RG 1	Red	Yield and seed uniformity
ICGV-SM 93561	ICGM 197 x RMP 40	Tan	Yield and seed uniformity
ICG 12991	Landrace from India, US25	Tan	Yield and rosette-resistance
ICG 12988	Landrace from India, US22	Tan	Yield and rosette-resistance
JL 24 (Control)	Commercial variety, released in Malawi in June 2000	Tan	Yield, seed uniformity and drought-tolerance

Table 2: Description of genotypes used in the long-duration (120-140 days) promising groundnut trial (b)

Genotype	Pedigree	Colour	Selection criteria
C851/7	(Chalimbana x Shul.) x RMP 93	Tan	Yield and seed uniformity
D27/3	(RG 1 x Shulamith) x RMP 93	Tan	Yield and seed uniformity
P49-6	Introduction	Red	Yield and seed uniformity
ICGV-SM 89709	Introduction	Tan	Yield and seed uniformity
CG 7 (Control)	Commercial variety	Red	Yield and seed uniformity

Location

The short-duration rosette-resistant groundnut genotypes trial was conducted both at research stations and on farmers' fields during summer and winter months after harvesting paddy rice. The summer experiments were conducted at several Extension Planning Areas (EPAs) across the country during the 1998/99 and 1999/00 crop seasons. The winter experiments were conducted at several sites in the Kaporo area of Karonga Agricultural Development Division (KRADD) during the 1999/00 crop season. The long-duration promising groundnut genotypes trial was conducted at on-station sites at Chitedze, Chitala, Baka and Makoka during the 1998/99 crop season, and at Chitedze and Chitala during the 1999/00 crop season.

Experimental Design

The two experiments, (a) and (b), were laid out in a Randomized Complete Block Design (RCBD) in three and four replications, respectively. Each plot consisted of four 6 m long rows spaced 75 cm apart. One seed was sown per planting station spaced 10 cm apart for the Spanish genotypes, and 15 cm apart for the Virginia genotypes. The net plot consisted of the two middle rows.

Data Recorded

At pod filling, between 70 and 80 days after sowing, the number of plants infected by rosette was recorded in each plot. At maturity, the genotypes were harvested from the two middle rows, and sun-dried to approximately 8-10% moisture content. After the pods were cleaned and weighed, a 500 g sample was drawn from each plot and shelled to determine shelling percentage. The seed size was determined as the weight of 100 seeds measured in grams (100 seed weight). Yield and yield components data were subjected to statistical analysis of variance using SAS Package (SAS, 1988).

Results and Discussion

Performance of Short-duration Rosette-resistant Groundnut Genotypes

The tests for homogeneity of variances for the on-farm, on-station and winter trials were performed separately. All the sites whose variances were not significant ($P \leq 0.05$), were pooled together. The results for the overall performance of the rosette-resistant groundnut genotypes conducted during the two seasons, 1998/99 and 1999/00, on-station and on-farm at various sites across the country, are presented in Tables 3a, 3b; 4a, 4b; and 5. The 1998/99 summer was favourable for groundnut production, unlike the 1999/00 crop season. The incidence of rosette was only significant in the 1999/00 summer season (Tables 3a and 4a) and not during the summer of 1998/99 and the winter of 2000 (Tables 3b; 4b; and 5).

The 1999/00 crop season was characterized by unpredictable, sporadic and erratic rainfall. Consequently, sowing at many sites was delayed, resulting in poor crop establishment across many sites, hence the high incidence of rosette (Tables 3a and 4a.). At all the sites where rosette was not a problem, the two genotypes, ICG 12991 and ICG 12988, consistently gave higher seed yields and good shelling percentages that were similar to that of the control variety, JL 24 (Tables 3a, 3b; 4b; and 5). But where rosette pressure was very high, JL 24, succumbed to the disease more than the test entries (Table 4a). However, seed size of the two genotypes, ICG 12991 and ICG 12,988, was inherently lower than that of the control (Tables 3a, 3b; 4a, 4b; and 5).

