Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2020; 9(1): 1502-1506
Received: 04-11-2019
Accepted: 06-12-2019

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Simultaneous selection for improvement of yield and nutritional components using classical selection index in foxtail millet [*Setaria italica* (L.) Beauv.]

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DOI: https://doi.org/10.22271/phyto.2020.v9.i1z.10675

Abstract
The present investigation was conducted to evaluate the sixty foxtail millet germplasm for simultaneous improvement of yield and nutritional components using classical selection index considering traits *viz.*, days to 50% flowering, plant height, panicle length, productive tillers per plant, days to maturity, test weight, protein, carbohydrate, calcium, iron, zinc, copper, manganese, phosphorus and grain yield per plant. The expected genetic advance for all the fifteen characters was estimated by assigning equal economic weights as well as by using inverse of means as economic weights. The traits plant height, carbohydrate and grain yield per plant recorded relatively higher values of genetic advance while copper, zinc and phosphorus recorded relatively lower values in both cases. Simultaneous selection taking all fifteen characters into consideration, found that Ise 238, Ise 1511, Ise 49 and Ise 132 recorded relatively higher selection index values in both the cases *i.e.*, when the equal economic weights were assigned as well as when inverse of means are used as economic weights for estimation of selection index scores. These results also indicate that the two methods of assigning economic weights is almost equally efficient in identifying superior genotypes during simultaneous selection.

Keywords: Simultaneous selection, expected genetic advance, classical index, foxtail millet

Introduction

Foxtail millet with short grown period is grown extensively in diverse agro-climatic regions for grain and fodder. It is known for its drought tolerance and is an indispensable crop of vast rainfed areas in semi-arid regions in India. It is cultivated in Andhra Pradesh, Karnataka, Maharashtra and Hilly areas of northern India. It is grown as staple food crop in north Africa, southeastern Europe, Japan and India. It is cooked whole or made into beer. It can also make useful hay or silage. Additionally, it is consume as stiff porridge called sargati, or as leavened bread as roti, after the dehulled grain has been milled into flour. This millet grains offers an excellent source of quality proteins (leucine and methionine), β- carotene, minerals (Ca, Fe, K, Mg and Zn), antioxditants, dietary fibre, phytochemicals, vitamins (thiamine, riboflavin and niacin) and have low glycemic index, a requisite for healthy human diet (Murugan and Nirmalakumari, 2006) [9].

Selection of plants indiscriminately from a field on the basis of phenotypic expressions might lead to disappointing results. It is not the phenotypic character but the genotypic value that should be accounted to form the basis for selecting plants. Thus, index based on economic characters should give weightage to the phenotypic expression in terms of genotype by eliminating environmental variation (Panse, 1957) [11]. Economic value of a genotype depends almost always on several component characters. The aim of most breeding programmes is simultaneous improvement of several characters, so that the economic value is improved. Selection carried out simultaneously on all the characters for rapid improvement in the economic value is also referred as multiple trait selection (Falconer, 1964) [2]. One way of simultaneous selection is combining all the component characters together into a 'score' or an 'index' in such a way that when selection is applied to that index, most rapid improvement of economic value is expected (Falconer and Mackay, 1996) [3]. Such an index was first proposed by Smith (1936) [18] based on the 'discriminant function' of Fisher (1936) [5].

Materials and methods:

The present investigation was carried out during *kharif*, 2018-19 at RARS, Lam, Guntur, Andhra Pradesh, which is located at 16.10^0 N latitude, 28.29^0 E longitude and 31.5 m altitude with 60 foxtail millet [*Setaria italica* (L.) Beauv.] germplasm including checks.

