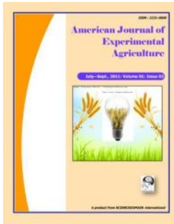

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Ranking Traditional Rice Cultivars Based on Yield and Some Morphological Traits using Path Analysis, Multi-Criteria Decision Making Model and Compromise Programming

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Authors' contributions

This work was carried out in collaboration among all authors. Author ALR designed the study and wrote the manuscript. Author UGSA managed the field experiments, collected and tabulated the field data. Authors ALR and UGSA managed the data analysis. Author SGJNS supervised the study. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

Aims: To rank traditional rice cultivars based on yield and some morphological traits.
Study Design: Experiment was conducted with four replications according to the randomized complete block design. Germinated seeds were planted in rows with 15 cm X 20 cm spacing with twenty plants per each line and three lines per each replication. Data were collected in middle raw of each three lines in four replicates.
Place and Duration of Study: A field experiment was carried out during 2011/2012 Maha and 2012 Yala seasons at Faculty of Agriculture, University of Ruhuna, Sri Lanka.
Methodology: Plant height (cm), number of tillers/plant and number of fertile tillers/plant were counted before harvesting and panicle length (cm), panicle weight (g), number of spikelets/panicle and number of fertile spikelets/panicle were measured after harvesting in 80 plants of each rice cultivar in four replicates. Hundred grain weight (g) and yield/plant (g) were measured after drying grains for 14% moisture content. Total effect of each yield attributing character to the final grain yield which is defined by total effect of path analysis was calculated using SPSS software. Traditional rice cultivars were ranked according to yield and agronomic characters by multi criteria analysis and compromise programming technique.
Results: According to the path coefficients, number of fertile spikelets/panicle (β=0.982) and number of fertile tillers/plant (β=0.787) recorded the highest positive direct effect on grain yield. Plant height (β = 0.036), panicle length (β=0.048), panicle weight (β=0.305)

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100-grain weight (β = 0.260) and filled grain percentage (β=0.130) recorded positive direct effects on grain yield. Negative direct effects were recorded for the number of tillers (β -0.267), number of spikelets per panicle (β =-0.363). Plant height (β =0.179), number of tillers/plant (β =0.838), number of fertile tillers/plant (β =0.077), panicle length (β =0.034) and number of spikelets/panicle (β =0.733) had positive indirect effects on grain yield while number of fertile spikelets/panicle (β=-0.122) recorded negative indirect effects on grain yield. Hence total effect of individual trait on yield was considered for ranking traditional rice cultivars in muti-criteria decision making model where number of fertile spikelets/panicle (0.870), number of fertile tillers/plant (0.864), plant height (0.571), panicle length (0.082), panicle weight (0.305), 100 grain weight (0.260) and filled grain percentage (0.141) effect differently on grain yield. All the rice cultivars were ranked from 1 to 100 according to yield and agronomic characters using total effect of path analysis.

Conclusion: Among tested hundred traditional rice cultivars Hondarawala was the best genotype followed by cultivar EAT Samba and cultivar Bathkiri el. All the other cultivars were placed in between 2-99 positions according to the results of multi criteria decision making model.

Keywords: Traditional rice; agronomic characters; multi criteria analysis; path coefficient.

1. INTRODUCTION

In Asia rice production must be increased up to 700 million tons to feed an additional 650 million rice eaters by 2025 using limited land and water resources [1]. Grain yield is a quantitative character, affected by different genetic factors and environmental fluctuations [2]. Morphological traits of rice play very important role in increase rice production with new plant architecture associated with the yield [3]. Breeding methodologies in rice mainly depend on the degree of association of different morphological characteristics and its variation [4,5]. Correlation coefficient quantifies the degree of association between a response variable and predictor variable(s) [6] is a tool for selection of rice lines in breeding programs [7]. The existence of correlation among characteristics may be attributed to the presence of effect of genes or environmental effect or in combination of all [8]. However the indirect effect through correlated, less complex traits is more efficient in decision making [9]. Efficiency of indirect selection depends on the strength of correlations between yield and yield attributing traits [9,10,11]. Path analysis reveals the amount of direct and indirect effect of the causal components on the effect component which has been utilized by plant breeders to identify promising traits to be considered as a selection criteria of rice [11-13]. And path analysis can be utilized to rank the genetic attributes according to their contribution.

In selection of rice cultivars suitable for farmer field, there cannot be exist one genotype, which optimize all the traits. There is a set of alternatives and each alternative could be a solution of the multi-criteria problem. In multi-criteria analysis several criteria are simultaneously optimized in the feasible set of alternatives.

Multi-criteria decision making is characterized by ranking techniques, multi-attribute utility techniques and mathematical programming techniques [14,15]. Multi-criteria decision making followed by compromise programming can be used to rank rice genotypes [16]. Compromise programming identifies the closest solution to the ideal solution through distance metric. Instead of seeking a single optimal solution, a subset of non-inferior solutions is determined in compromise programming. Here all criteria are unchanged or improved and at least one is strictly improved [14]. Minimization of this closeness is the standard maximization of the criterion function in compromise programming and whichever the parameter value is used, an alternative with minimum metric is considered as the best. Thus the minimum compromise distance (Lp) can be selected as the best solution in compromise solution at multi criteria decision making model [15].

Different methods have been developed to solve multi-criteria analysis problems [17-19]. In the present study characteristics namely plant height (cm), number of tillers/plant, number of fertile tillers/plant, panicle length (cm), panicle weight (g), number of spikelets/panicle, number of fertile spikelets/panicle, hundred grain weight (g) and yield/plant (g) of rice genotypes were considered as effective traits on genotype selection according to the direct and indirect effect of the traits on the final yield. Total effect of path analysis which contained both direct and indirect effect of the trait on the final yield was considered as the criterion weight for compromise programming technique. In this study 100 rice genotypes were ranked according to the yield and agronomic characters using path analysis, multi criteria decision making analysis and compromise programming.