Seed size is a very important parameter that influences consumer acceptance, particularly for Malawians who are used to the large-seeded Chalimbana. For confectionery purposes, the consumer requires good groundnut seeds with acceptable oil content, shape, size, colour and taste (Wynne and Gregory, 1981; Branch, 1979). Unfortunately, it is not possible to bring together all the desirable traits in one genotype.

Table 3a: Overall performance of short-duration, rosette-resistant groundnut genotypes evaluated at four on-station sites, 1998/99 crop season

Genotype	Seed yield (kg ha^{-1})	Shelling percentage (%)	Seed size (g)
ICG 12991	1817	73	32
ICG 12988	1733	73	33
ICGV-SM 93561	1441	62	43
ICGV-SM 93535	1129	59	44
JL 24	1597	72	45
Mean	1544	68	39
SE (±)	117.34	0.89	1.29
CV (%)	15	3	7
Significance level	**	***	***

Key: * = significant differences at P≤0.05, ** = significant differences at P≤0.01, *** = significant differences at P≤0.001 (LSD test); SE(±)=Standard error; CV(%)=Coefficient of variation.

Table 3b: Overall performance of short-duration, rosette-resistant groundnut genotypes evaluated at two on-station sites, 1999/00 crop season

Genotype	Seed yield (kg ha^{-1})	Shelling percentage (%)	Seed size (g)	Rosette %
ICG 12991	1158	67	38	4
ICG 12988	1294	74	33	3
ICGV-SM 93561	1143	69	39	6
ICGV-SM 93535	1019	61	46	4
JL 24	1115	74	49	6
Mean	1145	69	41	-
SE (±)	136.10	6.03	4.69	-
CV (%)	17	12	16	-
Significance level	NS	NS	NS	-

Key: NS=No significant differences at P=0.05 (LSD test); SE(±)=Standard error; CV(%)=Coefficient of variation; Dash=Data not collected or not applicable.

Table 4a: Overall performance of short-duration, rosette-resistant groundnut genotypes evaluated at eight on-farm sites, 1998/99 crop season

Genotype	Seed yield (kg ha^{-1})	Shelling percentage (%)	Seed size (g)
ICG 12991	1236	73	36
ICG 12988	1168	72	38
ICGV-SM 93561	881	61	47
ICGV-SM 93535	732	56	47
JL 24	1153	72	48
Mean	1034	67	43
SE (±)	44.13	1.42	1.79
CV (%)	10	5	9
Significance level	***	***	***

Key: * = significant differences at P≤0.05, ** = significant differences at P≤0.01, *** = significant differences at P≤0.001 (LSD test); SE(±)=Standard error; CV(%)=Coefficient of variation.

Table 4b: Overall performance of short-duration, rosette-resistant groundnut genotypes evaluated at eight on-farm sites across the country, 1999/00 crop season

Genotype	Seed yield (kg ha^{-1})	Shelling percentage (%)	Seed size (g)	Rosette %
ICG 12991	601	72	35	3
ICG 12988	483	71	34	4
ICGV-SM 93561	434	58	44	10
ICGV-SM 93535	267	47	41	7
JL 24	378	59	42	34
Mean	433	61	39	-
SE (±)	69.46	3.77	1.48	-
CV (%)	32	12	8	-
Significance level	*	**	***	-

Key: * = significant differences at P≤0.05, ** = significant differences at P≤0.01, *** = significant differences at P≤0.001 (LSD test); SE(±)=Standard error; CV(%)=Coefficient of variation; Dash=Data not collected or not applicable.

Table 5: Overall performance of short-duration, rosette-resistant groundnut genotypes evaluated at five on-farm sites under residual moisture conditions, Kaporo, 1999/00 crop season

Genotype	Seed yield (kg ha^{-1})	Shelling percentage (%)	Seed size (g)
ICG 12991	1908	68	42
ICG 12988	1673	63	40
ICGV-SM 93561	1749	55	57
ICGV-SM 93535	1251	49	55
JL 24	1914	61	61
Mean	1699	60	51
SE (±)	134.83	1.99	1.37
CV (%)	18	8	6
Significance level	*	***	***

Key: * = significant differences at P≤0.05, ** = significant differences at P≤0.01, *** = significant differences at P≤0.001 (LSD test); SE(±)=Standard error; CV(%)=Coefficient of variation.