The trial was laid out in a Augmented Randomised Complete Block Design (Federer, 1956) [4] with four checks *viz.*, Suryanandi, Prasad, Co 7 and Krishnadevaraya in each block. Each genotype was grown in a two rows of 4 m length with a spacing of 22.5 cm between the rows and 10 cm between the plants. Data were collected on five randomly selected plants per treatment for plant height, panicle length, productive tillers per plant and grain yield per plant. However data on days to 50% flowering, days to maturity, test weight, protein, carbohydrate, calcium, iron, zinc, copper, manganese and phosphorus were recorded on plot basis. Seed protein was estimated using Micro kjeldhal Distillation Method (Sadasivam and Manickam, 1996) [15]. Carbohydrate content was estimated using the procedure given by Sadasivam and Manickam (1997) [16]. Iron, Zinc, Copper and Manganese was estimated with the help of Atomic Absorption Spectrophotometer (AAS) as per Tandon (1999) [20]. Similary seed phosphorus content was also estimated as per procedure given by Tandon (1999) [20]. While calcium content was estimated using Versanate titration method (Jackson, 1967) [6].
Selection index or score should be constructed by assigning appropriate economic weights to different component characters. In the present study economic weights were assigned in two different ways. First, by assuming equal weights to all the characters *i.e.*, economic weights of all the characters under the study are considered as unity or equal to one and the second, by considering the inverse of means of respective characters as their economic weights. Both the procedures used for assigning economic weights will reduce the wide differences among the means of characters and will give better validity to the estimates of genetic advance.

Results and Discussion

When equal economic weights are considered, the economic weights (a_i values) for all the characters under study were taken as one. From these, weighing coefficients (b_i values) were calculated. These b_i values are used for estimation of genetic advance for each character. The weighing coefficients (b_i values) along with the corresponding estimates of genetic advances for all the characters were presented in the Table 1.
Among the characters studied, plant height (9.3462) recorded the maximum expected genetic advance followed by carbohydrate (3.9830), days to 50% flowering (3.6851), grain yield per plant (3.5164), days to maturity (3.4547), panicle length (2.5028), productive tillers per plant (0.7636), calcium (0.4047), test weight (0.3253), protein (0.2359), manganese (0.0730), phosphorus (0.0015), iron (-0.0074), zinc (-0.0679) and copper (-0.1097).
Genetic advance of the each character was also estimated using the weighing coefficients obtained when inverse of means of each character is taken as its economic weight. The weighing coefficients thus obtained for each character along with their expected genetic advances were presented in the table 2. The assigned economic weights using the inverse of mean values of the respective characters were also indicated in the same table.
When inverse of mean values were used as the economic weights, phosphorus (3.5971) recorded the maximum economic weight (a_i value) followed by manganese (1.3081), copper (1.1194), zinc (0.4453), test weight (0.3648), productive tillers per plant (0.3008), iron (0.2653), grain yield per plant (0.1479), protein (0.0872), calcium (0.0635), panicle length (0.0577), days to 50% flowering (0.0212), carbohydrate (0.0157), days to maturity (0.0124) and plant height (0.0083).
Among the fifteen different characters studied, plant height (7.7798) recorded the maximum expected genetic advance when inverse of means are used as economic weights. Plant height is followed by grain yield per plant (3.6192), carbohydrate (3.5018), panicle length (2.5692), days to 50% flowering (1.9641), days to maturity (1.3562), productive tillers per plant (0.7545), calcium (0.4176), iron (0.3787), test weight (0.3363), protein (0.1142), manganese (0.0933), zinc (0.0688), phosphorus (0.0191) and copper (-0.0174).
The traits plant height, carbohydrate and grain yield per plant recorded relatively higher values of genetic advance while copper, zinc and phosphorus recorded relatively lower values in both cases *i.e.*, when the equal economic weights were assigned as well as when inverse of means are used as economic weights.
The 'simultaneous selection index values' considering all the fifteen component characters considered in present study were calculated for sixty different genotypes using the weighing coefficients (b_i values) obtained by both methods and are presented in table 3 and 4.
When equal economic weights were used, the genotype Ise 238 (384.07) recorded highest index value followed by Ise 1511 (382.96), Ise 49 (371.93), Ise 663 (355.07) and Ise 132 (353.14) while Ise 1563 (268.87) had the least index value and is followed by Ise 1320 (270.52), Ise 302 (275.65), Ise 1119 (276.01) and Ise 1009 (279.43). The genotypes were arranged in the descending order of their selection index values and are presented graphically in the figure 1.
When inverse of means are used as economic weights, the genotypes Ise 1511 (19.36) recorded maximum selection index value and is followed by Ise 238 (18.64), Ise 49 (16.95), Ise 1335 (16.83) and Ise 132 (16.63) while the low index values were recorded by Ise 1137 (11.70), Ise 1312 (12.14), Ise 999 (12.15), Ise 1187 (12.28) and Ise 302 (12.62). The genotypes were arranged in descending order with respect to their selection index value and a graphical representation was given in figure 2.
The genotypes Ise 238, Ise 1511, Ise 49 and Ise 132 recorded relatively higher selection index values in both the cases *i.e.*, when the equal economic weights were assigned as well as when inverse of means are used as economic weights. These results indicate that these four genotypes are superior compared to all other genotypes when simultaneous selection for all the characters is carried out.
Earlier similar technique was employed by many researches and were successful in selecting superior genotypes in different crop species: Srilakshmi *et al.* (2017) [19] and Padmaja *et al.* (2006) [10] in finger millet, Kumar (2014) [8], Sireesha *et al.* (2010) [17] and Sabitha (2007) [14] in sugarcane, Ammu *et al.* (2013) [1] and Priya and Babu (2017) [13] in paddy, Prasanna *et al.* (2012) [12] in italian millet and Kumar *et al.* (2012) [7] in sorghum.
These results also indicate that the two methods of assigning economic weights is almost equally efficient in identifying superior genotypes during simultaneous selection. Such similar indications were earlier given by Priya and Babu (2017) [13] in rice and Srilakshmi *et al.* (2017) [19] in finger millet.

