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Research Article

Discriminate function analysis in cowpea (*Vigna unguiculata* (L.) Walp.)

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Abstract
The discriminant function technique was used to construct selection indices in forty two genotypes of cowpea (*Vigna unguiculata* (L.) Walp.). Sixty three selection indices involving seed yield per plant and its five components were constructed using the discriminant function technique. The efficiency of selection increased considerably when the selection was based on two character combinations *i.e.* the number of pods per plant and the number of seeds per pod followed by an index based on three characters *viz.,* the number of clusters per plant and the number of pods per plant and seed yield per plant. The use of these indices is advocated for selecting high yielding genotypes of cowpea as in practice the plant breeder might be interested in the maximum gain with the minimum number of characters.

Key words
Selection indices, discriminate function, relative efficiency and cowpea

INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp.) autogamous leguminous crop of India is an important versatile food crop. It has multifarious uses like fodder, cover crop and green manure and provides high quality protein in the form of vegetable and pulse to the human diet. It is a drought tolerant crop and thrives in warm weather (21 - 35ºC) and well adapted to the drier regions of the tropics, where other food legumes do not perform well. Bestowed with a series of merits, cowpea is also known for some biological bottlenecks of poor productivity due to inefficient plant types with the less and slow conversion of dry matters to the grain. Therefore, there is an urgent need to develop high yielding varieties in cowpea. Seed yield is governed by a polygenic system and highly influenced by the fluctuations in the environment. Selection of plants based directly on seed yield would not be very much reliable in many cases. It is felt that progress can be accelerated if simultaneous selection for most of the economic characters contributing to seed yield is considered. For this purpose, the utilization of appropriate multiple selection criteria based on the selection indices would be more desirable. An application of discriminant function developed by Fisher (1936) and first applied by Smith (1936) helps to identify an important combination of yield components useful for selection by formulating suitable selection indices. Therefore, the object of the present study was to construct and assesses the efficiency of selection indices in cowpea.

MATERIALS AND METHODS

A field trial was conducted using 42 diverse genotypes of cowpea in a Randomized Block Design with three replications at Pulses Research Station, Junagadh Agricultural University, Junagadh. A single row of 4 m length and plants were spaced at 45 x 10 cm. The recommended package of practices was followed for cultivation. In each replication, observations were recorded on five randomly selected competitive plants and their mean values were used for statistical analysis. The observations were recorded on 11 morphological characters *viz.,* days to 50 per cent flowering, days to maturity, plant height (cm), the number of primary branches per plant, the number of clusters per plant, the number of pods per cluster, the number of pods per plant, pod length (cm), the number of seeds per pod, 100-seed weight and seed yield per plant. Days to 50 per cent flowering and days to maturity were recorded on a plot basis. For constructing the selection indices, the characters which had a high and positive correlation with seed yield per plant and direct effects on seed yield were considered. In this context, 6 characters, namely, seed yield per plant (X_1), days to 50 per cent flowering (X_2), the number of clusters per plant (X_3), the number of pods per plant (X_4), the number of seeds per pod (X_5) and 100-seed weight (X_6) were identified and considered. A total of sixty three selection indices were constructed using five traits per sowing condition. The respective genetic advance through selection was also calculated as per the formula suggested by Robinson *et al.* (1951). The relative efficiency of different discriminant functions in relation to straight selection for seed yield were assessed and compared, assuming the efficiency of selection for seed yield per plant as 100 %. Relative efficiency per character was calculated by relative efficiency divided by the number of characters are involved in them.

RESULTS AND DISCUSSION

Selection indices for seed yield per plant and other characters were constructed and examined to identify their relative efficiency in the selection of superior genotypes. The results on selection indices, discriminant functions, expected genetic gain and relative efficiency are presented in **Table 1**. The results suggested that the selection efficiency was higher, in general, over straight selection when the selection was based on the component character like days to 50 per cent flowering and the number of pods per plant. Selection indices thus, aim at determining the most valuable genotypes as well as the most suitable combination of traits with intention of indirectly improving the yield in different plants. Hazel and Lush (1943) showed that the selection based on such an index was more efficient than selecting individually for the various characters.

