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Studies on intergenotypic competition in upland rice

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ABSTRACT

The competitive interactions of ten upland rice genotypes were assessed by growing binary mixtures and component monocultures for evaluating the agricultural value of variety mixture for higher productivity. Also attempt was made to correlate different characters with competitive ability and to use such information in selection strategies for developing upland varieties with high yields and competitive ability. The different parameters of de Wit's model like relative yield, relative crowding coefficient and relative reproductive rate were used for assessing competitive interactions. It was found that competitiveness is associated with the increased grains per panicle, higher grain fertility and better grain filling. The genotypes Kalinga III, Badami and Khandagiri were found to possess high competitive ability. It was also noticed that the binary mixtures like Badami + Annada, Pathara + Badami, Badami + Annada, Ghanteswari + Sidhant, Suphala + Annapurna, Parijat + Badami out yielded the best component parent.

Key words: *Binary mixture, intergenotypic competition, rice*

The ecologically handicapped rainfed upland environment contributes abysmally low to the total rice production, mainly due to a large number of interacting factors like unfavourable crop environment, poor crop husbandry, severe weed competition and lack of adaptability of varieties to moisture stress (Das and Ray, 1994). Use of varietal mixtures in such situation offers excellent possibilities of disease control and alleged advantage over monocultures which include greater stability of performance across diverse environment and yield synergism through efficient utilization of resources (Marshall and Brown, 1973; Chaudhury and Paroda, 1979 and Barret, 1981). In a mixture population, there is competition between component genotypes as well as the performance of genotype differs from its performance in homogenous monoculture. The genotypes also vary in their competitive ability.

During the present investigation an attempt was made to synthesize and evaluate binary mixtures and determine their agricultural value for higher productivity in risk prone rainfed upland situations. In addition to this an effort has also been made to correlate different characters with higher competitive ability and to use such information in future selection strategies where an equilibrium between competitive ability and agronomic productivity can be realized.

MATERIALS AND METHODS

The basic experimental material consisting of 10 high yielding upland rice varieties were utilized to develop forty five binary mixtures. These mixtures alongwith ten monocultures were evaluated in a Randomized Block Design at Rice Research Station, OUAT, Bhubaneswar during wet season 2000. The spacing was maintained at 10 x 10 cm to enforce adequate competition among the plants. Observations were recorded on nine metric characters. In the mixture plots, separate observations were recorded on each variety. The data were analysed according to de Wit's model (1960) to give a quantitative description of the competitive interactions. Parameters like Relative Yields (RY), Relative Crowding Coefficient (RCC) and Relative Reproductive Rate (RRR), were used to assess competitive interactions, among the varieties.

Relative Yield (RY) is the ratio of the yield of a genotype in mixture to its yield in monoculture.

Table 1. Performance of monoculture and mixture with deviation (%) from the mean of the constituent monoculture and the best component in upland rice