Table 1: Weighing coefficients and estimates of genetic advance for different characters in foxtail millet [*Setaria italica* (L.) Beauv.] when equal economic weights are assigned.

S. No.	Character	Economic weights (a_i values)	Weighing coefficients (b_i values)	Expected genetic advance
1.	Days to 50% flowering	1.000	0.7025	3.6851
2.	Plant height	1.000	0.4974	9.3462
3.	Panicle length	1.000	1.5151	2.5028
4.	Productive tillers per plant	1.000	0.7666	0.7636
5.	Days to maturity	1.000	1.1051	3.4547
6.	Test weight	1.000	5.5129	0.3253
7.	Protein	1.000	0.6645	0.2359
8.	Carbohydrate	1.000	0.8123	3.9830
9.	Calcium	1.000	0.5150	0.4047
10.	Iron	1.000	0.0088	-0.0074
11.	Zinc	1.000	2.0175	-0.0679
12.	Copper	1.000	0.5727	-0.1097
13.	Manganese	1.000	7.7378	0.0730
14.	Phosphorus	1.000	6.8233	0.0015
15.	Grain yield per plant	1.000	1.2447	3.5164

Table 2: Weighing coefficients and estimates of genetic advance for different characters in foxtail millet [*Setaria italica* (L.) Beauv.] when inverse of means are assigned as economic weights.

S. No.	Character	Economic weights (a_i values)	Weighing coefficients (b_i values)	Expected genetic advance
1.	Days to 50% flowering	0.0212	0.0251	1.9641
2.	Plant height	0.0083	0.0052	7.7798
3.	Panicle length	0.0577	0.0664	2.5692
4.	Productive tillers per plant	0.3008	0.1512	0.7545
5.	Days to maturity	0.0124	0.0080	1.3562
6.	Test weight	0.3648	0.8027	0.3363
7.	Protein	0.0872	0.0740	0.1142
8.	Carbohydrate	0.0157	0.0156	3.5018
9.	Calcium	0.0635	0.0571	0.4176
10.	Iron	0.2653	0.2161	0.3787
11.	Zinc	0.4453	0.4656	0.0688
12.	Copper	1.1194	1.0150	-0.0174
13.	Manganese	1.3081	1.2781	0.0933
14.	Phosphorus	3.5971	3.3159	0.0191
15.	Grain yield per plant	0.1479	0.1218	3.6192

Table 3: Selection index values of 60 foxtail millet genotypes when equal economic weights are assigned.

