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A SYSTEMATIC EVALUATION OF GERMPLASM FOR A BREEDING PROGRAMME IN NAVY BEANS

R.J. Redden
Hermitage Research Station
Queensland, Australia

ABSTRACT

To expand the genetic base of a dry bean breeding programme 1462 accessions were assembled in 1982. Specific screening nurseries were planted with unreplicated recurrent checks after every tenth plot to provide a grid adjustment for ranking of accessions. Nurseries included: common bacterial blight and rust screening under inoculation; screening for grain yield and agronomic characters, N fixation and drought tolerance using two plantings with and without irrigation, plus split application of N within plots; screening for tolerance of soil deficiency of zinc using plots with split application of zinc; and screening for sclerotinia resistance using serial tests in warm humid growth cabinets. Selections from a primary screening, 1-10% of accessions, were verified in replicated secondary and tertiary trials.

KEYWORDS

Dry beans, *Phaseolus vulgaris*, germplasm, rust, common blight, sclerotinia, nitrogen fixation, zinc deficiency.

INTRODUCTION

The breeding of navy and culinary beans *(Phaseolus vulgaris* L.*)* was a minor activity of the Queensland Department of Primary Industries (DPI), until a full time breeder was appointed in 1982. Breeding objectives included: increased yield potential; erect plant type with increased pod height; tolerance of zinc deficiency; resistance to rust *(Uromyces appendiculatua)*, bacterial blight *(Xanthomonus phaseoli)*, peanut mottle virus (PMV), and sclerotinia *(Sclerotia sclerotiorum)*; N fixation; and drought tolerance. To achieve these aims a broader genetic base was required (Redden *et al.* 1985a).

A collection of nearly 1500 *Phaseolus* accessions was assembled in the first year from the DPI collections at Kingaroy and Hermitage Research Stations, the Victorian Department of Agriculture, unevaluated introductions in the CSIRO germplasm bank, and newly introduced lines from the International Centre for Tropical Agriculture (CIAT) in Colombia both directly and through Queensland Agricultural College (QAC). The collection contained a range of seed types, varying in size from below 10 to more than 60 g per 100 seed, having colours from white to black with various colour patterns. The navy bean class of principal interest was white and weighed 15-22 g per 100 seed and was only a small part of the total variation. The entire germplasm collection was assessed for all characters of interest, mainly to select parental material, and for direct release after the requisite yield testing. Included in the culinary classes were medium sized (30-35 g per 100 seed) white and red beans, large (40-50 g per 100 seed) borlotti or sugar bean types, and small black beans.

METHOD

Seed in the germplasm collection ranged from four to seven years old, except for the recently imported CIAT lines for which only a limited seed supply was avaiblable after quarantine. To obtain adequte supplies of fresh seed all 1462 accessions were grown in 1982 in the winter/spring off-season. Before sowing, all lines had been classified for seed characteristics using the system of Rose and Farlow (J. Rose, pers. comm.), and registered in an accession catalogue.

Systematic evaluation began in specialised nurseries in the summer of 1982-83. The first sown was a common bacterial blight and rust combined screening nursery at QAC, using inoculation and the cultivars Gallaroy and Borlotti as resistant and susceptible checks respectively, sown after every tenth entry (Redden *et al.* 1985b). Inoculation was by knapsack using one petri dish of bacterial culture per litre of water and 0-2 g per litre suspension of rust urediospores, applied 30 days after sowing. Every alternate alleyway was pre-sown with a Galaroy spreader row for rust and blight, and plot size was a single 3 m row at 50 cm spacing. In all nurseries the collection was sown in accession order. A grid contour map representing the physical field based on the check data provided predicted values. These were subtracted from the actual ratings for each accession to give adjusted values for ranking and selection. The initial observations used a scale of 1 (resistant) to 9 (susceptile) for each disease (Redden *et al.* 1985b).

The second evaluation, for agronomic characters, was

made at Inglewood Field Station where two plantings were made, with and without irrigation. The main nursery was irrigated every 10-14 days to maintain a full moisture profile, while the stress nursery was only irrigated at sowing to assist emergence. The stress nursery received only 72 mm of rain up to flowering and 60 mm more to maturity. Harvest was delayed by 70 mm of rain at maturity which meant all harvest samples had to be oven dried immediately. The non-irrigated nursery plots had single rows 5 m long and 1.5 m apart. In the irrigated nursery, plots were 9 m long x 1.5 m apart and split for application of urea (80 kg/ha of N). This split provided a comparison within plots for nodulation with indigenous rhizobia. Plant roots were examined for nodule size (1-3 scale), frequency (1-3 scale) and colour. The local cultivar, Selection 46, was sown as a check after every tenth plot in both nurseries. Time to 50% first flower, post flowering canopy height, grain yield (per plot), and natural incidence of rust and bacterial blight were recorded. The comparison of height and yield between the two nurseries was expected to provide an index of drought tolerance. Additional records were made in the irrigated nursery for plant habit (1-5 scale erect-prostrate), vegetative vigor (1-5 scale low to high level), and pod height.