2. MATERIALS AND METHODS

One hundred traditional rice cultivars obtained from Plant Genetic Resources Center (PGRC) were geminated and planted in nursery beds. Ten day old seedlings were transplanted in the experimental field at Faculty of Agriculture, Mapalana, Kamburupitiya, Sri Lanka in rows with 15cmX20cm spacing according to the randomized complete block design. Four replications with 3 lines per each plot and twenty plants per each line were maintained in the field where the soil type was low humic glay soil with low base saturation. Data were collected on plant height (cm), number of tillers/plant and number of fertile tillers/plant before harvesting and panicle length (cm), panicle weight (g), number of spikelets/panicle number of fertile spikelets/panicle were measured after harvesting hundred grain weight (g) and yield/plant (g) were measured after harvesting. Path analysis was done using IBM SPSS AMOS statistical software 20 [20]. Hundred traditional rice genotypes were ranked according to their suitability for farmer field using multi criteria analysis and compromise programming technique.

Multi criteria analysis was done in the following steps.

1. Determined the nature of the relationships between yield and yield components. For this performance of each genotype was quantified with respect to the yield and yield attributing factors.
3. Ran path coefficient analysis for finding total effects, so that the contribution of each character to yield could be estimated. Consequently, the traits of most impacts on improving the crop yield were estimated.
4. Conducted compromise programming technique
   Compromise programming was used to choose the optimum genotypes considering the set of traits as proposed by [21].

The total value of the alternative was calculated based on the weighted sum method given in the following equation [22]:

$V_{(A)} = \sum_i w_i * v_{i\,(ai)}$
w_i : weight of the criterion i,
$v_{i\,(ai)}$: score of the alternative with respect to criterion i
$V_{(A)}$: value of the alternative A.

The criterion is determined for the variable weights according to the agronomist preferences in multi-criteria decision making model.

As the scores have different unit (variables are multivariate), scores were standardized to convert all units into the same range. The best strategy had a standardized score of 1 and the worst strategy had a standardized score of 0. Mathematically, the method was expressed for alternative k with respect to criterion j below:

For this case data were maximized:

STD_{kj} =| ($BEST_{kj}$ -ACT_{kj})|/|($BEST_{kj}$ - $WORST_{kj}$)|
STD_{kj} : Standardized score,
ACT_{kj} : Actual score,
$WORST_{kj}$: The worst (minimum) score
$BEST_{kj}$: Best (maximum) score [22].

Finally, the sensitivity analysis was carried out by changing weights of different criteria so that the role of each criterion on the selection of alternatives can be understood. For this standardized data matrix was multiplied by the criterion weight; respective total effect of the path analysis. These values are called as Ideal distances, and ideal distances of one genotype were summed up to obtain the compromised distances (Lp).

3. RESULTS AND DISCUSSION

3.1 Direct and Indirect Effect of the Yield Components on The Final Yield

Path analysis determines the direct and indirect effects of the yield components and other morphological characters on grain yield [9]. Path coefficients denoted as beta show the direct effect of an agronomic character on a dependent variable, yield in the path model [22]. According to path coefficients, number of fertile spikelets/panicle (β=0.982) and number of fertile tillers/plant (β=0.787) had the highest positive direct effect on the grain yield (Table 1). This indicates that varietal selection for the maximization of the yield can be done based on these two parameters; number of fertile spikelets/panicle and number of fertile tillers per plant in general. Osman et al. [23] also found that number of tillers per plant, 1000 grain weight, panicle length and number of filled grains per panicle were the most directly related traits to grain yield. Positive direct effect of productive tillers per plant on yield has further been confirmed by Surek and Baser [24] and Babu et al. [25].

According to Khan et al. [26] plant height had the highest direct effect on number of grains per panicle. However in the present study, plant height recorded a positive direct effect on the yield (β=0.036). Furthermore, panicle length (β=0.048), panicle weight (β=0.305) and 100 grain weight (β=0.260) had positive direct effects on grain yield. Positive direct effect of 1000-grain weight on grain yield was also reported by Cheng et al. Negative direct effects were recorded for the number of total tillers/plant (β=-0.267), and number of total spikelets per panicle (β=-0.363). Plant height (β=0.179), number of tillers per plant (β =0.838), number of fertile tillers per plant (β=0.077), panicle length (β=0.034) and number of spikelets per panicle (β=0.733) had positive indirect effects on grain yield. Traits such as panicle length, number of tillers per plant, number of filled grains per panicle and 1000 grain weight have been used as index traits for improving the total grain yield [23].

Table 1. Total effect, direct effect and indirect effect of yield attributing traits on grain yield of evaluated traditional rice cultivars as determined by the path analysis

Traits	Direct effect	Indirect effect	Total effect
Plant height (cm)	0.036	0.179	0.215
Number of tillers / plant	-0.267	0.838	0.571
Number of fertile tillers / plant	0.787	0.077	0.864
Panicle length (cm)	0.048	0.034	0.082
Panicle weight (g)	0.305	0.000	0.305
Number of total spikelets / panicle	-0.363	0.733	0.370
Number of fertile spikelets / panicle	0.982	-0.112	0.870
Filled grain percentage	0.130	0.011	0.141
100 grain weight (g)	0.260	0.000	0.260

3.1 Selection of Rice Genotype According to Yield and Yield Related Traits

For the selection of the best compromise genotypes according to the yield and yield related traits a multi criteria decision making model was used. The total effect of the parameter on the yield is given in path coefficient. Hence, the total contribution of the trait on the yield which is described by the total effect of path analysis was considered as the criteria weight (Table 2).