Performance of Long-duration Promising Groundnut Genotypes

The results on the performance of the long-duration promising groundnut genotypes evaluated under on-station conditions in the 1998/99 and 1999/00 crop seasons are presented in Tables 6 and 7. Generally, the performance of the genotypes across sites over the 2-year study period was good. The overall mean seed yield was over 1, 500 kg ha^{-1}. This is a significant improvement in groundnut yields when compared national average groundnut yields obtained over a 10-year period (1989 to 1998) as summarized and depicted in Table 8.

The selected response variables: seed yield, shelling percentage and seed size were significantly different (P≤0.05) in the 1999/2000 crop season, but not in the 1998/99 crop season. Nevertheless, seed yield, shelling percentage and seed size of P49-6 and C851/7 compared favourably with those of CG 7, the recommended variety.

Table 6: Overall performance of promising groundnut genotypes evaluated at four on-station sites at Chitedze, Chitala, Makoka and Baka, 1998/99 crop season

Genotype	Seed yield (kg ha^{-1})	Shelling percentage (%)	Seed size (g)
P49-6	1838	71	59
C851/7	1599	69	57
D27/3	1492	69	67
ICGV-SM 89709	1469	72	64
CG 7	1969	72	59
Mean	1673	71	61
SE (±)	136.11	1.29	2.79
CV (%)	16	4	9
Significance level	NS	NS	NS

Key: NS = No significant differences at P=0.05 (LSD test); SE(±)=Standard error; CV(%)=Coefficient of variation.

Table 7: Overall performance of promising groundnut genotypes evaluated on-station sites at Chitedze and Chitala, 1999/00 crop season

Genotype	Seed yield (kg ha^{-1})	Shelling percentage (%)	Seed size (g)
P49-6	1909	74	58
C851/7	1708	66	56
D27/3	1337	65	67
ICGV-SM 89709	1217	69	66
CG 7	1931	71	55
Mean	1620	69	60
SE (±)	99.30	0.89	2.16
CV (%)	9	2	5
Significance level	*	**	*

Key: * = significant differences at P≤0.05, ** = significant differences at P≤0.01, *** = significant differences at P≤0.001 (LSD test); SE(±)=Standard error; CV(%)=Coefficient of variation.

Table 8: Groundnut yields (kg ha^{-1}) in different agro-ecological zones in Malawi over a ten year period (1989 to 1998)

Parameter	Year									
	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
AY	249	385	444	187	523	321	342	563	686	745
PY	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
YG	3,751	3,615	3,556	3,813	3,477	3,679	3,658	3,437	3,314	3,255
YG%	94	90	89	95	87	92	91	86	83	81

Key :AY = Actual yield; PY= Potential yield, YG = Yield gap; YG% - Yield gap percentage

Conclusions

Two early maturing rosette-resistant groundnut genotypes, ICG 12991 and ICG 12988, gave similar yields as JL 24 during both the summer and winter cropping seasons. However, where rosette pressure was very high, the two genotypes out-yielded JL 24. The only shortfall with the two genotypes is that their seed size is smaller than JL 24, bearing in mind that Malawians prefer large-seeded nuts. Nonetheless, small-seeded genotypes produce high yields in areas with low and erratic rainfall, such as the Shire Valley, and in areas under winter (off-season) cultivation. Off-season groundnut production provides an important source of income to many farmers in some areas of Karonga (along the Songwe river in

Karonga ADD) and Nkhata Bay (Maula in the Nkhata Bay Rural Development Project (RDP) along the valleys of Kapata, Chipakasi, Lilezi, Kapembe, Lingwinya and M'dyaka rivers) (Subrahmanyam and Nyirenda, 1993). Amongst the promising long-duration genotypes, P49-6 and C851/7 gave yields that are similar to those of the control variety, CG 7. Although C851/7 is not as high yielding as P49-6 or CG 7, this variety has good seed characteristics, good pod filling, tan seed coat and good roasted flavour that is similar to that of Chalimbana. These genotypes will be further evaluated under on-farm conditions using "the farmer participatory research approach" to further ascertain their yield potential and general acceptability by farmers in Malawi.

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