i/j	i(gm/plot)	j(g/plot)	+ (g/plot)	i + j (t ha^{-1})	Deviation (%) MP	Deviation (%) BC
1			1280	3.56		
2			1430	3.97		
3			1220	3.39		
4			1705	4.74		
5			1420	3.94		
6			1435	3.99		
7			1710	4.72		
8			1635	4.54		
9			1570	4.36		
10			1435	4.15		
1+2	660	540	1200	3.33	-11.44	-29.82
1+3	960	455	1415	4.20	13.20	-17.25
1+4	605	645	1250	3.47	-16.25	-26.90
1+5	815	700	1515	3.93	12.22	-11.40
1+6	730	725	1455	4.04	7.16	-14.91
1+7	650	710	1360	3.77	-9.03	-20.46
1+8	750	550	1300	3.61	-10.81	-23.90
1+9	715	150	1165	3.24	-18.24	-31.87
1+10	735	450	1185	3.29	-12.71	-30.70
2+3	840	585	1425	3.96	7.54	-16.67
2+4	670	815	1485	4.13	-5.26	-13.16
2+5	785	830	1615	4.49	13.33	-5.56
2+6	720	995	1715	4.77	19.72	0.29
2+7	825	870	1695	4.15	7.96	-0.87
2+8	790	775	1565	4.35	2.12	-0.85
2+9	860	825	1685	4.68	12.33	-1.46
2+10	750	690	1440	4.00	0.52	-15.78
3+4	580	765	1345	3.74	-8.03	-21.35
3+5	520	715	1235	3.43	-6.44	-27.78
3+6	530	965	1495	4.15	12.62	-12.57
3+7	550	985	1535	4.27	4.78	-10.23
3+8	705	1025	1730	4.81	21.19	1.17
3+9	585	1125	1710	4.75	22.58	0.00
3+10	645	845	1490	3.84	12.24	-12.87
4+5	835	770	1605	4.47	2.72	-6.14
4+6	755	1060	1815	5.04	15.61	6.14
4+7	790	680	1470	4.09	-13.91	-14.04
4+8	705	590	1395	3.87	-16.47	-18.42
4+9	805	705	1510	4.19	-7.79	-11.70
4+10	860	810	1670	4.64	6.31	-2.34
5+6	785	775	1560	4.33	9.28	-8.77
5+7	790	905	1695	4.71	8.31	-0.88
5+8	690	810	1500	4.17	-1.80	-12.28
5+9	710	880	1590	4.42	4.09	-7.02
5+10	880	700	1580	4.39	10.68	-7.60
6+7	735	860	1595	4.33	1.43	-6.73
6+8	795	835	1630	4.53	8.19	-4.68
6+9	555	780	1335	3.71	-11.15	-21.93
6+10	1010	750	1760	4.89	22.65	2.92
7+8	785	880	1665	4.63	-0.45	-2.63
7+9	960	790	1750	4.86	6.71	2.34
7+10	690	530	1220	3.39	-22.42	-28.65
8+9	780	860	1640	4.56	2.34	-4.09
8+10	770	685	1455	4.34	-5.21	-14.91
9-10	700	735	1435	3.99	-4.49	-16.08
Mean	741.333	776.222	1503	4.16		
CV	14.829	20.059	11103	1.10		
SE(m)	16.368	22.941	22501	0.621		

1= KalingaIII, 2 – Parijat, 3 = Suphala, 4 = Pathara, 5= Khandagiri, 6= Badami, 7 = Ghanteswari, 8 = Annapurna, 9= Sidhant, 10= Annada

RESULTS AND DISCUSSION

The analysis of variance in respect of nine characters revealed highly significant differences among the treatments in respect of majority of the characters. The advantages of the mixtures over the mean performance of the corresponding monocultures and the best component parent (Table 1) indicated variations ranging from –22.42 % to 22.65 % and – 31.87 to 6.14 %, respectively. Twenty seven out of the forty five binary mixture out yielded the mean of the corresponding monocultures. The maximum increase of 22.65 % was observed in Badami + Annada combination followed by Suphala + Sidhant, Suphala + Annapurna, Parijat + Badami, Pathara + Badami, Parijat + Khandagiri, Kalinga III + Suphala, Suphala + Badami, Suphala + Annala, Kalinga III + Khandagiri and Khandagiri + Annada. Only five binary mixtures *viz*., Pathara + Badami, Badami + Annada, Ghanteswari + Sidhant, Suphala + Annapurna and Parijat + Badami out-yielded the best component parent. Higher grain yield and greater stability of performance over environments of the varietal mixture has also been reported by Allard, 1961; Simmonds, 1962; Qualset, 1968; Bhatt and Derera, 1973.This may possibly due to synergistic interaction of the component lines.

Average relative yield values for characters like plant height, panicle length, flag leaf area, grain number, fertility percentage and 100 seed weight was approximately 0.5 indicating the varieties were equally competitive with regard to these characters (Table 2). However, the relative yield values estimated for effective tillers plant^{-1}, grain yield plant^{-1} and grain yield plot^{-1}, in a binary mixture exhibited a different trend *i.e.*, existence of competitive interaction among the varieties for these characters. From the relative yield values, it was found that Badami exhibited highest average relative yield followed by Kalinga III, Khandagiri, Parijat and Sidhant. The relative yield (RY) is the ratio of the yield in mixture with that of the yield in monoculture. A perusal of average RCC (Table 3) revealed that varieties like Kalinga III, Badami, Khandagiri, Parijat and Sidhant exhibited higher estimates of RCC for characters, like grain yield plot^{-1}. Kalinga III, also exhibited higher RCC values for all other characters except for panicle length. Badami exhibited higher RCC values for all characters except flag leaf area. Higher RCC values for eight characters except plant height was exhibited by Khandagiri. Hence, it may be concluded that Kalinga III was found to be the most aggressive variety followed by Badami, Khandagiri, Parijat and Sidhant.