Table 2. Criteria weights for the evaluated traits

Traits	Criteria weights (Total effect)
Plant height (cm)	0.22
Number of tillers/plant	0.57
Number of fertile tillers/plant	0.86
Panicle length (cm)	0.08
Panicle weight (g)	0.31
Number of spikelets/panicle	0.37
Number of fertile spikelets/ panicle	0.87
Filled grain percentage	0.14
100 grain weight (g)	0.26
Yield (g/plant)	1.00

The mean values of trait data; plant height (cm), number of tillers per plant, number of fertile tillers/plant, panicle length (cm), panicle weight (g), number of spikelets per panicle, number of fertile spikelets per panicle, filled grain percentage, 100 grain weight (g) and yield (g/plant) were tabulated for the analysis (Annex 1). Maximized and standardized trait data were multiplied by the criterion weight to produce relative distances according to Mohammad et al. [16] (Table 3). Criterion weight for the multi criteria decision making model is the decision maker's global preference with respect to the quality of the alternatives required [14]. The indirect effect of the trait on the yield was greater than the direct effect of the trait on the yield in some traits (Table 1). Consideration of the total effect of the path analysis as the criterion weight instead of the direct effect of the trait on the yield which is defined by the path coefficient was done due to this reason (Table 2).

Table 3. Relative distances and compromised distance (Lp) calculated for each traditional rice genotype

Genotype	PH	NT	NFT	PL	PW	NS	NFS	FG	HGW	YLD	Lp
Kaluhan diran	0.006	0.512	0.755	0.039	0.250	0.310	0.694	0.054	0.096	0.933	3.650
Kirikara	0.140	0.512	0.744	0.051	0.227	0.271	0.672	0.070	0.103	0.922	3.713
Kotathavalu I	0.062	0.387	0.536	0.078	0.214	0.227	0.472	0.021	0.124	0.776	2.896
Dena wee	0.100	0.368	0.503	0.077	0.245	0.259	0.564	0.035	0.138	0.827	3.116
Herath banda	0.093	0.387	0.602	0.064	0.279	0.336	0.702	0.043	0.121	0.898	3.523
Hondarawala	0.000	0.000	0.000	0.038	0.122	0.108	0.184	0.000	0.114	0.025	0.591
Kottakaram	0.142	0.400	0.569	0.048	0.156	0.230	0.482	0.022	0.066	0.712	2.826
Dandumara	0.007	0.374	0.558	0.061	0.026	0.090	0.296	0.033	0.049	0.541	2.035
Karayal I	0.026	0.184	0.241	0.068	0.142	0.150	0.297	0.010	0.108	0.423	1.648
Dewaredderi	0.070	0.400	0.602	0.048	0.226	0.324	0.778	0.094	0.054	0.943	3.539
Sudu wee	0.115	0.394	0.569	0.070	0.062	0.093	0.312	0.036	0.078	0.600	2.327
Sudu goda wee	0.093	0.387	0.558	0.049	0.154	0.227	0.547	0.044	0.067	0.729	2.856
Kiri naran	0.074	0.440	0.634	0.049	0.169	0.258	0.626	0.057	0.054	0.814	3.175
Karayal II	0.106	0.387	0.547	0.045	0.173	0.208	0.573	0.064	0.100	0.775	2.978
Akuramboda	0.105	0.361	0.547	0.045	0.128	0.091	0.355	0.047	0.127	0.682	2.487
Puwakmalata samba	0.094	0.479	0.755	0.060	0.267	0.259	0.639	0.061	0.212	0.991	3.816
Palasithari 601	0.074	0.387	0.569	0.047	0.180	0.236	0.461	0.011	0.086	0.695	2.746
Murungakayan 3	0.089	0.466	0.711	0.047	0.226	0.276	0.636	0.051	0.104	0.896	3.503
Murungakayan 101	0.175	0.479	0.711	0.050	0.230	0.294	0.669	0.055	0.104	0.913	3.681
Bala Ma wee I	0.089	0.394	0.580	0.009	0.114	0.183	0.414	0.026	0.065	0.626	2.500
Pokuru samba	0.068	0.394	0.569	0.079	0.115	0.054	0.239	0.034	0.133	0.649	2.334
Rata wee	0.032	0.400	0.558	0.082	0.144	0.136	0.423	0.048	0.114	0.708	2.644
Suduru	0.094	0.394	0.558	0.070	0.268	0.236	0.645	0.074	0.207	0.944	3.490
Ingrisi wee	0.112	0.381	0.547	0.051	0.205	0.241	0.650	0.071	0.104	0.834	3.197
Kotathavalu II	0.117	0.354	0.492	0.067	0.184	0.243	0.665	0.077	0.079	0.797	3.075
Kalu karayal	0.127	0.368	0.536	0.063	0.194	0.226	0.629	0.069	0.103	0.814	3.129
Ranruwan	0.137	0.407	0.569	0.055	0.263	0.255	0.685	0.079	0.192	0.948	3.590
Rajes	0.151	0.400	0.569	0.064	0.168	0.219	0.609	0.069	0.082	0.790	3.122
Madoluwa	0.145	0.473	0.689	0.063	0.111	0.229	0.631	0.072	0.017	0.811	3.241
Suduru samba I	0.140	0.505	0.733	0.055	0.295	0.247	0.672	0.078	0.195	0.980	3.900
Handiran	0.051	0.387	0.558	0.058	0.153	0.167	0.757	0.128	0.104	0.911	3.274
Gunaratna	0.056	0.387	0.536	0.078	0.204	0.264	0.580	0.036	0.082	0.757	2.981
Polayal I	0.064	0.302	0.416	0.074	0.257	0.331	0.708	0.046	0.175	0.908	3.281
Tissa wee	0.063	0.361	0.525	0.050	0.171	0.204	0.579	0.065	0.096	0.765	2.880
Sudu karayal	0.097	0.354	0.481	0.063	0.191	0.228	0.785	0.124	0.098	0.906	3.327
Podisayam	0.116	0.479	0.700	0.061	0.266	0.166	0.396	0.027	0.198	0.902	3.310
Giress	0.107	0.492	0.722	0.059	0.167	0.123	0.419	0.051	0.137	0.843	3.121
Naudu wee	0.090	0.400	0.591	0.039	0.151	0.136	0.295	0.016	0.119	0.660	2.496
Kokuvellai	0.075	0.394	0.569	0.064	0.074	0.177	0.546	0.065	0.030	0.675	2.669
Karayal III	0.078	0.302	0.416	0.059	0.092	0.145	0.481	0.058	0.068	0.565	2.265
Murunga wee	0.113	0.440	0.623	0.056	0.275	0.316	0.870	0.136	0.126	1.000	3.955
Matara wee	0.090	0.433	0.623	0.056	0.065	0.115	0.398	0.046	0.067	0.654	2.548
Kaharamana I	0.083	0.433	0.634	0.064	0.142	0.224	0.640	0.077	0.052	0.819	3.169
Karabewa	0.121	0.486	0.733	0.058	0.256	0.254	0.659	0.067	0.149	0.947	3.729
Halabewa	0.145	0.512	0.777	0.063	0.258	0.257	0.579	0.038	0.149	0.937	3.715
Yakada wee I	0.118	0.479	0.700	0.059	0.266	0.362	0.778	0.061	0.053	0.937	3.813
Lumbini I	0.213	0.512	0.755	0.059	0.151	0.220	0.437	0.013	0.065	0.791	3.216
Polayal II	0.199	0.518	0.755	0.070	0.257	0.324	0.758	0.084	0.093	0.958	4.014
Heendik wee	0.215	0.466	0.667	0.047	0.115	0.116	0.323	0.030	0.102	0.713	2.794
Kahata samba	0.077	0.335	0.459	0.040	0.115	0.043	0.118	0.012	0.134	0.483	1.817
Muthumanikam	0.128	0.243	0.394	0.078	0.240	0.134	0.447	0.052	0.188	0.778	2.681
Induru karayal	0.008	0.308	0.558	0.052	0.190	0.237	0.522	0.031	0.090	0.734	2.730
Kalu gires	0.093	0.256	0.372	0.065	0.246	0.258	0.713	0.089	0.135	0.854	3.081
Madabaru	0.149	0.505	0.755	0.063	0.151	0.047	0.287	0.046	0.156	0.841	3.000
Balakara	0.152	0.308	0.525	0.072	0.252	0.332	0.794	0.092	0.075	0.907	3.510
Buruma thavalu	0.172	0.295	0.514	0.023	0.224	0.263	0.626	0.055	0.107	0.822	3.101
Seeraga samba batticaloa	0.154	0.479	0.766	0.047	0.072	0.050	0.251	0.038	0.114	0.783	2.754
H 10	0.148	0.276	0.492	0.046	0.197	0.255	0.562	0.033	0.085	0.714	2.808
Manchel perunel	0.108	0.348	0.547	0.060	0.206	0.243	0.536	0.033	0.103	0.752	2.935
Thunmar hamara	0.085	0.197	0.317	0.038	0.241	0.254	0.611	0.051	0.132	0.752	2.679
Dingiri menika	0.088	0.335	0.525	0.079	0.163	0.244	0.649	0.068	0.056	0.771	2.976
Madael	0.091	0.269	0.383	0.066	0.188	0.233	0.493	0.024	0.090	0.604	2.441
Miti riyan	0.111	0.256	0.405	0.000	0.253	0.191	0.403	0.018	0.177	0.740	2.554
Suduru samba II	0.093	0.341	0.514	0.049	0.262	0.261	0.554	0.030	0.215	0.915	3.234
Gangala	0.112	0.256	0.394	0.040	0.085	0.062	0.127	0.008	0.108	0.338	1.528
Heenpodi wee	0.122	0.256	0.383	0.061	0.265	0.236	0.501	0.027	0.192	0.811	2.854

