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Efficient selection intensity in early generation index selection in groundnut (*Arachis hypogaea* L.)

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Summary. The F_2 potential of single and three-way crosses was evaluated using a set of physiological and yield components. Results were based on an index of selection using (a) only yield components and (b) both physiological and yield components. The indices were constructed using the percentage improvement of F_2 over the better parent of the corresponding F_1 cross for every character. The performance of F_2 plants assessed by the expected value of the regression index was ranked in descending order to provide a ranked F_2 distribution (FRD). The FRD was divided into four equal parts, T_{25} (top 25%), T_{50} (26–50%), T_{75} (51–75%) and T_{100} (76–100%). F_3 families derived from F_2 plants in T_{25} were found to provide a higher frequency of selections for pod number than T_{50}, T_{75} and T_{100}. The frequency of selections was higher in three-way than single crosses. Selection index based on physiological and yield components was more efficient in trapping F_2 plants providing selections in F_3 than the index based on yield components only. The results brought out the importance of bunch × bunch crosses as a complement to the usually advocated bunch × runner ones.

Key words: Selection – Selection index – Selection intensity – Early generation – *Arachis hypogaea*

Introduction

When and how to select for canalising productive derivatives in segregating generations is still an open topic in groundnut breeding. There are both reports advocating early selection (Coffelt and Hammons 1974; Kolesnikov 1979; Kibite 1981; Gebre-Mariam 1982) and against (Wynne 1976; McNeal et al. 1978; Whan et al. 1981, 1982). The theoretical studies of Yonezawa and Yamagata (1981) support early generation selection as a cost- and time-efficient breeding strategy. Experimental evidence in groundnut based on extensive evaluation of F_1 to F_5 generations (Pungle 1983; Koteswara Rao 1984) has further shown that selection of heterotic F_1's followed by index selection in F_2 are valuable components of a resource-efficient breeding strategy. It was, however, based on a set of single crosses.

This study, on the other hand, uses the F_2 generation of a set of three-way, in addition to single, crosses. The F_2 selection indices based on a) only direct yield components and b) on both physiological and yield components were evaluated by the performance of the F_3.

Materials and methods

The F_2 generation of 50 single crosses from the F_1's of a 8 × 8 line-tester mating (Durgaprasad 1981) and of 49 three-way crosses from the F_1's of a 6 × 10 line-tester mating in which the female parents were themselves selected single cross F_1's (Arunachalam et al. 1985) formed the material. They will be denoted respectively as SC (single crosses) and TC (three-way crosses) hereafter, for brevity. The male and female parents of the F_1 of SC contained two each from the botanical varieties 'Spanish bunch' (SB), 'Valencia' (VL), 'Virginia bunch' (VB) and 'Virginia runner' (VR). The contribution of such various intra- and inter-varietal groups of crosses as SB × SB and SB × VR could hence be assessed.

The SC, their parents and the TC were grown in 5 m rows each spaced 60 cm apart with an inter-plant spacing of 10 cm during the rainy season of 1981 at the Indian Agricultural Research Institute, Hyderabad. The crop was given protective irrigation and disease-pest control measures.

Observations were recorded on samples of approximately 10 plants (depending on the survival of plants at maturity) per cross. Two sets of plants were marked in each cross. Yield components and some physiological attributes were observed on one set and yield components alone on the other. The two respective sets of SC were denoted as Sets I (212 plants) and II (256 plants) and of TC as Sets III (371 plants) and IV (385 plants).

Characters on which observations were made were:

A. Physiological (measured at first flowering): Height of main axis in cm (SH); number of primary branches (PB); leaf area of 5 fully opened leaves sampled at random in each plant in sq. cm (LA); leaf dry weight in gm (LW); specific leaf weight (SL).
B. Yield components: Number of mature pods (NM); number of immature pods (IM); number of aerial pegs (AP); weight of mature pods in gm (WM); weight of immature pods in gm (WI); number of kernels (NK); kernel weight in gm (KW); 100-kernel weight in gm (TW); percent mature pods $= [NM/(NM + IM)] \times 100$ (MP); shelling percentage (SP) and recovery percentage $= [NM/(NM + IM + AP)] \times 100$ (RP).

Only two physiological traits, PB and SL were observed in Set I and four, SH, LA, LW and SL in Set III. In addition, NK was not measured in Sets I and II.

A selection index was set up for each set of F_2 plants using a regression equation. A fair evaluation of F_2 potential across crosses would demand comparable values for various characters of the F_2 plants. These values, however, would be governed to a large extent by the potential of their corresponding parents of the F_1 cross. Hence the F_2 values were expressed as the percentage improvement over the value of the better parent in their F_1 cross. No difference should occur between the analysis based on individual F_2 values and that based on the percent improvement, if one deals with the F_2 of only one cross. The differences would be substantial when more than one cross is dealt with as in the present study. In the rest of the paper, we therefore mean by F_2 value of such variables as KW, percentage improvement over their better parent.