A perusal of average RRR values (Table 4) revealed that the varieties Kalinga III, Badami and Khandagiri had higher average RRR. The relative magnitude of RRR values of Kalinga III was higher (>1.0) in seven binary mixtures out of nine for grain yield/plot. In Badami and Khandagiri higher estimates of RRR were obtained in six and five mixture components, respectively. This indicated their better fitness to mixture population.

As our basic interest during the present investigation was to identify such characters which not

Table 2. Average relative yield of the 10 rice genotypes for different metric characters

Varieties	Plot yield	Grain yield plant^{-1}	Plant height	Panicle length	Flag leaf area	Grain number	Effective tillers plant^{-1}	Grain fertility (%)	100-seed weight
Kalinga III	0.572	0.516	0.486	0.482	0.463	0.550	0.470	0.527	0.522
Parijat	0.526	0.329	0.496	0.497	0.496	0.448	0.379	0.486	0.499
Suphala	0.470	0.342	0.499	0.507	0.478	0.443	0.413	0.477	0.518
Pathara	0.453	0.428	0.486	0.517	0.441	0.498	0.499	0.474	0.497
Khandagiri	0.537	0.543	0.492	0.508	0.503	0.538	0.494	0.583	0.510
Badami	0.589	0.504	0.501	0.500	0.391	0.508	0.500	0.517	0.517
Ghanteswari	0.482	0.424	0.494	0.506	0.519	0.461	0.480	0.457	0.499
Annapurna	0.481	0.389	0.499	0.502	0.503	0.450	0.466	0.461	0.500
Sidhant	0.512	0.323	0.468	0.486	0.474	0.461	0.407	0.509	0.496
Annada	0.462	0.386	0.481	0.481	0.433	0.456	0.413	0.454	0.468

Table 3. Average relative crowding coefficient of 10 rice varieties for different metric characters

Varieties	Plot yield	Grain yield plant^{-1}	Plant height	Panicle length	Flag leaf area	Grain number	Effective tillers plant^{-1}	Grain fertility (%)	100-seed weight
Kalinga III	1.524	1.756	1.033	0.988	1.012	1.281	1.187	1.101	1.064
Parijat	1.019	0.787	1.016	0.996	1.159	0.917	0.801	0.959	0.981
Suphala	0.802	0.728	1.032	1.015	1.025	0.889	0.783	0.968	1.033
Pathara	0.925	1.078	0.997	1.038	0.924	1.051	1.247	0.953	0.986
Khandagiri	1.038	1.038	0.989	1.012	1.104	1.144	1.084	1.222	1.017
Badami	1.183	1.183	1.014	1.011	0.856	1.084	1.135	1.067	1.032
Ghanteswari	0.984	0.984	1.015	1.016	1.072	0.958	1.299	0.947	1.004
Annapurna	0.978	0.948	1.007	1.001	1.081	0.952	1.035	0.946	1.015
Sidhant	1.037	0.789	0.952	0.984	1.021	0.982	0.878	1.022	0.967
Annada	0.884	0.922	0.959	0.949	0.868	0.900	0.944	0.899	0.921

Table 4. Average relative reproductive rate of 10 rice genotypes for different characters

Varieties	Plot yield	Grain yield plant^{-1}	Plant height	Panicle length	Flag leaf area	Grain number	Effective tillers plant^{-1}	Grain fertility (%)	100-seed weight
Kalinga III	1.326	1.517	1.393	1.102	0.808	0.953	1.271	1.046	1.244
Parijat	0.983	0.877	0.972	0.957	0.837	0.799	0.997	1.084	0.971
Suphala	0.637	0.707	0.869	0.929	1.079	1.154	0.924	0.981	0.671
Pathara	1.088	1.122	1.001	0.978	1.020	0.924	1.054	0.995	1.294
Khandagiri	1.101	1.070	0.998	0.952	1.045	0.931	1.075	1.452	1.047
Badami	1.162	1.059	0.972	1.088	1.213	1.067	1.001	0.962	1.115
Ghanteswari	1.069	1.221	0.977	1.091	1.074	1.029	1.067	0.904	1.104
Annapurna	1.059	1.003	0.916	1.113	1.213	1.046	0.939	0.953	1.124
Sidhant	1.099	1.119	1.105	0.878	0.916	1.275	0.978	1.053	0.789
Annada	0.893	0.801	0.937	0.977	0.987	1.003	0.796	0.962	1.103

Table 5. Percent increase or decrease over expected value (monoculture) for different yield attributing characters in Badami