Genotype	PH	NT	NFT	PL	PW	NS	NFS	FG	HGW	YLD	Lp
Sinnanayan 398	0.165	0.374	0.525	0.055	0.272	0.226	0.632	0.074	0.181	0.903	3.406
Geeraga samba	0.122	0.354	0.536	0.050	0.269	0.165	0.345	0.015	0.228	0.875	2.957
Dik wee 328	0.069	0.433	0.634	0.011	0.092	0.135	0.774	0.136	0.074	0.924	3.282
MI 329	0.135	0.433	0.645	0.029	0.211	0.236	0.478	0.018	0.113	0.794	3.091
Suwanda samba	0.124	0.171	0.361	0.048	0.239	0.091	0.167	0.006	0.200	0.655	2.062
Madael galle	0.108	0.492	0.711	0.058	0.085	0.069	0.125	0.006	0.105	0.659	2.417
Sudu wee ratnapura	0.100	0.368	0.558	0.082	0.054	0.126	0.258	0.016	0.064	0.479	2.103
Maha murunga badulla	0.113	0.361	0.569	0.016	0.036	0.060	0.475	0.082	0.099	0.719	2.528
Madael kalutara	0.094	0.368	0.612	0.054	0.068	0.054	0.087	0.004	0.100	0.574	2.016
Genotype	PH	NT	NFT	PL	PW	NS	NFS	FG	HGW	YLD	Lp
Seevalee ratnapura	0.092	0.249	0.339	0.062	0.116	0.000	0.000	0.006	0.150	0.339	1.354
EAT samba	0.094	0.354	0.514	0.036	0.000	0.022	0.022	0.002	0.000	0.033	1.078
Sirappu paleusithri	0.102	0.387	0.558	0.048	0.121	0.189	0.380	0.013	0.062	0.579	2.438
Muthu samba	0.126	0.335	0.536	0.064	0.194	0.031	0.738	0.141	0.187	0.960	3.312
Podi sudu wee	0.119	0.381	0.602	0.073	0.114	0.050	0.051	0.007	0.122	0.529	2.047
Wanni heenati	0.144	0.571	0.864	0.064	0.204	0.155	0.304	0.009	0.151	0.924	3.390
BG 35-2	0.148	0.374	0.580	0.060	0.155	0.196	0.406	0.018	0.087	0.700	2.724
BG 35-7	0.148	0.256	0.448	0.046	0.185	0.215	0.440	0.019	0.102	0.620	2.479
BG 34-8	0.155	0.341	0.514	0.054	0.218	0.237	0.503	0.026	0.120	0.771	2.939
A 6-10-37	0.146	0.473	0.733	0.061	0.091	0.023	0.017	0.000	0.127	0.686	2.358
Periamorungan	0.114	0.486	0.722	0.022	0.272	0.370	0.795	0.074	0.099	0.974	3.927
Mudukiriel	0.089	0.341	0.470	0.075	0.195	0.245	0.520	0.028	0.091	0.689	2.744
Suduru samba III	0.168	0.289	0.427	0.041	0.305	0.046	0.078	0.004	0.260	0.887	2.504
Kaharamana II	0.149	0.381	0.558	0.049	0.102	0.144	0.290	0.013	0.077	0.543	2.307
Bala ma wee II	0.174	0.276	0.361	0.052	0.160	0.172	0.354	0.014	0.106	0.497	2.166
Chinnapodiyan	0.171	0.368	0.525	0.061	0.226	0.277	0.591	0.033	0.126	0.811	3.188
Kiri murunga wee	0.098	0.374	0.547	0.022	0.193	0.203	0.424	0.019	0.138	0.737	2.754
Heendikki	0.180	0.381	0.547	0.058	0.073	0.060	0.101	0.004	0.100	0.457	1.961
Jamis wee I	0.096	0.381	0.547	0.043	0.099	0.155	0.314	0.012	0.067	0.526	2.239
Lumbini II	0.121	0.400	0.558	0.056	0.254	0.295	0.631	0.039	0.146	0.870	3.371
Sinnanayam	0.176	0.427	0.612	0.050	0.187	0.131	0.262	0.010	0.149	0.723	2.726
Yakada wee II	0.068	0.302	0.405	0.075	0.206	0.251	0.515	0.021	0.096	0.647	2.586
Jamis wee II	0.054	0.302	0.405	0.037	0.040	0.068	0.226	0.027	0.076	0.328	1.563
Bathkiri el	0.066	0.151	0.142	0.055	0.074	0.037	0.047	0.002	0.111	0.000	0.685
Kalukanda	0.084	0.276	0.372	0.033	0.044	0.027	0.024	0.000	0.098	0.182	1.138

