# Progress in Breeding Early Maturing Peanut Cultivars with Resistance to Groundnut Rosette Disease in West Africa

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**ABSTRACT**

Rosette is the most destructive virus disease of peanut (*Arachis hypogaea* L.) in Sub-Saharan Africa. Resistant cultivars have the greatest potential for minimizing the risk of losses due to the disease. The objectives of this study were to develop and evaluate new peanut breeding lines for reaction to rosette disease and determine their yield potential. Rosette-resistant parents were crossed with early maturing susceptible spanish types. The $F_2$, $F_4$, and $F_5$ generations were grown in a rosette disease screening nursery. A modified bulk-pedigree method was followed in which the populations were grown in bulk until $F_4$. Single plant selections were made in $F_4$-derived $F_5$ progenies. Yield assessment began with $F_7$ lines from 1996 to 1998 growing seasons at three sites. High yielding rosette resistant lines with a maturity range of 90 to115 d were identified. Some of these new lines produced pod yields significantly higher than the previously developed resistance varieties. Promising lines have been made available to researchers in West and Central Africa and should contribute to an integrated rosette disease management program.

Key Words: *Arachis hypogaea*, groundnut.

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Peanut (*Arachis hypogaea* L.) is an important oil and forage crop grown in many countries in the semi-arid tropics. West Africa is the largest producer of peanut in Sub-Saharan Africa, but average yields of 500-800 kg/ha are below potential yields. One reason for low yields is the susceptibility of currently grown cultivars to rosette disease. Rosette is the most destructive disease of peanut in Nigeria, Ghana, Gambia, Senegal, Burkina Faso, Chad, and Cameroon. These countries produce more than 75% of the total production in the region. Although rosette epidemics are sporadic, yield losses approach 100% whenever the disease occurs in epidemic proportions. For example, the rosette epidemic of 1975 destroyed 0.75 million ha of peanut in Nigeria incurring a loss of an estimated $250 million in regional trade (Yayock *et al.*, 1976). Recurrent epidemics (Olorunju *et al.*, 1992) have limited production since 1975. Rosette disease is transmitted by an aphid (*Aphis craccivora* Koch) in a persistent, circulative manner (Okusanya and Watson, 1966). It is caused by a complex of three agents—groundnut rosette virus (GRV), genus *Umbravirus* (Murant *et al.*, 1995); its satellite RNA (sat RNA) (Blok *et al.*, 1995); and groundnut assistor virus (GRAV), genus *Luteovirus* (Reddy *et al.*, 1985). On their own, either GRAV or GRV cause symptomless infection or transient mild mottle symptoms. All three agents must be present in the host plant for successful transmission by the aphid vector. Disease symptoms are largely due to sat RNA and variants of sat RNA are responsible for the different forms of rosette (Murant and Kumar, 1990). Symptoms occur in two predominant forms, chlorotic and green rosette,

although other symptomatic forms have been reported (Naidu *et al.*, 1999).

Previous work showed that rosette could be managed by chemical control of the vector and cultural practices such as manipulating sowing dates and plant density (Subrahmanyam and Hildebrand, 1994). However, smallholder farmers seldom use these practices due to lack of resources, labor constraints and costs, sowing sequence of crops, and differential crop priorities. The sporadic occurrence of the disease from year to year and among fields and the lack of adoption of cultural control measures make it desirable to have cultivars with genetic resistance or tolerance to the disease. Resistant cultivars have the greatest potential for minimizing risks of losses due to rosette disease.

Pioneering research on the development of peanut cultivars with resistance to rosette was initiated in the early 1950s by the French Institut de Recherches pour les Huiles et Oléagineux (IRHO) in West Africa. Sources of resistance were first discovered in late maturing virginia (*A. hypogaea* L. subsp. *hypogaea* var. *hypogaea* ) landraces from Burkina Faso (then Haut Volta) and Cote d 'Ivoire in 1952. These sources formed the basis for rosette resistance breeding programs throughout Africa. These earlier attempts resulted in the development of long duration virginia cultivars such as 69-101 (120-125 d to maturity), RMP 12 and RMP 91 (140-150 d), and early maturing (90 d) spanish (*A. hypogaea* subsp. *fastigiata* var. *vulgaris*) types such as KH 149 A, KH 241 C, KH 241 D, and QH 243 C (Bockelée-Morvan, 1960). Resistance among these cultivars was effective against both chlorotic and green rosette forms of the disease and was governed by two independent recessive genes (Berchoux, 1960; Nigam and Bock, 1990; Olorunju *et al.*, 1992). Unfortunately, the rosette resistant, long duration varieties developed are not adapted to the short growing seasons of the dry savannah of West Africa where the crop is largely grown. The few early maturing, rosette-resistant cultivars were not widely adopted by farmers, as their characteristics did not meet farmers' preferences, such as seed size and color. Our objectives were to develop and evaluate new breeding lines for resistance to rosette disease and yield potential.