KW was the dependent variable in the multiple regression equation. The expected values of KW obtained from the equation were ranked in descending order to provide the ranked F_2 distribution. It was divided into four equal parts; the top 25% was denoted by T_{25}, 26–50% by T_{50}, 51–75% by T_{75} and 76–100% (bottom) by T_{100}.

The F_3 families of F_2 plants that survived to maturity were raised on a plant to progeny row basis during the rainy season of 1982 in a manner similar to the F_2. In each F_3 progeny row, selection was made on the most easily-measured trait, pod number, at harvest. Only those plants which yielded more pods than the national check, 'Robut 33-1' were selected. Based on the number of pods in excess of the check, five types of selection, A to E, were made:

A – plants exceeding pod number of the check by 1 to 10
B – plants exceeding pod number of the check by 11 to 20
C – plants exceeding pod number of the check by 21 to 30
D – plants exceeding pod number of the check by 31 to 40
E – plants exceeding pod number of the check by more than 40.

The potential of the F_2 groups, T_{25} to T_{100} was assessed by a selection score, WS, defined as

$$WS = \sum_{i=1}^{n} w_i \, p_i \text{ where}$$

w_i = score for selection type, 1 for A, 2 for B, 3 for C, 4 for D and 5 for E
p_i = percentage of plants in selection types A to E
n = number of selection types available in any group under consideration.

Results

Only two types of selections, A and B, could be obtained in the F_3 of SC, compared to four, A to D, in TC. While only 5% of the plants were superior to the check in SC (over the sets I and II), 20% of such plants were obtained in TC (over the sets III and IV). Further, the F_3 families where at least one selection was available were only 6.4% in SC as compared to 25.7% in TC. Such superiority was clear when individual types of selection A to D were also considered (Table 1).

The proportion of selections of the type A was much higher in the F_3 families raised from T_{25}, the top 25% of the F_2 distribution, than the corresponding ones raised from T_{50}, T_{75} and T_{100} both in SC and TC, and in all the sets I to IV. Such differences existed, though less marked, in the selections of the type B in TC. Selections of the type B in SC and types C and D in TC were too few to come to reliable conclusions. The order of importance of the F_2 segments in producing selections exceeding the check in pod number in F_3 was T_{25}, T_{50}, T_{75} and T_{100} both in TC and SC, except for a minor discrepancy in Set II where selections obtained from the F_3 of T_{50}, T_{75} and T_{100} were only a few in number. The order of superiority of the F_2 segments was upheld in TC by the selection score also; minor discrepancies, attributable to sporadic occurrence of selections of B type, were found in the order of superiority in SC (Table 1).

Most of the F_3 selections in SC were found in the progeny of F_2 plants from the T_{25} and T_{50} groups. Since the SC was obtained from crosses between botanical varieties, SB, VL, VB and VR, as explained earlier, the proportion of selections obtained in F_3 from the F_2 of such various group-crosses as SB × SB, SB × VL, etc., was examined and a selection score was computed to take into account the frequency of A, B, etc., types of selection (Table 2). Most of the groups of crosses gave selections of type A only, except for SB × VB, VB × VR and VR × VR which also gave type B selections. The ranked order of preference based on selection score placed VL × VR, SB × VB, VR × VR and SB × VL in the first four positions out of nine, two of which were bunch × bunch crosses. Further, the top two groups of crosses involved the bunch parents, SB and VL. The most interesting result was the high order of preference of the bunch × bunch cross, SB × VL, which is usually relegated to the background by plant breeders in preference to bunch × runner crosses – 'Spanish' × 'Virginia' or 'Valencia' × 'Virginia'.

The percentage of selections in F_3 derived from the F_2 segment, T_{25} was higher in Set III than Set IV. Such superiority of Set I over II was masked in SC (Sets I and II) due to the irregular occurrence of type B selections in T_{50} of Set I. The superiority of Sets I and

Table 1. Frequency of F_3 selection with respect to ranked F_2 distribution

		Category				
		A	B	TNS	TNP	WS
Set I						
T_{25}	n	5	0	5	55	9.1
	p	9.1	0.0	9.1	100	
T_{50}	n	2	2	4	49	12.3
	p	4.1	4.1	8.2	100	
T_{75}	n	2	0	2	49	4.1
	p	4.1	0.0	4.1	100	
T_{100}	n	1	0	1	40	2.5
	p	2.5	0.0	2.5	100	
	n	10	2	12	193	7.3
	p	5.2	1.0	6.2	100	
Set II						
T_{25}	n	10	0	10	97	10.3
	p	10.3	0.0	10.3	100	
T_{50}	n	2	0	2	83	2.4
	p	2.4	0.0	2.4	100	
T_{75}	n	3	1	4	87	5.7
	p	3.4	1.1	4.6	100	
T_{100}	n	1	0	1	78	1.3
	p	1.3	0.0	1.3	100	
	n	16	1	17	345	5.2
	p	4.6	0.3	4.9	100	
Over I and II	p	4.8	0.6	5.4	100	6.0