PH = Plant height (cm), NT = Number of tillers/plant, NFT = Number of leaves/plant, PL = Panicle length (cm), PW = Panicle weight (g), NS = Number of spikelets/panicle, NFS = Number of fertile spikelets/panicle, FG = Filled grain percentage, HGW = Hundred grain weight (g), YLD = Yield/pant (g)

The closeness between a solution and an ideal point is measured by a function and this function is called as a family of Lp matrices. Standardized data set and criterion weights enable determination of compromise distance (Lp) for each genotype. Compromise distance (Lp) to ideal point was quantified as cumulative values of relative distances (Table 3).

In the present study, various traits have been taken in to consideration to evaluate and rank the traditional rice genotypes where the genotype with minimum Lp distance was considered as the best genotype for cultivation. Cultivar Hondarawala was the best genotype among ninety five traditional rice cultivars followed by cultivar Bathkiri el, EAT Samba and Kalukanda (Table 4). All the other rice cultivars were ranked from 1-100 according to the yield, agronomic characters and their effect on the final yield.

Table 4. Ranking traditional rice cultivars according to compromise distance to ideal point (Lp)

Genotype	Lp	Rank
Hondarawala	0.591	1
Bathkiri el	0.685	2
EAT samba	1.078	3
Kalukanda	1.138	4
Seevalee ratnapura	1.354	5
Gangala	1.528	6
Jamis wee II	1.563	7
Karayal I	1.648	8

Genotype	Lp	Rank
Kahata samba	1.817	9
Heendikki	1.961	10
Madael kalutara	2.016	11
Dandumara	2.035	12
Podi sudu wee	2.047	13
Suwanda samba	2.062	14
Sudu wee ratnapura	2.103	15
Bala ma wee II	2.166	16
Jamis wee I	2.239	17
Karayal III	2.265	18
Kaharamana II	2.307	19
Sudu wee	2.327	20
Pokuru samba	2.334	21
A 6-10-37	2.358	22
Madael galle	2.417	23
Sirappu paleusithri	2.438	24
Madael	2.441	25
BG 35-7	2.479	26
Akuramboda	2.487	27
Naudu wee	2.496	28
Bala ma wee I	2.500	29
Suduru Samba III	2.504	30
Maha murunga badulla	2.528	31
Matara wee	2.548	32
Miti riyan	2.554	33
Yakada wee II	2.586	34
Rata wee	2.644	35
Kokuvellai	2.669	36
Thunmar hamara	2.679	37
Muthumanikam	2.681	38
BG 35-2	2.724	39
Sinnanayam	2.726	40
Induru karayal	2.730	41
Mudukiriel	2.744	42
Palasithari 601	2.746	43
Seeraga samba batticaloa	2.754	44
Kiri murunga wee	2.754	45
Heendik wee	2.794	46
H 10	2.808	47
Kottakaram	2.826	48
Heenpodi wee	2.854	49
Sudu goda wee	2.856	50
Tissa wee	2.880	51
Kotathavalu I	2.896	52
Manchel perunel	2.935	53
BG 34-8	2.939	54
Geeraga samba	2.957	55
Dingiri menika	2.976	56
Karayal II	2.978	57
Gunaratna	2.981	58
Madabaru	3.000	59
Kotathavalu II	3.075	60
Kalu gires	3.081	61
MI 329	3.091	62
Buruma thavalu	3.101	63
Dena wee	3.116	64
Giress	3.121	65
Rajes	3.122	66
Kalu karayal	3.129	67
Kaharamana I	3.169	68
Kiri naran	3.175	69
Chinnapodiyan	3.188	70
Ingrisi wee	3.197	71
Lumbini I	3.216	72
Suduru samba II	3.234	73
Madoluwa	3.241	74
Handiran	3.274	75
Polayal I	3.281	76
Dik wee 328	3.282	77
Podisayam	3.310	78
Muthu samba	3.312	79
Sudu karayal	3.327	80

