Paper 42

BREEDING COWPEA VARIETIES FOR MULTIPLE DISEASE RESISTANCE IN RWANDA

M. Price, D. Cishahayo
Institut des Sciences Agronomique du Rwanda at Karama
Kigali, Rwanda

ABSTRACT

The semi-arid Bugesera, Gisaka-Migongo region of Rwanda is plagued by insects, crop diseases, drought and poor soil. To increase food production and protein intake in this region, drought-tolerant cowpea varieties were introduced. Because most cowpea lines (*Vigna unguiculate*) were highly susceptible to cowpea scab disease (*Elsinoe phaseoli* Jenkins) and ascochyta blight (*Ascochyta phaseolorum* Sacc.), the major objective of cowpea breeding was to develop populations resistant to these and other major diseases.

This was achieved in 1983 by using a modified version of Jensen's (1970) dialled selective cyclic mating method in combination with other methods. Blend populations with greater yield stability, disease resistance, and adaptability were produced.

Population blend, a form of population engineering which places compatible genotypes together, uses conventional breeding methods and techniques that allow for the increase of genetic variability by intermating selected groups and assembling compatible genotypes. At any cycle or generation, superior genotypes can be added to the population and the mating system, or inferior genotypes can be eliminated. Most significantly, heavy natural and artificial selection pressures are applied, thus eliminating high numbers of inferior genotypes.

KEYWORDS

Scab disease, ascochyta blight, diallel selective cyclic mating, population blend, compatible genotypes, populations engineering.

INTRODUCTION

Price *et al.* (1983) conducted a survey on food production by small-scale farmers in the semi-arid Bugesera, Gisaka-Migongo (BGM) region of Rwanda. Some of the major constraints identified were crop disease and insect problems, poorly adapted and low-yielding crop varieties, low and unpredictable rainfall, and poor soils which degrade quickly because of over exploitation.

To increase food production in the region, one strategy involved the introduction of high-yielding, drought-tolerant cowpea varieties (*Vigna unguiculate*). Many of these varieties are adapted to low soil fertility. Furthermore, cowpea grain is accepted by the farmer as a source of protein. Unfortunately, most of these cowpea varieties are highly susceptible to cowpea scab disease (*Elsinoe phaseoli* Jenkins) and ascochyta blight (*Ascochyta phaseolorum* Sacc.). These diseases are widely distributed and extremely devastating in the BGM region. They can cause 50% yield loss to complete crop failure on susceptible varieties, and most farmers are reluctant to grow cowpeas. Hence, the cultivation of cowpeas is threatened because of cowpea scab disease and ascochyta blight.

The major objective of this study was to develop cowpea populations that would be resistant to major diseases, especially to scab disease and ascochyta blight, and either tolerant of or resistant to many biological and environmental stresses such as insects, drought, low soil fertility and high acid soils.

A different approach from breeding for high yielding and adaptable cowpea varieties was required. Thus, in March/April 1983, cowpea breeding was started using a modified version of Jensen's (1970) dialled selective cyclic mating method in combination with other methods. The advantage of this method was that it allowed the continuous sythesis of a wide range of genetically different genotypes at different times (years) and stages (generations).

MATERIALS AND METHODS

Multiple disease-resistant cowpea lines were developed by hybridisation among the lines Kinyama, RIET-40, Mwanza X, and IET 120-4. Details of the characteristics of each variety are given in Table 1. Seed size in the former variety was extremely small — a characteristic not preferred by farmers in the region. Since the cowpea lines Mwanza X and IET 120-4 are large seeded, they were also used as parents for crossing. However, they have low levels of resistance to scab disease and ascochyta blight.

Another consideration when selecting the parents was maturity. Kinyama and RIET-40 matured between 75 and 120 days. Due to the two short cropping seasons, farmers wanted early maturing varieties to plant in October and harvest in January so they could plant other crops (e.g., sorghum or maize) in February during the second rainy

Table 1. Characteristics of the parents used for diallel cyclic mating.