		Category						
		A	B	C	D	TNS	TNP	WS
Set III								
T_{25}	n	27	9	5	1	42	124	51.6
	p	21.8	7.3	4.0	0.8	33.9	100	
T_{50}	n	20	4	3	0	27	117	31.7
	p	17.1	3.4	2.6	0.0	23.1	100	
T_{75}	n	12	1	0	0	13	95	14.8
	p	12.6	1.1	0.0	0.0	13.7	100	
T_{100}	n	8	0	0	1	9	82	14.6
	p	9.8	0.0	0.0	1.2	11.0	100	
	n	67	14	8	2	91	418	30.4
	p	16.0	3.3	1.9	0.5	21.8	100	
Set IV								
T_{25}	n	32	5	2	2	41	133	42.2
	p	24.1	3.8	1.5	1.5	30.8	100	
T_{50}	n	19	4	0	2	25	116	30.0
	p	16.4	3.4	0.0	1.7	21.5	100	
T_{75}	n	18	3	0	0	21	112	21.5
	p	16.1	2.7	0.0	0.0	18.8	100	
T_{100}	n	7	0	1	0	8	89	11.2
	p	7.9	0.0	1.1	0.0	9.0	100	
	n	76	12	3	4	95	450	27.8
	p	16.9	2.7	0.7	0.9	21.1	100	
Over III and IV	p	16.5	3.0	1.3	0.7	21.4	100	29.2

n = number of plants; p = Prop. (in %) of the total number of plants; TNS = Total number of selections; TNP = Total number of plants; WS = Selection score

Table 2. Selection score (WS) and percentage of selections (s) obtained inF_3 from F_2 of various intra- and inter-group single crosses

Cross	s	WS	Order of preference
SB×SB	6.7	6.7	8
SB×VL	19.0	19.0	4
SB×VB	25.9	28.1	2
SB×VR	6.0	6.0	9
VL×VL	9.1	9.1	7
VL×VB	9.1	9.1	7
VL×VR	33.3	33.3	1
VB×VB	16.7	16.7	5
VB×VR	12.8	15.4	6
VR×VR	15.8	21.1	3

III in providing higher frequency and number of types of selections in F_3 was confirmed by the selection score.

Discussion

Examination of selections in F_3 derived from the four segments, T_{25}, T_{50}, T_{75} and T_{100} of F_2, helps to understand, in a broad sense, the intensity of selection in F_2 that would be adequate to realise selection advance in F_3. The top 25% of ranked F_2 distribution was found to provide most of the selections in F_3. If the number of F_2 plants is not adequate, it is possible to reduce the intensity of selection to 50%. Evidence was robust, however, that the advantage to be gained by reducing selection intensity further would be meagre, if at all. This observation was based on the results of applying four different selection intensities on a ranked F_2 distribution. Two regression indices of selection – one based on physiological and yield attributes and the other only on yield components, were used to set up the F_2 distributions. The former index scored high over the latter in detecting desirable F_3 selections. This result is of value to plant breeders who usually place more emphasis on selection based on yield and a few of its direct components. The index employed in the F_2 of three-way crosses used four physiological characters compared to two in the F_2 of single crosses. The results showed a substantial gain in the frequency of selections in the former. Further, the high genetic variability entailed in three-way crosses might also be a cause for such a result.

The need to utilise physiological attributes in selection will gain further ground when we note that early vigour (Bains and Sood 1980 in soybean; Gupta and Ahmad 1982 in wheat), height of main axis and leaf area (Venkateswaran 1980 in groundnut) were reported to have increased the efficiency of selection indices. A stepwise multiple regression index constructed with a large number of physiological and yield attributes in F_2 identified 24 of the 53 high yielding F_4 bulks in wheat at 15% selection intensity (McVetty and Evans 1980). A possible reason appears to be that a large number of characters, including physiological, morphological and yield attributes, measured from seedling to harvest stage, can differentiate between genotypes much better than yield components measured only at harvest. Further, an index using a large number of characters would avoid the need to attach arbitrary weights to them (Sneath and Sokal 1973). It is known that physiological characters are highly but unequally correlated with yield. However, the extreme order statistics have a monotonic property as a function of intra-class correlation (Tong 1982). This is true even when the family sizes in which selection is practised are not equal. Our present study in groundnut provides evidence of this property envisaged by Tong (1982) and is of considerable utility in selection in small families. The cost of measuring a large number of characters is more than offset by the substantial advantage to raise only the top 25% to the next generation to locate potential derivatives. It is possible to effect economy in the number of characters to be measured, if a few important physiological and yield components are located in the particular crop using stepwise regression analysis on extensive data.

Further, this study has provided evidence that bunch × bunch crosses, especially 'Spanish' × 'Valencia', would be a useful complement to the currently emphasized bunch × runner crosses. The advantage of bunch × bunch crosses could be more in the context of combining productivity with early maturity (Durgaprasad et al. 1985; Arunachalam et al. 1982).

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