## Materials and Methods

The breeding program was conducted in Malawi and Nigeria. Initial crosses were generated in 1988/89 at Chitedze, Malawi (14°S and 33°45'E, 1149 m asl), and various selected and unselected bulk populations were sent to Nigeria for further evaluation and selection. In Nigeria the research was carried out at three locations representing three important agro-ecological zones for peanut production. The first was Minjibir (12°8'N, 8°4'E, 500 m asl) with an average annual rainfall of 700 mm and a growing season of about 100 d. The soil is well drained with 0-1% slope and is classified as hypothermic, ustic Plinthic Quartzipsamment (USDA taxonomy). The second was Bagauda (11°40'N, 8°30'E, 475 m asl) with an average annual rainfall of 900 mm and an average growing season of 120 d with moderately well drained clay-loam soils. The third was Samaru (11°8'N, long 7°E, 450 m asl) with an average annual rainfall of 1200 mm and a growing season of 130-150 d. Soils are well drained leached luvisols described as ferruginous tropical soils.

***Development of Populations***. Rosette-resistant parents used in the crosses were RG1 and RMP 40 (long duration virginia type) from Malawi and Cote d' Ivoire, respectively, and KH 241-D (short duration spanish type) from Burkina Faso. These were crossed with early maturing, susceptible spanish types, which included 55-437, JL 24, ICGM 284, ICGV 86035, ICGV 86061, ICGV 86105, ICGV 87722, ICGV-SM 83001, ICGV-SM 85057, and ICGV-SM 85725. The cultivars 55-437 and JL 24 are well adapted in semi-arid West Africa and India, respectively. The remaining entries were advanced breeding lines from the ICRISAT breeding program in Malawi. A total of 16 cross combinations were made at Chitedze during the 1988/89 growing season. About 30 $F_1$ seeds per cross combination were grown in the screen house under disease-free conditions to produce $F_2$ populations.

***Evaluation of Segregating Populations***. The infector row technique developed by Bock and Nigam (1988) was used. This technique results in disease incidence of 99% in susceptible test entries. A chlorotic rosette culture maintained in the screen house was used in all screening trials. At sowing time, one infector row of susceptible cultivar 55-437 was sown after every two contiguous rows of test lines, such that every test row was adjacent to one infector row. Seedlings (cv. 55-437) showing severe rosette symptoms and heavily infested with aphids were raised in the screen house and transplanted in the infector rows (one plant per 1.5-2-m row) 10 d after sowing. A long duration, rosette-resistant (cv. RMP 12) was sown after every 20 rows.

In the $F_2$, only plants with no rosette symptoms were harvested. Plant numbers harvested ranged from 45 to 788 per cross. A modified bulk-pedigree method was followed in which the material was grown in bulk until the $F_4$ generation. Single plant selections were made in the $F_4$, and $F_4$-derived $F_5$ progenies. Promising and homogeneous $F_5$ and $F_6$ progenies were bulked and seed was increased for further purification and elimination of late maturing plants

***Evaluation of $F_{5:7}$ and $F_{5:8}$ Lines for Resistance to Rosette***. Selected lines including checks were grouped into very early (<100 d to maturity), early (101-115 d to maturity), and medium duration (116-120 d to maturity). The early maturing lines were predominantly spanish types with a few intermediates and the medium maturing group was mainly virginia types. The lines were screened in rosette disease nurseries at Samaru and Bagauda (1996 and 1997) and only at Samaru in 1997 using the infector-row technique. Plots were unreplicated, single rows 4 m long and 0.75 m apart. Spacing within rows was 10 cm. Plants in each plot were evaluated for symptoms of green as well as chlorotic rosette 60 d after sowing. The number of plants showing rosette symptoms was recorded in each plot to compute the percentage of disease incidence. Plants showing severe rosette symptoms were stunted and bushy in appearance due to reduced internodes length. Leaves of the infected plants were reduced in size and the plants did not produce pods. Lines were considered resistant when no susceptible plants were found within the complete entry (0% incidence), highly susceptible when no resistant plants were present (100% incidence), and moderately resistant when at least one plant within the entry had mild symptoms (<10% incidence). No yield data were recorded in the

nurseries.