Table 1. Selection index, discriminant function, expected genetic advance in seed yield and relative efficiency from the use of different selection indices in 42 genotypes of cowpea

Sr. No.	Selection index	Discriminant function	Expected genetic advance	Relative efficiency (%)	Relative coefficient per character (%)
(1)	(2)	(3)	(4)	(5)	(6)
1	X_1 Seed yield per plant	0.9446 X_1	6.977	100.000	100.000
2	X_2 Days to 50 per cent flowering	0.9462 X_2	10.129	145.178	145.178
3	X_3 Number of clusters per plant	0.9796 X_3	4.579	65.637	65.637
4	X_4 Number of pods per plant	0.9586 X_4	12.433	178.213	178.213
5	X_5 Number of seeds per pod	0.737 X_5	2.538	36.371	36.371
6	X_6 100-seed weight	0.9898 X_6	6.320	90.587	90.587
7	$X_1.X_2$	$0.9277X_1 + 0.9360X_2$	9.746	139.694	69.847
8	$X_1.X_3$	$1.7579X_1 + 0.8206X_3$	12.600	180.603	90.302
9	$X_1.X_4$	$3.7638X_1 + 2.9607X_4$	5.656	81.069	40.535
10	$X_1.X_5$	$1.4426X_1 + 0.5485X_5$	10.914	156.437	78.219
11	$X_1.X_6$	$1.0998X_1 + 0.5664 X_6$	3.527	50.551	25.275
12	$X_2.X_3$	$1.6111X_2 + 0.3416X_3$	11.972	171.600	85.800
13	$X_2.X_4$	$1.7849X_2 + 1.9962X_4$	10.544	151.132	75.566
14	$X_2.X_5$	$2.1931X_2 + 0.5946X_5$	14.976	214.658	107.329
15	$X_2.X_6$	$2.8298X_2 + 1.1857X_6$	5.613	80.450	40.225
16	$X_3.X_4$	$1.4962X_3 + 1.8418X_4$	18.566	266.116	133.058
17	$X_3.X_5$	$0.7287X_3 + 0.8101 X_5$	6.377	312.608	37.406
18	$X_3.X_6$	$0.3730X_3 + 0.3492X_6$	3.703	53.070	26.535
19	$X_4.X_5$	$3.7284X_4 + 1.1280X_5$	25.506	365.594	182.797
20	$X_4.X_6$	$2.5325X_4 + 0.6467X_6$	17.293	247.875	123.937
21	$X_5.X_6$	$0.3376X_5 + 0.4160X_6$	12.635	181.103	90.551
22	$X_1.X_2.X_3$	$0.9431X_1 + 0.9229X_2 + 0.9262X_3$	9.686	138.828	46.276
23	$X_1.X_2.X_4$	$0.9310X_1 + 0.8943X_2 + 0.9212X_4$	14.655	210.060	70.020