Cowpea line	Origin of the line	Characteristics DR[1] scab	DR Asco-chyta	Maturity (days)	Seed size (g/100 seeds)
Kinyama	selection made from local cowpea in Rwanda	27	32	75	8
REIT-40	TVu 123 X[2] TVu 1190 (R_7)	49	58	120	17
Mwanza X	single plant selection in Tanzania in 1981	75	78	145	26
IET 120-4	(TVu 1190 X[2] TVu 1247) X TVu 2616 X (RIET-40)	59	59	120	20

[1] Disease rating was calculated using the formula of Mukelar *et al.* (1979) where:

$$DR = \frac{1n_1 + 2n_2 + 3n_3 + 4n_4}{4N} \times 100$$

[2] Parents obtained from the International Institute of Tropical Agriculture.

season. They were also interested in a late maturing variety to plant at the end of the first rainy season (January), so that they would have crops carrying over into the second cropping season.

The only requirements for cowpea production were disease resistance (especially to scab disease and ascochyta blight), some insect tolerance (especially to flower thrips), and large seeds. Uniformity of varieties was not a great concern to the farmer.

For the first intermating used to develop the populations, each line was mated in all possible combinations. The second mating consisted of crossing F_1's in all combinations. Hybrid seeds from the second mating were bulked and divided into two categories.

- Category 1. This category consisted of two groups: Group 1 was planted at Kagasa under both biological and environmental stress conditions. Group II was seeded at Kayuvo under heavy disease pressure from scab disease and Ascochyta blight. For both groups, the third and succeeding matings involved intermating each plant. At this point and in succeeding generations, undesirable genotypes were eliminated. Also, at any generation, a superior genotype could be added into the population.
- Category 2. Half of the hybrid seeds from the double crosses of (Kinyama X Mwanza X) X (IET 120-4 X RIET-40) and (Kinyama X RIET-40) X (Mwanza X X IET 120-4) were collected and each hybrid plant was self-pollinated to produce S_0 seeds. S_1 lines resulted from individual plant selections within the S_0 population. As in category 1, each S_1 line was divided into two groups. One group was seeded at Kayuvo in the disease nursery where heavy disease pressure was applied to the populations. The other group was planted at Kagasa under both biological and environmental stress conditions. The most adapted and disease resistant lines were selected from the two locations, and the lines were further divided on the basis of maturity.

The superior S_1 plants were selfed, and the seeds produced by these lines were blended with 20% seeds from other lines which had outstanding characteristics such as high disease resistance and/or superior agronomic characteristics. These lines varied slightly from the S_2 populations in seed size and colour, pod size and colour, maturity, levels of resistance, and drought tolerance. In some instances, an original parent was one of the lines used to develop the population blend. This new blended population (S_2B_{1-3}) was evaluated at Kayuvo and Kagasa for disease resistance and adaptability. Performance of the S_2B populations was compared with that of the check varieties. At any point and in the succeeding generations, genotype(s) can be added (or blended) into the S or SB populations. Also, undesirable genotype(s) can be eliminated if necessary.

The composition of the population blends was as follows:

S_2: Denotes two cycles of selections.

S_2B_0: Progeny developed from two cycles of selection from the double cross (Kinyama X Mwanza X) X (IET 102-4 X RIET-40). No other genotype added.

S_2B_1: Selected S_2 individuals plus Rilima X (White), RIET-35.

S_2B_2: S_2 individuals plus Rilima X (White), RIET-39.

S_2B_3: S_2 individuals plus Rilima X (White), RIET-39, Lm[1], Ng-x[2].

[1]Lm was the individual genotype selected from the third cycle of mating in Category 1.
[2]Ng-x was derived for population improvement of the local variety selected in Ngenda commune, Rwanda.

RESULTS AND DISCUSSION

Genetic improvement in cowpeas has been restricted

Table 2. Disease rating and other agronomic traits of three different population blends at two locations in Rwanda.