***Virus Detection.*** In 1996 and 1997, leaf samples showing rosette symptoms (both green and chlorotic) were assayed for GRAV using a triple antibody sandwich form of enzyme-linked immunosorbent assay (TAS-ELISA) (Rajeshwari *et al.*, 1987). No diagnostic tests were conducted for GRV and sat RNA because previous studies showed good correlation between symptoms and the presence of GRV and its sat RNA in either rosette-susceptible or resistant accessions (Bock *et al.*, 1990; Blok *et al.*, 1995; Naidu *et al.*, 1998).

***Evaluation of Advanced Lines for Yield Potential.*** Replicated trials were conducted to evaluate yield potential from 1996 to 1998 at Samaru, Bagauda, and Minjibir. Individual plots were four rows, 4 m long and 0.75 m apart. Within row spacing was about 10 cm. A basal dose of 100 kg/ha of single superphosphate was incorporated into the soil by broadcasting during land preparation. Seeds were hand-sown at each location. A lattice experimental design with three replications was used. Fields were kept weed free by regular manual weeding. The trials were rainfed and no fungicides were used to control foliar diseases. At Bagauda in 1997, border rows were infested with aphids reared on peanut seedlings having rosette disease symptoms. Disease incidence in each plot was assessed as described in the disease nursery.

Before harvest, days to flowering, days to maturity, and rosette disease incidence were recorded for each plot. At harvest all plants in a plot were hand-lifted. Plants were determined as mature by the blackening of the internal pod wall (Williams and Drexler, 1981). Pods were separated from haulms by hand and dried in the sun. The pods were weighed after cleaning and removal of soil and plant debris. Shelling percentage was determined from a 200-g sample of pods, and seed weight was taken by weighing 100 sound mature kernels from each plot. The data on rosette incidence were analyzed for each season, while for pod yield the analysis was for each season and over seasons using GENSTAT statistical procedures (Genstat 5 Committee, 1993).

## Results and Discussion

***Rosette Disease Incidence.*** Both chlorotic and green rosette symptoms were observed at Samaru, where green rosette tended to develop at an earlier stage of the crop than chlorotic rosette. Chlorotic rosette symptoms were more than 90% at Bagauda and Minjibir. Rosette disease incidence was very high in infested plots at both Samaru and Bagauda reaching 100% in susceptible lines (Table 1). Many plants in resistant lines were symptomless while in others symptoms were restricted to one or two branches with no significant effect on pod production. Susceptible lines with 100% disease incidence exhibited uniform plant mortality.

***GRAV Detection.*** All lines tested positive for GRAV antigen irrespective of symptoms suggesting that all plants without symptoms were infected with GRAV (data not shown). This suggests that distinct mechanisms might operate against the three agents (GRV and its sat RNA and GRAV) in the resistant material. The understanding of these mechanisms would enable the development of better strategies for incorporating resistance to all agents of rosette disease.

***Yield Performance.*** Under natural infection, rosette disease was present at all sites and years and disease incidence in test plots ranged from 0 to 45%. At Bagauda, where plots were infested with aphids, incidence ranged from 5% on resistant to 100% on susceptible lines. Due to a large number of lines in each trial series, only data for selected entries are presented. Average yields achieved across sites in different years in the three series of trials are presented in Tables 2-4. For very early maturing lines, mean pod yield over sites and years ranged from 0.51 to 1.60 t/ha. ICGV-IS 96894 and ICGV-IS 96900 produced the highest average pod yield and were significantly superior to the resistant (KH 241D) and susceptible (55-437 and RRB) checks (Table 2). Under induced rosette epidemic at Bagauda in 1997, susceptible checks produced negligible yields compared to the resistant lines. Pod yield variation across locations and in different years may have been due to the different levels of disease incidence at each location and year. Correlations of pod yield and rosette incidence were negative and significant ($P = 0.05$-$0.01$). Correlations (r values) ranged from -0.25 to -0.89 depending on location and year. The greater the mean and range in rosette incidence values, the higher the correlations. Significant ($P \leq 0.05$) differences were observed among early maturing lines for pod yield. Lines that produced on average over 1.5 t/ha were significantly higher than the checks (Table 3). As for the very early maturity group, correlations of yield and rosette incidence were significant and negative and ranged from $r = -0.30$ at Samaru to $r = -0.91$ at Minjibir. The higher degree of resistance in some very early and early maturing lines compared to the resistant parent KH 241D suggests transgressive segregation in crosses between KH 241D and other spanish parental lines.