Genotype	Lp	Rank
Lumbini II	3.371	81
Wanni heenati	3.390	82
Sinnanayan 398	3.406	83
Suduru	3.490	84
Murungakayan 3	3.503	85
Balakara	3.510	86
Herath banda	3.523	87
Dewaredderi	3.539	88
Ranruwan	3.590	89
Kaluhandiran	3.650	90
Murungakayan 101	3.681	91
Kirikara	3.713	92
Halabewa	3.715	93
Karabewa	3.729	94
Yakada wee I	3.813	95
Puwakmalata Samba	3.816	96
Suduru Samba I	3.900	97
Periamorungan	3.927	98
Murunga wee	3.955	99
Polayal II	4.014	100

4. CONCLUSION

Number of fertile spikelets/panicle (β=0.982), number of fertile tillers/plant (β=0.787), plant height (β=0.036), panicle length (β=0.048), panicle weight (β=0.305), filled grain percentage (β=0.130) and 100 grain weight (β=0.260) had positive direct effects on grain yield according to the path coefficients. However, the total effect of number of fertile spikelets/panicle (0.870), number of fertile tillers/plant (0.864), plant height (0.571), panicle length (0.082), and filled grain percentage (0.141) on yield were slightly differed from the direct effect while panicle weight (0.305) and 100 grain weight (0.260) recorded constant values for both direct and total effects hence there is no indirect effect. The traditional rice genotypes could be ranked by a multi criteria analysis and compromise programming, providing variable and equal criteria weights for the yield and yield attributing traits. The results revealed that the cultivar Hondarawala was the best cultivar followed by EAT samba and Bathkiri el al.

CONSENT

Written informed consent was obtained for publication of this report and accompanying the image.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

1 Raw data of rice cultivars used for the study

No	Acc. no	Name	PH (cm)	NT	NFT	PL(cm)	PW (g)	NS	NFS	FG (%)	HGW (g)	YLD(g)	Rank
1	3673	*Kaluhandiran*	151.93	3.40	3.10	26.34	1.74	77.20	46.50	61.30	2.64	3.83	90
2	3674	*Kirikara*	101.63	3.40	3.20	24.51	2.04	91.30	50.00	54.00	2.56	4.15	92
3	3675	*Kotathavalu I*	131.00	5.30	5.10	20.50	2.21	107.40	82.10	76.20	2.31	8.58	52
4	3676	*Dena wee*	116.45	5.60	5.40	20.55	1.80	95.70	67.30	70.10	2.14	7.03	64
5	3677	*Herath banda*	119.35	5.30	4.50	22.65	1.36	67.90	45.20	66.40	2.35	4.90	87
6	3678	*Hondarawala*	154.38	11.20	10.00	26.48	3.41	150.40	128.30	85.70	2.43	31.28	1
7	3679	*Kottakaram*	100.90	5.10	4.80	25.05	2.96	106.40	80.50	75.80	3.01	10.52	48
8	3681	*Dandumara*	151.65	5.50	4.90	23.03	4.65	157.10	110.30	70.80	3.21	15.68	12
9	3686	*Karayal I*	144.58	8.40	7.80	22.04	3.14	135.30	110.10	81.10	2.50	19.26	8
10	3687	*Dewaredderi*	128.10	5.10	4.50	24.94	2.04	72.20	33.00	43.50	3.16	3.52	88
11	3469	*Sudu wee*	110.85	5.20	4.80	21.74	4.18	156.10	107.80	69.30	2.87	13.90	20
12	3477	*Sudu goda wee*	119.13	5.30	4.90	24.85	2.98	107.30	70.10	65.90	3.00	9.99	50
13	3479	*Kiri naran*	126.33	4.50	4.20	24.88	2.79	96.10	57.50	59.90	3.15	7.43	69
14	3480	*Karayal II*	114.35	5.30	5.00	25.43	2.73	114.20	65.90	56.90	2.60	8.62	57
15	3482	*Akuramboda*	114.90	5.70	5.00	25.48	3.32	156.60	100.80	64.40	2.28	11.43	27
16	3486	*Puwakmalata Samba*	119.00	3.90	3.10	23.26	1.52	95.80	55.40	58.10	1.25	2.06	96
17	3487	*Palasithari 601*	126.55	5.30	4.80	25.14	2.64	104.10	83.90	80.90	2.76	11.03	43
18	3489	*Murungakayan 3*	120.63	4.10	3.50	25.20	2.05	89.60	55.80	62.60	2.55	4.95	85
19	3490	*Murungakayan 101*	88.40	3.90	3.50	24.75	1.99	83.10	50.50	60.90	2.54	4.43	91
20	3496	*Bala Ma wee I*	120.60	5.20	4.70	30.90	3.50	123.40	91.40	74.20	3.02	13.10	29
21	3654	*Pokuru samba*	128.58	5.20	4.80	20.37	3.50	169.90	119.40	70.40	2.20	12.41	21
22	3655	*Rata wee*	142.43	5.10	4.90	19.93	3.11	140.50	90.00	64.10	2.43	10.62	35
23	3660	*Suduru*	118.75	5.20	4.90	21.70	1.50	104.20	54.30	52.20	1.31	3.50	84
24	3658	*Ingrisi wee*	111.90	5.40	5.00	24.61	2.32	102.30	53.50	53.70	2.55	6.81	71
25	3659	*Kotathavalu II*	110.20	5.80	5.50	22.16	2.60	101.70	51.20	50.80	2.85	7.93	60
26	3653	*Kalu Karayal*	106.23	5.60	5.10	22.66	2.47	107.70	57.00	54.50	2.56	7.42	67
27	3668	*Ranruwan*	102.48	5.00	4.80	23.99	1.57	97.30	48.00	50.00	1.49	3.36	89
28	3669	*Rajes*	97.33	5.10	4.80	22.51	2.80	110.30	60.10	54.50	2.82	8.16	66
29	3670	*Madoluwa*	99.43	4.00	3.70	22.78	3.54	106.70	56.70	53.30	3.60	7.52	74
30	3671	*Suduru samba I*	101.60	3.50	3.30	23.92	1.15	100.10	50.00	50.70	1.45	2.41	97
31	3688	*Handiran*	134.98	5.30	4.90	23.52	3.00	129.30	36.40	28.00	2.55	4.49	75
32	3691	*Gunaratna*	133.28	5.30	5.10	20.50	2.33	94.00	64.80	69.50	2.81	9.14	58
33	3661	*Polayal I*	130.10	6.60	6.20	21.01	1.65	69.60	44.30	65.20	1.69	4.57	76
34	3664	*Tissa wee*	130.65	5.70	5.20	24.75	2.76	115.70	64.90	56.30	2.64	8.90	51
35	3665	*Sudu karayal*	117.75	5.80	5.60	22.66	2.51	107.20	31.90	29.80	2.62	4.65	80
36	3666	*Podisayam*	110.40	3.90	3.60	23.09	1.53	129.60	94.30	73.40	1.41	4.77	78
37	3423	*Giress*	113.88	3.70	3.40	23.35	2.82	145.10	90.60	62.60	2.15	6.55	65
38	3427	*Naudu wee*	120.53	5.10	4.60	26.30	3.03	140.30	110.50	78.50	2.37	12.10	28
39	3434	*Kokuvellai*	125.93	5.20	4.80	22.53	4.02	125.60	70.30	56.30	3.44	11.64	36
40	3463	*Karayal III*	124.90	6.60	6.20	23.36	3.79	137.10	80.60	59.40	2.98	14.97	18
41	3438	*Murunga wee*	111.85	4.50	4.30	23.77	1.41	75.10	18.30	24.40	2.28	1.80	99