S. No.	Genotype	Selection index value	S. No.	Genotype	Selection index value
1	Ise 2	299.39	31	Ise 1009	279.43
2	Ise 18	320.65	32	Ise 1037	290.81
3	Ise 49	371.93	33	Ise 1118	279.97
4	Ise 90	334.52	34	Ise 1119	276.01
5	Ise 96	349.53	35	Ise 1129	342.61
6	Ise 132	353.14	36	Ise 1134	296.70
7	Ise 156	332.07	37	Ise 1137	283.72
8	Ise 238	384.07	38	Ise 1151	285.87
9	Ise 267	296.29	39	Ise 1162	321.82
10	Ise 289	321.66	40	Ise 1187	294.24
11	Ise 302	275.65	41	Ise 1201	311.97
12	Ise 388	290.17	42	Ise 1209	319.38
13	Ise 398	303.65	43	Ise 1251	312.19
14	Ise 480	311.91	44	Ise 1254	281.28
15	Ise 663	355.07	45	Ise 1299	293.82
16	Ise 717	324.24	46	Ise 1312	284.44
17	Ise 719	290.57	47	Ise 1320	270.52
18	Ise 746	337.24	48	Ise 1335	351.77
19	Ise 751	320.63	49	Ise 1387	342.03
20	Ise 758	331.56	50	Ise 1400	339.74
21	Ise 771	297.14	51	Ise 1454	310.36
22	Ise 828	341.00	52	Ise 1458	311.47
23	Ise 842	311.72	53	Ise 1511	382.96
24	Ise 846	339.91	54	Ise 1563	268.87
25	Ise 900	301.09	55	Ise 1581	309.06
26	Ise 946	332.75	56	Ise 1610	345.32
27	Ise 956	326.97	57	Ise 1638	321.49

28	Ise 969	321.73	58	Ise 1647	314.07
29	Ise 983	306.89	59	Ise 1655	318.21
30	Ise 999	285.77	60	Ise 1664	302.29

Table 4: Selection index values of 60 foxtail millet genotypes when inverse of means are assigned as economic weights.

S. No.	Genotype	Selection index value	S. No.	Genotype	Selection index value
1	Ise 2	13.36	31	Ise 1009	14.63
2	Ise 18	13.95	32	Ise 1037	13.71
3	Ise 49	16.95	33	Ise 1118	13.09
4	Ise 90	16.49	34	Ise 1119	13.80
5	Ise 96	15.75	35	Ise 1129	15.38
6	Ise 132	16.63	36	Ise 1134	13.46
7	Ise 156	14.32	37	Ise 1137	11.70
8	Ise 238	18.64	38	Ise 1151	12.99
9	Ise 267	13.23	39	Ise 1162	13.30
10	Ise 289	14.17	40	Ise 1187	12.28
11	Ise 302	12.62	41	Ise 1201	14.66
12	Ise 388	13.68	42	Ise 1209	16.04
13	Ise 398	14.18	43	Ise 1251	14.65
14	Ise 480	15.21	44	Ise 1254	13.49
15	Ise 663	16.08	45	Ise 1299	13.33
16	Ise 717	15.35	46	Ise 1312	12.14
17	Ise 719	15.76	47	Ise 1320	13.17
18	Ise 746	15.95	48	Ise 1335	16.83
19	Ise 751	16.22	49	Ise 1387	15.68
20	Ise 758	15.10	50	Ise 1400	15.93
21	Ise 771	14.00	51	Ise 1454	14.73
22	Ise 828	15.54	52	Ise 1458	12.63
23	Ise 842	14.88	53	Ise 1511	19.36
24	Ise 846	15.80	54	Ise 1563	12.64
25	Ise 900	14.40	55	Ise 1581	15.24
26	Ise 946	13.67	56	Ise 1610	15.15
27	Ise 956	14.14	57	Ise 1638	13.98
28	Ise 969	13.84	58	Ise 1647	14.45
29	Ise 983	14.05	59	Ise 1655	14.64
30	Ise 999	12.15	60	Ise 1664	13.88