Binary mixture combinations	Plot yield	Panicle length	Grain number	Grain fertility (%)	100-grain weight	Tillers plant^{-1}
Badami + Kalinga III	1.12	-3.09	-8.56	-1.36	-0.85	0.00
Badami + Parijat	38.77	-1.32	9.65	8.21	5.95	9.30
Badami + Suphala	34.58	-0.88	2.41	-2.99	-0.52	9.30
Badami + Pathara	47.38	3.98	5.67	8.21	3.40	-13.95
Badami+ Handagiri	8.08	-0.86	1.45	-0.57	4.25	-6.98
Badami + Ghanteswari	2.51	-0.44	0.36	6.23	10.21	-6.98
Badami + Annapurna	10.87	1.33	11.33	9.26	-0.85	-4.65
Badami + Sidhant	-22.59	-0.44	-11.45	-8.84	2.13	2.33
Badami + Annada	40.86	-0.44	4.70	10.46	3.40	9.30
Total	161.58	-2.16	15.56	28.61	27.12	-2.33
Average	17.91	-0.24	1.73	3.18	3.01	-0.26

only determine high yield in mixture but also responsible for maintaining higher productivity in monoculture, a comparison between grain yield and other associated characters was made under competitive situations. A study of increased (%) performance of component cultures in mixture as compared to performance in monoculture (Table 5, 6 and 7) for different characters in three highly competitive genotypes like Badami, Khandagiri and Kalinga III, revealed that the competitiveness was associated with the increased number of grains panicle^{-1}, higher grain fertility and better grain filling (high grain weight).Therefore, it maybe concluded that high grain number/panicle, higher grain fertility and better seed filling strengthens the view that highly competitive plants are those which are capable of producing larger and more number of viable seeds. But it is a foregone conclusion that where genetic selection has been made for large seeds, there was usually been a corresponding decrease in number of grains/panicle and the best means of increasing yield may be to select for high grain number/panicle and allow the seed size to move as a more or less random variable (Grafius *et al.*, 1976).

Table 6. Percent increase or decrease over expected value (monoculture) for different yield attributing characters in Khandagiri

Binary mixture combinations	Plot yield	Panicle length	Grain number	Grain fertility (%)	100-grain weight	Tillers plant^{-1}
Khandagiri + Kalinga III	-1.40	1.50	8.77	11.63	1.33	-21.56
Khandagiri – Parijat	16.90	2.50	7.76	15.68	4.00	7.84
Khandagiri + Suphala	0.70	1.00	4.74	21.40	3.16	27.45
Khandagiri + Pathara	8.45	0.05	9.20	12.37	-5.33	-3.92
Khandagiri + Badami	10.56	2.50	6.18	19.60	3.11	-1.96
Khandagiri + Ghentaswari	11.26	-1.00	11.94	18.76	2.66	0.90
Khandagiri+ Annapurna	-2.82	0.00	3.88	15.23	2.22	-17.64
Khandagiri-Sidhant	0.00	0.00	1.74	15.97	-0.88	-3.92
Khandagiri + Annada	23.94	3.00	12.37	13.37	2.22	3.92
Total	67.59	9.55	66.58	144.01	12.49	-8.89
Average	7.51	1.06	7.40	16.00	1.39	0.99

Table 7. Percent increase or decrease over expected value (monoculture) for different yield attributing characters in Kalinga III

Binary mixture combinations	Plot yield	Panicle length	Grain number	Grain fertility (%)	100-grain weight	Tillers plant^{-1}
Kalinga III + Parijat	3.12	-0.12	13.65	5.49	1.32	-0.18
Kalinga III + Suphala	50.00	0.42	24.65	9.36	1.76	30.90
Kalinga III + Pathara	-5.46	-4.27	1.73	1.59	3.08	-21.81
Kalinga III + Khandagiri	27.34	-2.99	18.99	7.35	5.28	-10.90
Kalinga III + Badami	14.06	-5.55	10.36	2.48	3.96	-14.54
Kalinga III + Ghanteswari	1.56	-2.56	5.81	2.06	3.52	-10.90
Kalinga III + Annapurna	17.18	-1.28	17.58	5.08	5.28	-10.90
Kalinga III + Sidhant	11.72	11.11	-8.47	5.16	4.84	-0.36
Kalinga III + Annada	14.84	-2.13	10.05	6.18	7.92	-12.72
Total	134.36	-7.37	94.35	44.77	36.96	-51.41
Average	14.93	-0.82	10.40	4.97	4.11	-5.71

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