Population blend	Disease rating: Scab Kagasa	Scab Kayuvo	Scab Means	Ascochyta Kagasa	Ascochyta Kayuvo	Ascochyta Means	Days to maturity	Seed size (g/100)	Yield (kg/ha) Kagasa	Yield (kg/ha) Kayuvo	Mean yield
S_2B_0	35	40	37	42	50	46	105-120	15.0	500	453	476
S_2B_1	10	20	15	34	40	37	100-110	17.0	1000	882	941
S_2B_2	29	30	29	17	20	18	100-105	20.0	1500	1416	1458
S_2B_3	9	10	9	20	30	25	95-105	22.0	1800	1792	1796
Kinyama	25	30	27	31	34	32	85	8.0	1500	980	1240
RIET-40	48	50	49	51	60	58	120	17.0	500	175	212
Mwanza X	70	80	75	76	80	78	145	26.0	200	43	121
IET 120-4 (R-40)	59	60	59	58	60	59	120	20.0	300	105	202
LSD	10.5	14.0	-	16.3	17.7	-	-	-	196.7	158.3	-
CV %	7.9	12.5	-	14.0	15.0	-	-	-	28	32	-

mainly to conventional breeding methods (pedigree and backcrossing breeding). Since the objective of our breeding programme was to develop varieties or populations having multiple disease resistance or tolerance to certain other stresses, it was necessary to use a modified version of the diallel selective cyclic mating system.

After only two cycles of selection, the response to selection for disease, maturity, and seed size was determined. These results are presented in Table 2. The disease ratings were much lower for the population blends than the susceptible parents and about the same or lower than the most resistant parent (Kinyama). The populations in Table 2 were developed to tolerate high levels of disease pressures, especially of scab and ascochyta blight. Additionally, other agronomic traits (which were dictated by the farmers) were considered while developing the populations.

The blended populations matured between 95 and 120 days (Table 2). Within each blended population, there was a range in maturity among the different genotypes of about five days. Furthermore, the seed size of the different genotypes within each population blend differed slightly, but the sizes were in the range accepted by farmers: medium-large. Other characteristics of the blended population also differed slightly.

S_2B_3 performed the best at both locations. Its overall mean yield was 1796 kg/ha (Table 2). The overall means for S_2B_2 and Kinyama were 1459 and 1240 kg/ha, respectively. Kinyama was the most resistant parent used in the cross. Disease ratings for S_2B_3 were also the lowest (Table 2). S_2B_3 gave an overall disease ratings of 9 for scab disease and 25 for Ascochyta blight. The susceptible varieties Mwanza X and IET 120-4 yielded the lowest 121 and 202 kg/ha respectively. They also gave the highest disease ratings.

Line S_2B_3 was composed of five different genotypes. One genotype (LM) was obtained from the cyclic mating population in category 1. This genotype, however, was not used in the other populations. This suggests that the population blends may be even better with the right combination of compatible genotypes.

Although the blended populations were more tolerant to environmental stress conditions (low soil fertility and drought) and more resistant to diseases, especially scab disease and ascochyta blight, it is possible that greater response to selection can be achieved. Therefore, selection and improvement of the population will continue until a few more cycles have been completed.

CONCLUSION

The production of population blends using the modified diallel selective cyclic mating system is extremely effective in producing populations having greater yield stability, disease resistance, and adaptability. Population blend is a form of population engineering in which compatible genotypes are placed together. This method is unique because it utilises conventional breeding methods and uses techniques that allow the increase of genetic variability in a population by intermating selected groups and assembling compatible genotypes. Moreover, at any cycle or generation, superior genotypes can be added to the population and the mating system, or inferior genotypes can be eliminated.

The most significant advantage of the system is that extremely heavy natural and artificial selection pressure is applied, eliminating high numbers of inferior genotypes. The populations developed by this method are either nearly homogenous and highly heterozygus, or heterogenous and heterozygous.

ACKNOWLEDGEMENTS

The authors would like to acknowledge and thank the Director of the Institut des Sciences Agronomique du Rwanda for giving us the support and permission to present this paper. We appreciate assistance of the Grain Legume Programme at the International Institute of Tropical Agriculture for providing the varieties required and the backup necessary for the success of this research.

REFERENCES

Jensen, N.F. 1970. A diallel selective mating system for cereal breeding. *Crop Science 10:* 629-635.

Price, M. *et al*. 1983. Preliminary survey of food crop farming systems in the Bugesera region of Rwanda. ISAR-IITA-BGM II-WB FSR Project. International Institute of Tropical Agriculture, Ibadan, Nigeria. 47 p.

Mukelar, A., Sudjadi, M., Kajiwara, T. 1976. Chemical Control for Mung Bean Scab. Contr. Centr. Res. Inst. Agric. Bogor. *No. 24* 7 p.