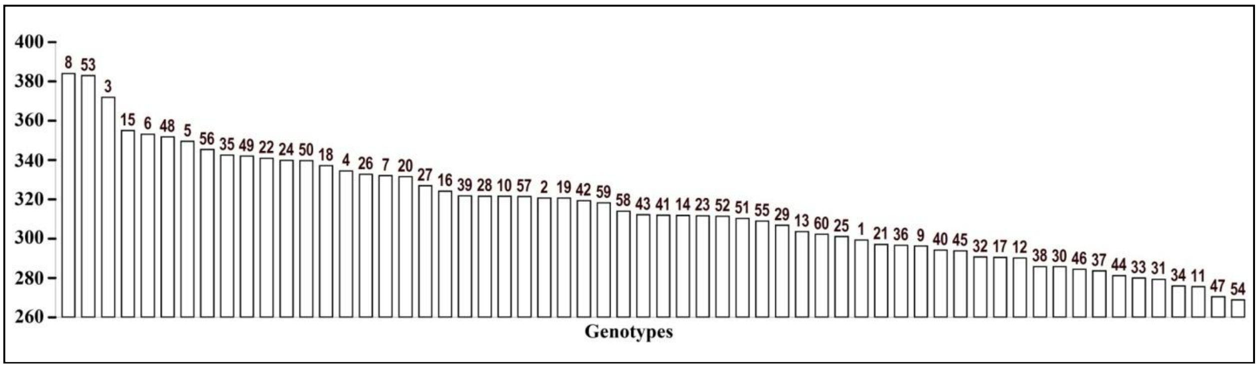

Fig 1: Selection index values of 60 foxtail millet genotypes when equal economic weights are assigned as economic weights for simultaneous selection

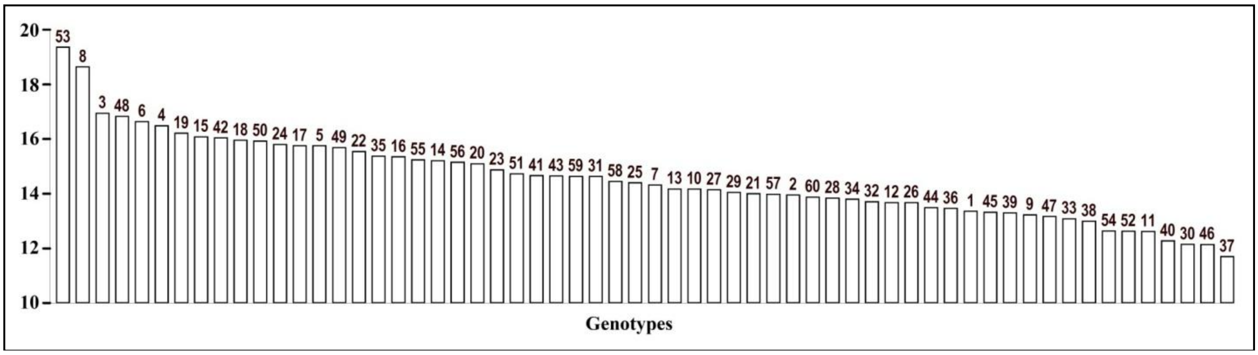

Fig 2: Selection index values of 60 foxtail millet genotypes when inverse of means are assigned as economic weights for simultaneous selection

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