No	Acc. no	Name	PH (cm)	NT	NFT	PL(cm)	PW (g)	NS	NFS	FG (%)	HGW (g)	YLD(g)	Rank
42	3435	*Matara wee*	120.43	4.60	4.30	23.73	4.14	147.80	94.00	64.90	3.00	12.28	32
43	3440	*Kaharamana I*	123.15	4.60	4.20	22.53	3.15	108.50	55.10	51.20	3.17	7.27	68
44	3447	*Karabewa*	108.60	3.80	3.30	23.56	1.66	97.60	52.20	55.50	2.01	3.40	94
45	3451	*Halabewa*	99.58	3.40	2.90	22.78	1.63	96.40	64.90	68.40	2.00	3.71	93
46	3445	*Yakada wee I*	109.83	3.90	3.60	23.41	1.53	58.40	33.00	58.20	3.16	3.71	95
47	3638	*Lumbini I*	73.90	3.40	3.10	23.30	3.02	110.10	87.70	79.80	3.02	8.12	72
48	3639	*Polayal II*	79.40	3.30	3.10	21.69	1.64	72.30	36.30	47.90	2.69	3.08	100
49	3641	*Heendik wee*	73.18	4.10	3.90	25.14	3.49	147.50	106.00	72.10	2.57	10.49	46
50	3642	*Kahata samba*	125.48	6.10	5.80	26.19	3.49	173.90	138.80	80.20	2.18	17.43	9
51	3645	*Muthumanikam*	106.13	7.50	6.40	20.44	1.87	141.20	86.10	62.30	1.53	8.52	38
52	3646	*Induru karayal*	151.45	6.50	4.90	24.36	2.52	103.80	74.10	71.80	2.71	9.85	41
53	3647	*Kalu gires*	119.15	7.30	6.60	22.41	1.79	96.00	43.50	45.50	2.18	6.23	61
54	3650	*Madabaru*	98.20	3.50	3.10	22.66	3.02	172.70	111.80	65.00	1.92	6.60	59
55	3651	*Balakara*	97.15	6.50	5.20	21.41	1.71	69.30	30.50	44.20	2.90	4.60	86
56	3652	*Buruma thavalu*	89.48	6.70	5.30	28.76	2.07	94.40	57.40	61.10	2.51	7.18	63
57	3517	*Seeraga samba Batticaloa*	96.33	3.90	3.00	25.08	4.05	171.50	117.60	68.60	2.42	8.36	44
58	3518	*H 10*	98.50	7.00	5.50	25.24	2.42	97.30	67.70	71.00	2.78	10.44	47
59	3519	*Manchel perunel*	113.48	5.90	5.00	23.18	2.30	101.60	71.90	71.00	2.56	9.31	53
60	3562	*Thunmar hamara*	122.15	8.20	7.10	26.46	1.85	97.60	59.80	62.60	2.21	9.30	37
61	3567	*Dingiri menika*	120.98	6.10	5.20	20.38	2.87	101.20	53.80	55.10	3.13	8.74	56
62	3570	*Madael*	119.83	7.10	6.50	22.23	2.55	105.20	78.80	74.80	2.72	13.77	25
63	3571	*Miti riyan*	112.50	7.30	6.30	32.26	1.70	120.30	93.20	77.40	1.66	9.67	33
64	3572	*Suduru samba II*	119.30	6.00	5.30	24.91	1.57	94.90	69.00	72.40	1.21	4.36	73
65	3589	*Gangala*	112.25	7.30	6.40	26.28	3.89	167.20	137.50	82.00	2.50	21.82	6
66	3588	*Heenpodi wee*	108.45	7.30	6.50	23.03	1.54	104.20	77.40	73.60	1.48	7.51	49
67	3497	*Sinnanayan 398*	92.15	5.50	5.20	24.01	1.45	107.80	56.40	52.30	1.62	4.74	83
68	3498	*Geeraga samba*	108.48	5.80	5.10	24.73	1.49	129.80	102.50	79.00	1.05	5.59	55
69	3504	*Dik wee 328*	128.15	4.60	4.20	30.64	3.80	140.80	33.70	24.30	2.91	4.10	77
70	3506	*MI 329*	103.38	4.60	4.10	27.84	2.24	104.20	81.20	77.60	2.44	8.04	62
71	3507	*Suwanda samba*	107.68	8.60	6.70	25.03	1.87	156.50	131.00	82.80	1.39	12.25	14
72	3508	*Madael galle*	113.45	3.70	3.50	23.54	3.88	164.70	137.80	83.10	2.54	12.13	23
73	3510	*Sudu wee Ratnapura*	116.53	5.60	4.90	19.86	4.29	144.10	116.40	78.70	3.03	17.57	15
74	3511	*Maha murunga Badulla*	111.73	5.70	4.80	29.83	4.52	168.00	81.70	48.70	2.61	10.31	31
75	3514	*Madael kalutara*	118.90	5.60	4.40	24.03	4.11	170.10	143.80	84.00	2.59	14.68	11
76	3516	*Seevalee ratnapura*	119.45	7.40	6.90	22.88	3.47	189.60	157.80	83.20	1.99	21.80	5
77	3383	*EAT samba*	118.88	5.80	5.30	26.81	4.99	181.60	154.30	84.60	3.81	31.04	3
78	3389	*Sirappu paleusithri*	116.03	5.30	4.90	25.03	3.42	121.00	96.90	79.90	3.05	14.55	24
79	3394	*Muthu samba*	106.93	6.10	5.10	22.59	2.46	178.20	39.40	22.20	1.54	3.02	79
80	3395	*Podi sudu wee*	109.28	5.40	4.50	21.26	3.51	171.40	149.70	82.40	2.33	16.05	13
81	3401	*Wanni heenati*	99.98	2.50	2.10	22.57	2.34	133.30	109.10	81.60	1.98	4.11	82
82	3409	*BG 35-2*	98.38	5.50	4.70	23.15	2.97	118.60	92.70	77.80	2.75	10.88	39
83	3410	*BG 35-7*	98.63	7.30	5.90	25.24	2.58	111.80	87.20	77.20	2.57	13.30	26
84	3415	*BG 34-8*	96.00	6.00	5.30	24.05	2.15	103.70	77.20	74.10	2.36	8.72	54
85	3416	*A 6-10-37*	99.08	4.00	3.30	23.00	3.80	181.20	155.00	85.60	2.27	11.31	22
86	3417	*Periamorungan*	111.28	3.80	3.40	28.98	1.44	55.60	30.40	52.50	2.61	2.60	98
87	3591	*Mudukiriel*	120.85	6.00	5.70	20.88	2.45	100.70	74.40	73.10	2.70	11.22	42
88	3594	*Suduru samba III*	91.10	6.80	6.10	26.02	1.02	173.10	145.30	83.90	0.66	5.21	30