The medium maturing lines appeared to be better adapted to conditions prevailing at Bagauda and Samaru as indicated by the low yields at Minjibir (Table 4). Minjibir is a much drier site with a shorter growing season than the other locations. The degree of resistance in these lines was much higher that in the early maturing lines, but their pod yield did not significantly differ from those of the resistant checks. On the other hand, their yield under induced rosette epidemic was over 10x higher than the susceptible checks. Correlations between rosette incidence and pod yield were also negative and ranged from $r = -0.34$ to $-0.81$.

Yield loss due to rosette depended on the stage of growth at which infection occurred. Complete loss of pod yield may result if infection was before flowering, as was the case in the rosette disease nursery. Yield loss was variable if infection occurred between flowering and pod maturity. Late infections in the season tended to cause negligible effects. The results of this study indicate that under rosette epidemic conditions, the level of resistance incorporated in both early and medium maturing lines will prevent crop failure.

For the early and medium maturing lines, the most frequent resistant parent in crosses was RG1. This line has shown broad-based resistance to rosette (Subrahmanyam *et al.*, 1998). On the other hand, ICGV-

**Table 1. Reaction of the highest yielding early and medium maturing rosette-resistant breeding lines in a rosette disease nursery at Samaru (S) and Bagauda (B) in 1996 and 1997.**

| Very early maturing genotypes (<100 d) | Rosette incidence S 1996 | B 1996 | S 1997 | Early maturing genotypes (100-115 d) | Rosette incidence S 1996 | B 1996 | S 1997 | Medium maturing genotypes (115-120 d) | Rosette incidence S 1996 | B 1996 | S 1997 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | ----------% ---------- | | | | ----------% ---------- | | | | ----------% ---------- | | |
| ICGV IS 96894 | 2 | 3 | 2 | ICGV IS 96826 | 1 | 0 | 3 | ICGV-IS 96806 | 6 | 2 | 2 |
| ICGV IS 96900 | 0 | 5 | 2 | ICGV IS 96801 | 0 | 0 | 3 | ICGV-IS 96840 | 2 | 1 | 2 |
| ICGV IS 96901 | 0 | 0 | 3 | ICGV IS 96848 | 3 | 1 | 3 | ICGV-IS 96812 | 1 | 3 | 1 |
| ICGV IS 96859 | 0 | 0 | 2 | ICGV IS 96808 | 2 | 3 | 3 | ICGV-IS 96811 | 1 | 1 | 2 |
| ICGV IS 96909 | 5 | 3 | 2 | ICGV IS 96804 | 1 | 3 | 2 | ICGV-IS 96813 | 1 | 3 | 1 |
| ICGV IS 96871 | 8 | 6 | 2 | ICGV IS 96805 | 0 | 2 | 3 | ICGV-IS 96839 | 0 | 4 | 2 |
| ICGV IS 96898 | 3 | 1 | 4 | ICGV IS 96855 | 0 | 0 | 5 | ICGV-IS 96843 | 2 | 2 | 2 |
| ICIAR18AR | 1 | 2 | 2 | ICGV IS 96802 | 0 | 0 | 6 | ICGV-IS 96844 | 2 | 0 | 2 |
| ICIAR7B | 0 | 0 | 1 | ICGV IS 96845 | 2 | 4 | 2 | ICGV-IS 96803 | 1 | 1 | 1 |
| ICIAR18AT | 0 | 7 | 3 | ICGV IS 96827 | 3 | 0 | 4 | ICGV-IS 96821 | 2 | 3 | 1 |
| ICIAR19 BT | 1 | 5 | 4 | ICGV IS 96840 | 0 | 3 | 7 | ICGV-IS 96822 | 0 | 2 | 1 |
| ICIAR9 AT | 7 | 1 | 4 | ICGV IS 96809 | 0 | 2 | 1 | ICGV-IS 96814 | 0 | 2 | 2 |
| ICIAR12AR | 0 | 2 | 0 | ICGV IS 96828 | 0 | 0 | 4 | ICGV-IS 96837 | 3 | 1 | 2 |
| ICIAR10B | 0 | 0 | 0 | ICGV IS 96835 | 0 | 2 | 3 | ICGV-IS 96846 | 0 | 5 | 1 |
| | | | | ICGV IS 96810 | 0 | 2 | 2 | ICGV-IS 96817 | 1 | 2 | 2 |
| Resistant check | | | | | | | | | | | |
| | | | | ICGV IS 96841 | 5 | 2 | 3 | ICGV-IS 96815 | 0 | 1 | 2 |
| KH241D | 6 | 6 | 3 | ICGV IS 96847 | 4 | 3 | 4 | ICGV-IS 96819 | 0 | 0 | 2 |
| | | | | ICGV IS 96825 | 5 | 0 | 4 | ICGV-IS 96836 | 0 | 2 | 2 |
| | | | | ICGV IS 96824 | 3 | 6 | 1 | ICGV-IS 96842 | 3 | 0 | 1 |
| | | | | ICGV IS 96816 | 0 | 0 | 3 | ICGV-IS 96833 | 1 | 2 | 2 |
| | | | | | | | | ICGV-IS 96895 | 2 | 3 | 2 |
| | | | | | | | | ICGV-IS 96818 | 1 | 1 | 2 |
| | | | | | | | | ICGV-IS 96838 | 0 | 3 | 0 |
| | | | | | | | | ICGV-IS 96820 | 1 | 3 | 0 |
| | | | | | | | | Resistant check | 4 | 2 | 1 |
| | | | | | | | | UGA 2 | 0 | 2 | 2 |
| Susceptible checks | | | | | | | | Susceptible checks | | | |
| RRB | 100 | 100 | 100 | | | | | ICGV 92082 | 100 | 100 | 100 |
| 55-437 | 100 | 100 | 100 | | | | | ICGV 92088 | 100 | 100 | 100 |

