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Formulation of suitable selection index by assigning equal economic weights in rice (*Oryza sativa* L.)

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Abstract
The present study was carried out for formulating suitable selection index using forty rice genotypes. In the process of attaining at suitable index, equal economic weights were assigned to all the eleven traits *viz.,* days to 50% flowering, days to maturity, productive tillers per plant, plant height, panicle length, grains per panicle, 1000-seed weight, kernel length, kernel breadth, L/B ratio and grain yield per plant. It was observed that increased estimates of genetic advance were resulted with addition of traits one after another while constructing the selection index. Finally the index formulated using all the eleven characters, recorded maximum expected genetic advance and percent gain over grain yield per plant compared to all 2047 possible combinations.

Keywords: Selection index, equal economic weights, rice, discriminant function and expected genetic advance

Introduction
Being complex trait yield depends on a number of component traits therefore, direct selection for improvement of yield is very difficult in any breeding programme. Further due to its quantitative nature, grain yield is known to be highly influenced by the environmental conditions. An Appropriate method is to be employed while carrying out simultaneous selection of different traits in any crop. This commonly faced problem can be resolved to a great extent by formulating a selection index. Such an index was first proposed by Smith (1936) [9] utilizing the concept of discriminant function developed by Fisher (1936) [4]. Since, the grain yield levels in rice are attaining plateau, the present investigation was planned to develop a suitable selection index which can be utilized for performing selection in different rice genotypes to select high yielding genotypes along with some quality components.

Material and Methods
The experiment was carried out using forty genotypes of rice collected from different rice research stations of Andhra Pradesh state namely, Bapatla, Ragolu, Maruteru, Nellore and Jangamaheswarapuram. These genotypes were evaluated during kharif, 2015 at Agricultural College Farm, Bapatla, which is located at an altitude of 5.4 m MSL, $15^0$54' N latitude and $80^0$25' E longitude. The genotypes were tested in a Randomized Complete Block Design (RCBD) with three replications. The seeds were raised on nursery bed and seedlings were transplanted in main field after 28 days. Each genotype was planted in two rows of 4 m length with a spacing of 20 cm between rows and 15 cm within the rows. Observations were recorded on 10 randomly chosen plants for 11 quantitative characters, *viz.,* days to 50% flowering, days to maturity, productive tillers per plant, plant height, panicle length, grains per panicle, test weight, kernel length, kernel breadth, L/B ratio and grain yield per plant. Mean value of the recorded data was subjected to analysis of variance.
The restricted selection indices were computed as per Kempthorne and Nordskog (1959) [5] which enables us to obtain improvement only in desired characters without affecting other characters. A series of constructs to the tune of 2047 were constructed using all the eleven characters considered for this study to evolve a suitable selection index using restricted selection index as per the procedure given by Singh and Chaudhary (1977) [8]. For making easy and accurate selection to select superior genotypes particularly for grain yield per plant, suitable selection index is necessary.

In this process of constructing and identifying suitable construct, equal economic weights were assigned for all the eleven characters (one of the three possible ways of assigning weights to each trait) and 2047 constructs were developed.

Results and Discussion

The indices which gave higher estimates of genetic advance compared to the direct selection of yield alone, were discussed here under (Table.1). Among the selection indices constructed by allotting equal economic weights, 2004 constructs out of 2047 possible indices resulted in higher genetic advance than the direct selection on yield alone. When the independent traits were considered singly for construction of index, the three indices *viz.*, grains per panicle (30.44 g/plant, 1157.23%), Plant height (6.65 g/plant, 252.23%) and Test weight (2.86 g/plant, 108.89%) recorded higher genetic advance and relative gain over grain yield plant^{-1} respectively.

When selection index is formulated using two characters, 30 out of 55 possible two characters combinations recorded higher genetic advance and more relative gain over grain yield plant^{-1}, out of which, grain yield per plant + grains per panicle (34.89 g/plant, 1326.44%), grains per panicle + test weight (33.45 g/plant, 1271.68%) and plant height + grains per panicle (33.34 g/plant, 1267.46%) recorded maximum values of genetic advance and relative gain over grain yield plant^{-1}, respectively. In case of selection indices constructed using three character combinations, 121 out of 133 possible indices recorded higher genetic advance and relative gain over seed yield per plant. Among them, the combinations *viz.*, grain yield per plant + plant height + grains per panicle (38.11 g/plant, 1448.75%), grain yield per plant + grains per panicle + test weight (37.40 g/plant, 1421.75%) and grain yield per plant + panicle length + grains per panicle (37.02 g/plant, 1407.18%) recorded higher values of genetic advance and relative gain over grain yield plant^{-1}, respectively.