No	Acc. no	Name	PH (cm)	NT	NFT	PL(cm)	PW (g)	NS	NFS	FG (%)	HGW (g)	YLD(g)	Rank
89	3595	*Kaharamana II*	97.95	5.40	4.90	24.78	3.66	137.50	111.30	79.70	2.87	15.61	19
90	3598	*Bala Ma wee II*	88.70	7.00	6.70	24.45	2.91	127.20	101.00	79.30	2.53	17.01	16
91	3606	*Chinnapodiyan*	89.65	5.60	5.20	23.07	2.05	89.30	63.10	70.70	2.29	7.53	70
92	3607	*Kiri murunga wee*	117.40	5.50	5.00	29.00	2.48	116.00	89.80	77.30	2.14	9.75	45
93	3610	*Heendikki*	86.33	5.40	5.00	23.54	4.04	167.70	141.60	83.70	2.60	18.22	10
94	3612	*Jamis wee I*	118.05	5.40	5.00	25.78	3.71	133.40	107.40	80.20	3.00	16.15	17
95	3613	*Lumbini II*	108.65	5.10	4.90	23.78	1.69	82.60	56.60	68.10	2.04	5.72	81
96	3614	*Sinnanayam*	87.93	4.70	4.40	24.77	2.56	142.10	115.80	81.20	2.01	10.18	40
97	3615	*Yakada wee II*	128.70	6.60	6.30	20.95	2.31	98.80	75.20	76.10	2.64	12.48	34
98	3616	*Jamis wee II*	133.80	6.60	6.30	26.62	4.47	165.00	121.50	73.70	2.89	22.12	7
99	3550	*Bathkiri el*	129.33	8.90	8.70	23.90	4.03	176.30	150.30	84.90	2.47	32.05	2
100	3713	*Kalukanda*	122.78	7.00	6.60	27.26	4.42	180.00	154.00	85.60	2.63	26.55	4

PH = Plant height (cm), NT = Number of tillers/plant, NFT = Number of fertile tillers/plant, PL = Panicle length (cm), PW = Panicle weight (g), NS = Number of spikelets per panicle, NFS = Number of fertile spikelets per panicle, FG = Filled grain percentage, HGW = 100 grain weight (g), YLD = Yield (g/plant)

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