**Table 2. Pod yield of very early (< 100 d maturity) rosette-resistant lines at three locations in Nigeria, 1996, 1997, and 1998.**

| Entry | Samaru 1996 | Samaru 1997 | Bagauda 1997 | Bagauda 1998 | Minjibir 1996 | Minjibir 1997 | Minjibir 1998 | Means |
|---|---|---|---|---|---|---|---|---|
| | --------t/ha------- | | -------t/ha------- | | ----------t/ha---------- | | | t/ha |
| ICGV IS 96894 | 2.21 | 1.85 | 1.47 | 1.26 | 2.08 | 1.08 | 1.24 | 1.60 |
| ICGV IS 96900 | 1.70 | 1.84 | 1.78 | 1.92 | 1.69 | 0.97 | 0.99 | 1.56 |
| ICGV IS 96901 | 0.75 | 0.41 | 0.81 | 2.63 | 0.69 | 0.86 | 2.22 | 1.20 |
| ICGV IS 96859 | 1.43 | 0.93 | 1.19 | 1.52 | 0.81 | 0.83 | 1.38 | 1.16 |
| ICGV IS 96909 | 1.15 | 1.12 | 1.17 | 1.66 | 0.89 | 0.78 | 1.30 | 1.15 |
| ICGV IS 96871 | 1.50 | 1.05 | 1.08 | 1.41 | 0.94 | 0.50 | 1.22 | 1.10 |
| ICGV IS 96898 | 1.47 | 1.00 | 1.03 | 1.34 | 1.03 | 0.61 | 0.89 | 1.05 |
| ICIAR7B | 1.23 | 0.73 | 1.06 | 1.98 | 0.89 | 0.67 | 1.36 | 1.13 |
| ICIAR10B | 1.04 | 0.62 | 0.97 | 1.33 | 0.78 | 0.67 | 1.52 | 0.99 |
| ICIAR18AR | 1.19 | 1.06 | 1.00 | 1.09 | 1.19 | 0.75 | 0.95 | 1.03 |
| ICIAR9 AT | 1.29 | 0.89 | 1.03 | 1.70 | 0.58 | 0.36 | 1.25 | 1.01 |
| ICIAR18AT | 1.73 | 0.58 | 1.17 | 2.00 | 1.28 | 1.00 | 1.45 | 1.32 |
| ICIAR19 BT | 1.59 | 1.26 | 1.44 | 1.37 | 1.53 | 0.78 | 1.06 | 1.29 |
| ICIAR12AR | 1.04 | 0.84 | 0.89 | 1.35 | 1.11 | 0.67 | 0.73 | 1.05 |
| Mean (49 entries) | 1.26 | 1.62 | 0.87 | 1.57 | 1.05 | 0.76 | 1.30 | 1.20 |

**Table 2 (Continued)**

| Entry | Samaru 1996 | Samaru 1997 | Bagauda 1997 | Bagauda 1998 | Minjibir 1996 | Minjibir 1997 | Minjibir 1998 | Means |
|---|---|---|---|---|---|---|---|---|
| | t/ha | | t/ha | | t/ha | | | t/ha |
| Resistant check | | | | | | | | |
| KH 241D | 1.15 | 1.04 | 0.69 | 1.14 | 1.25 | 0.72 | 1.25 | 1.02 |
| Susceptible checks | | | | | | | | |
| RRB | 1.22 | 1.72 | 0.14 | 1.69 | 1.22 | 0.94 | 1.38 | 1.19 |
| 55-437 | 0.51 | 0.58 | 0.14 | 1.17 | 0.78 | 0.92 | 1.72 | 0.83 |
| SE (±) | 0.238 | 0.22 | 0.448 | 0.171 | 0.556 | 0.226 | 0.222 | |
| CV (%) | 33 | 27 | 51 | 19 | 23 | 30 | 29 | |