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24	$X_1.X_2.X_5$	$0.9757X_1 + 0.9307X_2 + 0.6010X_5$	10.363	148.532	49.511
25	$X_1.X_2.X_6$	$0.9217X_1 + 0.9380X_2 + 0.9890X_6$	11.753	168.468	56.156
26	$X_1.X_3.X_4$	$0.9104X_1 + 1.3318X_3 + 0.8698X_4$	22.014	315.534	105.178
27	$X_1.X_3.X_5$	$0.9814X_1 + 1.0893X_3 + 0.5060X_5$	11.927	170.959	56.986
28	$X_1.X_3.X_6$	$0.9232X_1 + 1.0197X_3 + 0.9705X_6$	10.361	148.508	49.503
29	$X_1.X_4.X_5$	$1.0568X_1 + 0.9720X_4 + 0.1885X_5$	19.144	274.393	91.464
30	$X_1.X_4.X_6$	$0.9353X_1 + 0.9319X_4 + 0.8905X_6$	16.174	231.827	45.182
31	$X_1.X_5.X_6$	$1.0076X_1 + 0.4933X_5 + 0.9460X_6$	9.457	135.547	77.276
32	$X_2.X_3.X_4$	$0.9152X_2 + 0.8580X_3 + 0.9758X_4$	10.019	143.600	47.867
33	$X_2.X_3.X_5$	$0.9248X_2 + 0.9276X_3 + 0.7965X_5$	8.156	116.909	38.970
34	$X_2.X_3.X_6$	$0.9152X_2 + 0.8580X_3 + 0.9758X_6$	10.019	143.600	47.867
35	$X_2.X_4.X_5$	$0.8809X_2 + 0.9223X_4 + 0.5174X_5$	10.343	148.256	49.419
36	$X_2.X_4.X_6$	$0.8913X_2 + 0.8878X_4 + 0.8991X_6$	8.722	125.017	51.401
37	$X_2.X_5.X_6$	$1.0354X_2 + 0.5521X_5 - 0.2465X_6$	10.758	154.203	41.672
38	$X_3.X_4.X_5$	$1.4588X_3 + 0.8396X_4 + 0.3939X_5$	17.425	249.757	83.252
39	$X_3.X_4.X_6$	$1.2201X_3 + 0.8632X_4 + 0.9000X_6$	14.355	205.753	68.584
40	$X_3.X_5.X_6$	$4.2564X_3 - 0.4265X_5 + 1.8092X_6$	10.205	146.270	48.757
41	$X_4.X_5.X_6$	$0.9447X_4 + 0.4412X_5 + 0.8828X_6$	11.020	157.960	52.653
42	$X_1.X_2.X_3.X_4$	$0.9316X_1 + 0.9171X_2 + 1.2327X_3 + 0.8599X_4$	17.693	253.595	63.399
43	$X_1.X_2.X_3.X_5$	$0.9759X_1 + 0.9312X_2 + 0.9922X_3 + 0.5949X_5$	10.742	153.963	38.491
44	$X_1.X_2.X_3.X_6$	$0.9386X_1 + 0.9226X_2 + 0.9100X_3 + 0.9689X_6$	10.662	152.816	38.204
45	$X_1.X_2.X_4.X_5$	$1.1461X_1 + 0.8544X_2 + 0.8481X_4 + 0.2064X_5$	15.508	222.279	55.570
46	$X_1.X_2.X_4.X_6$	$0.9748X_1 + 0.8744X_2 + 0.8559X_4 + 0.8577X_6$	13.138	188.312	47.078
47	$X_1.X_2.X_5.X_6$	$0.9711X_1 + 0.9338X_2 + 0.5837X_5 + 0.9680X_6$	12.024	172.349	43.087
48	$X_1.X_3.X_4.X_5$	$1.1832X_1 + 1.6852X_3 + 0.6988X_4 + 0.0338X_5$	23.106	331.192	82.798
49	$X_1.X_3.X_4.X_6$	$0.9496X_1 + 1.3618X_3 + 0.8093X_4 + 0.8666X_6$	19.953	285.994	71.498
50	$X_1.X_3.X_5.X_6$	$0.9820X_1 + 1.0669X_3 + 0.4878X_5 + 0.9575X_6$	11.628	166.662	41.666
51	$X_1.X_4.X_5.X_6$	$1.2226X_1 + 0.8293X_4 + 0.0805X_5 + 0.7777X_6$	17.158	245.929	61.482
52	$X_2.X_3.X_4.X_5$	$0.9120X_2 + 1.3369X_3 + 0.8369X_4 + 0.4770X_5$	13.267	190.167	47.542
53	$X_2.X_3.X_4.X_6$	$0.9017X_2 + 1.1047X_3 + 0.8575X_4 + 0.8928X_6$	10.581	151.656	37.914
54	$X_2.X_3.X_5.X_6$	$0.9245X_2 + 0.9113X_3 + 0.7790X_5 + 0.9692X_6$	9.905	141.978	35.495
55	$X_2.X_4.X_5.X_6$	$0.8622X_2 + 0.8763X_4 + 0.5016X_5 + 0.8568X_6$	8.759	125.545	31.386
56	$X_3.X_4.X_5.X_6$	$1.4893X_3 + 0.7941X_4 + 0.3780X_5 + 0.8589X_6$	15.137	216.965	54.241
57	$X_1.X_2.X_3.X_4.X_5$	$1.1786X_1 + 0.9024X_2 + 1.5527X_3 + 0.6963X_4 + 0.1198X_5$	18.695	267.964	53.593
58	$X_1.X_2.X_3.X_4.X_6$	$0.9823X_1 + 0.8955X_2 + 1.2469X_3 + 0.7820X_4 + 0.8386X_6$	15.728	225.443	45.089
59	$X_1.X_2.X_3.X_5.X_6$	$0.9764X_1 + 0.9300X_2 + 0.9688X_3 + 0.5768X_5 + 0.9588X_6$	11.370	162.970	32.594
60	$X_1.X_2.X_4.X_5.X_6$	$1.3157X_1 + 0.8016X_2 + 0.6932X_4 - 0.0218X_5 + 0.7045X_6$	13.919	199.512	39.902
61	$X_1.X_3.X_4.X_5.X_6$	$1.3079X_1 + 1.7695X_3 + 0.5580X_4 - 0.0781X_5 + 0.7190X_6$	21.051	301.733	60.347
62	$X_2.X_3.X_4.X_5.X_6$	$0.8934X_2 + 1.3507X_3 + 0.7850X_4 + 0.4598X_5 + 0.8489X_6$	11.070	158.668	31.734
63	$X_1.X_2.X_3.X_4.X_5.X_6$	$1.3217X_1 + 0.8561X_2 + 1.6000X_3 + 0.5313X_4 - 0.0096X_5 + 0.6931X_6$	16.731	239.816	39.969