In case of four character combinations, 323 out of 329 possible indices recorded higher genetic advance and more relative gain over grain yield plant^{-1}, among them, the combinations *viz.*, grain yield per plant + plant height + grains per panicle + test weight (40.66 g/plant, 1545. 47%), grain yield per plant + plant height + panicle length + grains per panicle (40.36 g/plant, 1534.29%) and grain yield per plant + days to 50% flowering + plant height + grains per panicle (40.08 g/plant, 1523.48%) recorded higher values of genetic advance and relative gain over grain yield plant^{-1}, respectively.

Among five character combinations, all the 469 possible indices recorded higher genetic advance and higher relative gain over seed yield per plant. Among them, the constructs *viz.*, grain yield per plant + plant height + panicle length + grains per panicle + test weight (42.75 g/plant, 1624.94%), grain yield per plant + days to 50% flowering + plant height + grains per panicle + test weight (42.53 g/plant, 1616.77%) and grain yield per plant + days to 50% flowering + plant height + panicle length + grains per panicle (42.30 g/plant, 1608.06%) recorded higher values of genetic advance and relative gain over grain yield plant^{-1}, respectively.

In the indices constructed using, six characters, all the possible 462 combinations recorded higher genetic advance and more relative gain over grain yield per plant. Among them, the combinations *viz.*, grain yield per plant + days to 50% flowering + plant height + panicle length + grains per panicle + test weight (44.61 g/plant, 1695.75%), grain yield per plant + days to maturity + plant height + panicle length + grains per panicle + test weight (44.19 g/plant, 1679.60%) and grain yield per plant + days to 50% flowering + days to maturity + plant height + grains per panicle + test weight (44.10 g/plant, 1676.36%) recorded higher values of genetic advance and relative gain over grain yield plant^{-1}, respectively.

In case of selection indices formulated using seven character combinations, all the possible 330 indices recorded higher genetic advance and higher relative gain over grain yield per plant. Among them, the combinations *viz.*, grain yield per plant + days to 50% flowering + days to maturity + plant height + panicle length + grains per panicle + test weight (46.15 g/plant, 1754.10%), grain yield per plant + days to 50% flowering + productive tillers per plant + plant height + panicle length + grains per panicle + test weight (45.73 g/plant, 1738.41%) and grain yield per plant + days to maturity + productive tillers per plant + plant height + panicle length + grains per panicle + test weight (45.26 g/plant, 1720.22%) recorded higher values of genetic advance and relative gain over grain yield plant^{-1}, respectively.

All the possible 165 indices constructed using eight character combinations recorded higher genetic advance and more relative gain over grain yield per plant. Among them, the combinations, without kernel length, kernel breadth and L/B ratio (47.22 g/plant, 1795.04%), without productive tillers per plant, kernel breadth and L/B ratio (46.42 g/plant, 1764.43%) and the one without productive tillers per plant, kernel length and L/B ratio (46.27 g/plant, 1758.76%) recorded higher values of genetic advance and relative gain over grain yield plant^{-1}, respectively.

Among the selection indices constructed using the nine characters, all the possible 55 combinations recorded higher genetic advance and relative gain over grain yield per plant. Among them, the combinations without Kernel length and L/B ratio (47.35 g/plant, 1799.84%) and the one without Kernel length and Kernel breadth (47.21 g/plant, 1794.36%) recorded higher values of genetic advance and relative gain over grain yield plant^{-1}, respectively.

When ten characters are included, 11 out of 11 possible indices recorded higher genetic advance and relative gain over seed yield per plant. Among them, the combinations which do not include the L/B ratio (47.57 g/plant, 1808.10%), Kernel length (47.52 g/plant, 1806.15%) and Kernel breadth (47.47 g/plant, 1804.33%) registered higher estimate of genetic advance and relative gain over grain yield plant^{-1}, respectively.

The index constructed using all the eleven characters, recorded maximum expected genetic advance (47.79) and maximum percent gain over grain yield per plant (1816.47%) compared to all 2047 possible combinations. Such results were also reported by Bhat and Shariff (1994)[3], Padmaja *et al.*, (2006) [6], Padmaja *et al.*, (2007) [7], and Srilakshmi and Babu (2017) [11] in finger millet and Ammu (2011) [1] in rice. Further it is observed that addition of characters one by one in the construction of selection index resulted in the increased estimates of genetic advance. These findings are in tune with the results of Basavaraja and Sheriff (1992) [2], Bhat and Shariff (1994) [3], Padmaja *et al.* (2007) [7], Srilakshmi *et al.* (2017) [10] and Srilakshmi and Babu (2017) [1].