**Table 3. Pod yield of early (110-115 d maturity) rosette-resistant lines at three locations in Nigeria, 1996, 1997, and 1998.**

| Entry | Samaru 1996 | Samaru 1997 | Bagauda 1996 | Bagauda 1997 | Bagauda 1998 | Minjibir 1997 | Minjibir 1998 | Means |
|---|---|---|---|---|---|---|---|---|
| | t/ha | | t/ha | | | t/ha | | t/ha |
| ICGV IS 96826 | 2.08 | 1.20 | 1.91 | 2.69 | 2.44 | 1.58 | 1.01 | 1.84 |
| ICGV IS 96801 | 1.80 | 1.12 | 2.21 | 2.72 | 1.89 | 2.09 | 1.01 | 1.83 |
| ICGV IS 96848 | 1.93 | 1.38 | 2.37 | 2.35 | 1.92 | 1.73 | 1.11 | 1.83 |
| ICGV IS 96808 | 1.53 | 2.13 | 1.86 | 2.42 | 1.92 | 1.76 | 1.14 | 1.82 |
| ICGV IS 96804 | 1.86 | 1.49 | 1.84 | 2.32 | 2.03 | 1.88 | 1.02 | 1.78 |
| ICGV IS 96805 | 1.56 | 1.25 | 2.14 | 2.84 | 2.11 | 1.60 | 0.82 | 1.76 |
| ICGV IS 96855 | 0.89 | 1.83 | 2.20 | 2.22 | 2.25 | 1.94 | 0.79 | 1.73 |
| ICGV IS 96802 | 1.67 | 1.25 | 2.25 | 2.81 | 1.89 | 1.26 | 0.87 | 1.71 |
| ICGV IS 96827 | 1.88 | 0.85 | 1.73 | 2.67 | 1.89 | 1.31 | 1.17 | 1.64 |
| ICGV IS 96840 | 1.61 | 0.86 | 2.67 | 1.83 | 2.06 | 1.23 | 0.90 | 1.59 |
| ICGV IS 96809 | 1.53 | 1.14 | 1.88 | 2.42 | 1.92 | 1.20 | 0.68 | 1.54 |
| ICGV IS 96828 | 1.89 | 1.43 | 1.48 | 2.44 | 1.64 | 1.27 | 0.61 | 1.54 |
| ICGV IS 96835 | 0.85 | 1.00 | 1.87 | 2.28 | 1.92 | 1.49 | 1.09 | 1.50 |
| ICGV IS 96810 | 1.94 | 1.40 | 1.89 | 1.95 | 1.50 | 1.05 | 0.73 | 1.49 |
| ICGV IS 96841 | 0.54 | 1.03 | 2.00 | 2.24 | 1.86 | 1.75 | 1.00 | 1.49 |
| ICGV IS 96847 | 1.48 | 1.06 | 1.69 | 2.03 | 1.39 | 1.65 | 0.71 | 1.43 |
| ICGV IS 96825 | 1.45 | 0.79 | 1.62 | 2.25 | 1.69 | 1.08 | 0.84 | 1.39 |
| ICGV IS 96824 | 1.12 | 0.53 | 1.90 | 2.20 | 1.50 | 1.14 | 1.00 | 1.34 |
| ICGV IS 96816 | 1.49 | 0.70 | 1.48 | 1.88 | 1.03 | 0.43 | 0.47 | 1.07 |
| Mean (42 entries) | 1.02 | 1.05 | 2.22 | 1.35 | 1.80 | 1.29 | 0.93 | 1.46 |
| Resistant check | | | | | | | | |
| KH 241D | 1.15 | 1.04 | 1.14 | 0.69 | 1.25 | 0.72 | 1.25 | 1.19 |
| Susceptible checks | | | | | | | | |
| RRB | 1.22 | 1.72 | 1.69 | 0.16 | 1.22 | 0.94 | 1.38 | 1.19 |
| 55-437 | 0.51 | 0.58 | 1.17 | 0.16 | 0.78 | 0.92 | 1.72 | 0.83 |
| SE (±) | 0.218 | 0.191 | 0.304 | 0.023 | 0.167 | 0.207 | 0.208 | |
| CV (%) | 27 | 26 | 24 | 33 | 16 | 28 | 39 | |

SM 85035 a spanish type maturing in 100 d and susceptible to rosette frequently appeared in the parentage of newly developed lines. Very few resistant segregates were recovered from populations involving KH 241D and other spanish types.