The maximum relative efficiency in single character discriminant function was 178.213 per cent which was exhibited by the number of pods per plant. However, it increased up to 365.594 per cent in two character combinations (the number of pods per plant and the number of seeds per pod); 315.534 per cent, in three character combinations (seed yield per plant, the number of clusters per plant and the number of pods per plant); 331.192 per cent , in four character combinations (seed yield per plant, the number of clusters per plant, the number of pods per plant and the number of seeds per pod); 301.733 per cent, in five character combinations (seed yield per plant, th number of clusters per plant, the number of pods per plant, the number of seeds per pod and 100-seed weight); 239.816 per cent, in six character combinations (seed yield per plant, days to 50 per cent flowering, the number of clusters per plant, the number of pods per plant, the number of seeds per pod and 100-seed weight). Further, it was observed that the straight selection for seed yield was not that much rewarding

(GA = 6.977 g, RI = 100 %) as it was through its components like the number of clusters per plant, the number of pods per plant and the number of seeds per pod or in their combinations. The maximum efficiency in selection for seed yield was exhibited by a discriminant function involving the number of pods per plant and the number of seeds per pod, which had a genetic advance and relative efficiency of 25.506 g and 365.594 per cent, respectively, followed by an index of three characters (seed yield per plant, the number of clusters per plant and the number of pods per plant) with 22.014 g genetic advance and 315.534 per cent, relative efficiency. Similar results were reported by Patel *et al.* (2007), Jatav (2011), Khanpara *et al*. (2015) and Siddhi Shah *et al.* (2016).

Further, there was an increase in the relative efficiency of the succeeding index which contained a character *viz.,* the number of pods per plant in common in all character combinations. However, in practice, the plant breeder might be interested in the maximum gain with the minimum number of characters. In this context, the selection index involving the number of pods per plant and the number of seeds per pod ($X_4.X_5$) could be advantageously exploited in the cowpea breeding programmes. The present study also revealed that the discriminant function method of making selections in plants appeared to be the most useful as compared to the straight selection for seed yield alone and hence, due weightage should be given to the important selection indices while making the selection for yield advancement in cowpea.

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