Table 1: Expected genetic advance and Relative efficiency over Grain yield per plant of different constructs formulated using equal economic weights.

S. NO	Selection index	Expected genetic advance (g/plant)	Relative efficiency over X_1 (%)
1	Grain yield per plant ($X_{1)}$	2.63	100.00
2	Test weight (X_8)	2.86	108.89
3	Plant height(X_5)	6.65	252.75
4	Grains per panicle (X_7)	30.44	1157.23
5	X_{5+} X_7	33.34	1267.46
6	X_{7+} X_8	33.45	1271.68
7	X_{1+} X_7	34.89	1326.44
8	X_{1+} X_{6+} X_7	37.02	1407.18
9	X_{1+} X_{7+} X_8	37.40	1421.75
10	X_{1+} X_{5+} X_7	38.11	1448.75
11	X_{1+} $X_{2+}X_{5+}$ X_7	40.08	1523.48
12	$X_{1+}X_{5+}$ X_{6+} X_7	40.36	1534.29
13	$X_{1+}X_{5+}$ X_{7+} X_8	40.66	1545.47
14	X_{1+} $X_{2+}X_{5+}$ X_{6+} X_7	42.30	1608.06
15	X_{1+} $X_{2+}X_{5+}$ X_{7+} X_8	42.53	1616.77
16	X_{1+} X_{5+} X_{6+} X_{7+} X_8	42.75	1624.94
17	X_{1+} X_{2+} $X_{3+}X_{5+}$ X_{7+} X_8	44.10	1676.36
18	X_{1+} $X_{3+}X_{5+}$ X_{6+} X_{7+} X_8	44.19	1679.60
19	X_{1+} $X_{2+}X_{5+}$ X_{6+} X_{7+} X_8	44.61	1695.75
20	X_{1+} X_{3+} X_{4+} X_{5+} X_{6+} X_{7+} X_8	45.26	1720.22
21	X_{1+} X_{2+} X_{4+} X_{5+} X_{6+} X_{7+} X_8	45.73	1738.41
22	X_{1+} X_{2+} X_{3+} X_{5+} X_{6+} X_{7+} X_8	46.15	1754.10
23	X_{1+} X_{2+} X_{3+} X_{5+} X_{6+} X_{7+} X_{8+} X_{10}	46.27	1758.76
24	X_{1+} X_{2+} X_{3+} X_{5+} X_{6+} X_{7+} X_{8+} X_9	46.42	1764.43
25	X_{1+} X_{2+} X_{3+} X_{4+} X_{5+} X_{6+} X_{7+} X_8	47.22	1795.04
26	X_{1+} X_{2+} X_{3+} X_{4+} X_{5+} X_{6+} X_{7+} X_{8+} X_{11}	47.21	1794.36
27	X_{1+} X_{2+} X_{3+} X_{4+} X_{5+} X_{6+} X_{7+} X_{8+} X_{10}	47.35	1799.84
28	X_{1+} X_{2+} X_{3+} X_{4+} X_{5+} X_{6+} X_{7+} X_{8+} X_9	47.49	1805.12
29	X_{1+} X_{2+} X_{3+} X_{4+} X_{5+} X_{6+} X_{7+} X_{8+} X_{9+} X_{11}	47.47	1804.33
30	X_{1+} X_{2+} X_{3+} X_{4+} X_{5+} X_{6+} X_{7+} X_{8+} X_{10}+ X_{11}	47.52	1806.15
31	X_{1+} X_{2+} X_{3+} X_{4+} X_{5+} X_{6+} X_{7+} X_{8+} X_{9+} X_{10}	47.57	1808.10
32	X_{1+} X_{2+} X_{3+} X_{4+} X_{5+} X_{6+} X_{7+} X_{8+} X_{9+} X_{10}+X_{11}	47.79	1816.47

Where, X_1 = Grain yield per plant, X_2 = Days to 50% flowering, X_3= Days to maturity,
X_4 = Productive tillers per plant, X_5 = Plant height, X_6 = Panicle length,
X_7 = Grains per panicle, X_8 = Test weight, X_9 = Kernel length,
X_{10} = Kernel breadth & X_{11} = L/B ratio

Conclusion

It can be concluded that, the selection index formulated using all the eleven characters, recorded maximum expected genetic advance and per cent gain over grain yield plant^{-1} compared to all other possible combinations and it was also observed that with addition of single trait one after another, the resultant indices had shown increased expected genetic advance with each additional trait. The present investigation conclusively proved that the index formulated using all the traits under study is the best possible index for selecting the superior genotypes for the studied traits.

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