Average shelling percentage and seed size indicated by 100-seed weight of the top 10 highest yielding rosette resistant lines are shown in Table 5. Overall shelling percentage was as good as the susceptible check cultivars. Some of the lines, however, had significantly larger seed size than the checks.

Identification of rosette-resistant lines combining

**Table 4. Pod yield (t/ha) of medium-duration (115-120 d) rosette-resistant lines in Nigeria, 1996, 1997, and 1998.**

| Entry | Samaru | | Bagauda | | | Minjibir | | Means |
|---|---|---|---|---|---|---|---|---|
| | 1996 | 1997 | 1996 | 1997 | 1998 | 1997 | 1998 | |
| | -------t/ha ------ | | ----------t/ha ---------- | | | ---------t/ha------ | | t/ha |
| ICGV-IS 96840 | 1.61 | 1.20 | 2.67 | 1.93 | 1.75 | 0.64 | 1.32 | 1.59 |
| ICGV-IS 96812 | 1.67 | 1.60 | 1.90 | 2.70 | 1.84 | 0.37 | 1.02 | 1.59 |
| ICGV-IS 96811 | 1.83 | 1.34 | 1.64 | 2.34 | 1.72 | 0.67 | 1.54 | 1.58 |
| ICGV-IS 96813 | 1.77 | 0.80 | 1.55 | 2.73 | 1.46 | 0.75 | 1.19 | 1.46 |
| ICGV-IS 96839 | 2.11 | 1.31 | 1.74 | 2.09 | 1.32 | 0.70 | 0.93 | 1.46 |
| ICGV-IS 96843 | 2.00 | 0.64 | 1.75 | 2.09 | 1.43 | 0.78 | 1.33 | 1.43 |
| ICGV-IS 96844 | 2.00 | 0.93 | 1.57 | 2.26 | 1.21 | 0.89 | 1.12 | 1.43 |
| ICGV-IS 96803 | 1.91 | 1.28 | 1.79 | 2.44 | 1.22 | 0.52 | 0.79 | 1.42 |
| ICGV-IS 96821 | 1.81 | 1.23 | 1.91 | 1.73 | 0.92 | 1.11 | 1.01 | 1.39 |
| ICGV-IS 96822 | 1.79 | 1.32 | 1.87 | 1.55 | 0.94 | 1.02 | 1.01 | 1.36 |
| ICGV-IS 96814 | 2.01 | 0.38 | 1.50 | 2.03 | 1.35 | 0.86 | 1.33 | 1.35 |
| ICGV-IS 96837 | 1.45 | 1.06 | 1.67 | 1.71 | 1.35 | 0.86 | 1.17 | 1.32 |
| ICGV-IS 96846 | 1.78 | 1.19 | 1.45 | 2.33 | 1.38 | 0.50 | 0.51 | 1.31 |
| ICGV-IS 96817 | 1.73 | 1.22 | 1.07 | 2.02 | 1.27 | 0.61 | 1.18 | 1.30 |
| ICGV-IS 96815 | 1.16 | 1.17 | 1.29 | 2.12 | 1.12 | 0.64 | 1.51 | 1.29 |
| ICGV-IS 96819 | 1.85 | 1.07 | 1.22 | 1.89 | 1.08 | 0.69 | 1.07 | 1.27 |
| ICGV-IS 96836 | 1.33 | 0.97 | 1.47 | 2.22 | 1.19 | 0.64 | 0.99 | 1.26 |
| ICGV-IS 96842 | 1.33 | 0.75 | 1.23 | 2.16 | 1.28 | 0.83 | 1.08 | 1.24 |
| ICGV-IS 96833 | 1.47 | 1.18 | 1.58 | 1.90 | 1.33 | 0.52 | 0.61 | 1.23 |
| ICGV-IS 96895 | 0.96 | 1.04 | 1.31 | 1.48 | 1.37 | 0.89 | 1.49 | 1.22 |
| ICGV-IS 96818 | 1.59 | 0.91 | 1.29 | 1.85 | 1.15 | 0.61 | 0.86 | 1.18 |
| ICGV-IS 96838 | 1.47 | 0.78 | 1.74 | 1.93 | 1.07 | 0.64 | 0.61 | 1.18 |
| ICGV-IS 96820 | 1.44 | 1.15 | 1.07 | 1.67 | 1.06 | 0.39 | 0.8 | 1.08 |
| Mean (36 entries) | 1.63 | 1.14 | 1.71 | 1.99 | 1.32 | 0.66 | 1.02 | 1.35 |
| Resistant Checks | | | | | | | | |
| UGA 2 | 1.82 | 1.23 | 1.62 | 2.35 | 1.11 | 0.56 | 0.54 | 1.32 |
| UGA 5 | 1.86 | 1.04 | 1.71 | 2.25 | 1.16 | 0.5 | 0.54 | 1.29 |
| Susceptible checks | | | | | | | | |
| ICGV 92082 | 1.10 | 1.25 | 1.15 | 0.05 | 1.05 | 0.86 | 0.82 | 0.89 |
| ICGV 92088 | 1.11 | 1.18 | 1.10 | 0.06 | 1.09 | 0.61 | 0.46 | 0.63 |
| SE (±) | 0.126 | 0.217 | 0.118 | 0.191 | 0.132 | 0.102 | 0.115 | |
| CV (%) | 13 | 33 | 12 | 27 | 17 | 27 | 19 | |