The third evaluation at Hermitage Research Station in 1984, was for sensitivity to zinc deficiency. A field was used with 0.6 ppm zinc and pH 8.5. Plots were 4 m long x 70 cm apart. The sensitive control Gallaroy was used for the grid adjustment. All plots were split for application of zinc sulphate hepta-hydrate at 30 kg/ha. Both plot sections were rated for leaf chlorosis (1-9 scale) and canopy height 64 days after sowing.

The final evaluation was a seedling inoculation test for reaction to sclerotinia. Tests were made using growth cabinets for a 2-day incubation period, and about 100 accessions in each batch, with Selection 46 and Gallaroy as controls.

Harvests from the yield evaluation provided fresh seed for both long and medium term germplasm storage.

RESULTS

As indicated in Table 1, 1 to 9% of the germplasm was selected for respective characters based on ranking of adjusted values from the grid of controls. Truncation selection was applied for expression of resistance or nodule mass superior to the resistant or adapted control. Additional selection for yield and pod height involved rejection of lines susceptible (score 6) for rust or common blight. Where a high proportion of the germplasm was acceptably resistant to rust or tolerant of zinc deficiency no selection was applied.

For confirmation of the primary selection, accessions were evaluated one to two years later, in trials of two to four replicates according to whether there were many or few entries selected per trait. Only 10-20% of the primary selection (2-21) were retained after these trials for detailed evaluation in tertiary trials involving larger plots, multi-location tests, and yield measurements in all cases.

Table 1: Selection of germplasm accessions by key characters. Number and proportion (bracketed) selected at each stage.

Key character	Primary evaluation[1]	Secondary evaluation
Common bacterial blight resistance	115 (8.2%) rating>3.5	9 (7.8%) rating>3.5
N fixation	92 (7.8%) nodule mass>4.8	21 (22.8%) nodule mass>7.5
Sclerotinia resistance	18 (1.5%) rating<4.0	5 rating<4.0
Tolerance of zinc deficiency	1,400 (95%)	—
Rust resistance	963 (66%)	—
Improved yield	82 (5.9%) upper 10% plus rust and blight resistance	16 (50%) prior selection seed type, virus
Increased pod height	18 (1.2%) >12 cm upper 10% plus rust and blight resistance	2 (16.7%) >12 cm prior selection seed type, virus

[1] Disease reactions: 1 = resistant to 9 = susceptible.

Since selections for yield and pod type could be directly released as either a navy or culinary bean, all accessions were screened for resistance to PMV and for acceptability of seed to a market class, before entry into the secondary evaluation. This effectively eliminated 60-80% of primary selections.

DISCUSSION

Germplasm was assessed firstly for availability and secondly for potential gains. In the latter case the aim was to identify parents for use in breeding and genetic programmes after verification trials, and to use germplasm directly as new varieties.

Resistance for common blight is quantitative (Webster *et al.* 1980; Valladares *et al.* 1983; Redden *et al.* 1985b). Accessions identified in secondary evaluation have already been used in crosses for two seasons, and will be involved in future genetic studies. Similarly, up to 30 accessions chosen as parents for yield or pod height characteristics, have been used in crosses for two seasons. Crosses involving unsuitable parents were culled, a penalty in effort against a gain of one to two seasons in broadening the genetic base of the breeding programme. Parents will not be chosen until after tertiary evaluation, for both sclerotinia resistance and N fixation, because of expected low heritability (Fuller *et al.* 1984; Graham and Temple, 1984).

Scope for further exploitation of this germplasm involves correlations of characters, use of derived characters, and multiple sorting of the data for both direct

and derived characters in combination with assigned limits for disease levels. Ranking of accessions for economic efficiency using ratios such as yield to flowering, and yield to vegetative vigour may indicate materials of value as parents. It may also indicate assessions directly selected for high grain yield ignoring maturity (Wallace, 1985).

Multiple sorting on combinations of characters, including specification of subjects of seed classes, could not be carried out until the data was placed in a suitable computer programme. Having made selection initially for characters of urgent priority, selections of parents will now be made for yield efficiency, plant type, and drought tolerance characters regardless of seed type, since segregation of the navy type is expected with reasonable frequency (Sax, 1926; Korban *et al.*, 1980).

Genotype x environment (G x E) interaction can be expected to influence the evaluation of germplasm (Redden *et al.,* 1985a). This problem is inherent in any germplasm assessment because of seed supplies and resource limitations which result in one to two locations only being represented and unreplicated entries. Seed supply problems and germination failures meant 30-80 entries were absent for any one screening. Secondary evaluation in another season with multi-location trials reduces the G x E problem, as does repeated selection from the same data base using different criteria. The presence of two yield assessments, irrigated and non-irrigated, is also of assistance. At the very least, the unadapted germplasm is identified.

CONCLUSION

To ensure that exploitation of genetic resources is maximised, the assembly of a germplasm collection and its systemic evaluation are essential to the establishment of a breeding programme. Without a systemic plan it is likely that germplasm assessment will be inefficient for various characters. After trials to confirm the value of selected accessions, only a small proportion of germplasm is used by the breeder. The efficiency of effort in screening a large germplasm collection can be improved by separating the agronomic and disease assessments, yet combining as many character assessments as technically suitable into each test, e.g. by using split plots and different irrigation treatments.

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