shorter maturity seasons, reasonable pod yield, and other agronomic attributes gives an indication of potential benefit to peanut producers in rosette endemic areas in West Africa. These resistant lines yield much higher than the susceptible checks under both moderate and high disease pressure. In Nigeria, four lines---ICGV-IS 96808, ICGV IS 96855, ICGV 96891, and ICGV-IS 96894---have been recommended for cultivar release. These and other promising lines such as ICGV-IS 96900, ICGV-IS 96859, ICGV-IS 96801, and ICGV-IS 96895 were made available to researchers in West and Central Africa. This is the first time such breeding material was distributed in the region and should restore farmers' confidence for growing peanuts without losing their harvest to rosette disease.

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**Table 5. Shelling percentage and 100-seed weight of the top 10 highest yielding lines averaged over three locations from 1996 to 1998.**

| Genotype | Shelling | 100-seed weight |
|---|---|---|
| | % | g |
| **<100 d** | | |
| ICGV IS 96894 | 54.1 | 38.6 |
| ICGV IS 96900 | 58.0 | 42.8 |
| ICGV IS 96901 | 67.2 | 28.0 |
| ICGV IS 96859 | 60.5 | 36.5 |
| ICGV IS 96909 | 57.2 | 36.8 |
| ICGV IS 96871 | 60.0 | 32.3 |
| ICGV IS 96898 | 58.4 | 44.0 |
| ICIAR7B | 61.6 | 33.3 |
| ICIAR18AT | 64.9 | 29.1 |
| ICIAR19 BT | 59.5 | 35.0 |
| ICIAR12AR | 56.0 | 35.5 |
| KH 241D (resistant check) | 64.4 | 39.2 |
| RRB (susceptible check) | 60.8 | 32.0 |
| 55-437 (susceptible check) | 58.5 | 27.0 |
| SE (mean) | 5.32 | 2.76 |
| **100-115 d** | | |
| ICGV IS 96826 | 60.8 | 30.0 |
| ICGV IS 96801 | 69.5 | 45.0 |
| ICGV IS 96848 | 56.6 | 34.1 |
| ICGV IS 96808 | 62.8 | 42.9 |
| ICGV IS 96804 | 61.4 | 36.2 |
| ICGV IS 96805 | 63.4 | 27.6 |
| ICGV IS 96855 | 65.9 | 41.3 |
| ICGV IS 96802 | 70.9 | 41.7 |
| ICGV IS 96827 | 58.8 | 30.0 |
| ICGV IS 96840 | 58.4 | 34.6 |
| KH 241D (resistant check) | 58.0 | 39.3 |
| RRB (susceptible check) | 66.2 | 32.6 |
| 55-437 (susceptible check) | 68.4 | 29.4 |
| SE (mean) | 5.62 | 2.68 |
| **115-120 d** | | |
| ICGV-IS 96840 | 58.3 | 36.5 |
| ICGV-IS 96812 | 62.3 | 26.2 |
| ICGV-IS 96811 | 61.0 | 36.9 |
| ICGV-IS 96813 | 62.6 | 45.7 |
| ICGV-IS 96839 | 57.1 | 50.2 |
| ICGV-IS 96843 | 62.7 | 45.7 |
| ICGV-IS 96844 | 66.9 | 51.4 |
| ICGV-IS 96803 | 60.4 | 50.0 |
| ICGV-IS 96821 | 63.3 | 45.5 |
| ICGV-IS 96822 | 65.3 | 43.8 |
| UGA 2 (resistant check) | 68.5 | 46.9 |
| ICGV 92082 (susceptible check) | 68.7 | 44.5 |
| SE (mean) | 4.14 | 2.63 |

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