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Performance of Pure and Mixed Stands for Biomass and Grain Yield in Hexaploid Wheat

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Abstract
The performance of ten biblends, each grown in a 1:1 genotypic ratio was compared with the performance of the involved five bread wheat genotypes grown in pure stands. Land Equivalent Ratio (LER) was calculated by using the concept of De Wit and Van den Berg (1965). Most of the biblends exhibited reduction in biomass and grain yield per plant than their respective midcomponent of pure stand. However, two biblends, Rohtas 90 - Chakwal 86 and 6500 - Chakwal 86 showed significant increase of 9.40 and 16.36 percent for biomass yield (LER values of 1.10 and 1.16) and 14.26 and 18.73 percent for grain yield per plant (LER values of 1.15 and 1.19), respectively. It was concluded that varietal mixtures do have potential as a means of increasing crop yield but identification of correct genotypic combination is essential.

Key words: wheat, mixtures, biblends, mixted stand, pure stand, land equivalent ratio, biomass, grain yield

Introduction
Wheat being a major cereal occupies an eminent place in the economy of our country. Considerable time and effort has been spent on its improvement. But still its per acre yield (2026 kg/ha) in Pakistan is less than that of the developed countries. With the ever-increasing population the production of wheat seems insufficient to meet the nutritional demands of our country. There is an alarming danger of food crisis which obviously demands a matching increase in grain productivity. Constant efforts to boost the production are, therefore, needed to meet the domestic requirements and also spare some for export to earn foreign exchange for the development of the country.

In general the high production is associated with a high cost technology. High capital inputs in terms of high seed rates, chemicals, fertilizers, insecticides and fungicides are often beyond the reach of subsistence and small farmers. Moreover the farmer is reluctant to use high cost technology due to capital investment required on margin land. With inevitable increase in agro-chemicals there is a need to investigate the modified agricultural systems and develop low cost production technology for the farming community throughout the world.

Intra-specific or inter-genotypic effects have been reported generally as competition effects. The magnitude of the inter-genotypic effects is important in breeding methodology and crop production. To increase production by blending, the mixtures would have to perform better than the mean of the component genotypes in pure cultures.

Different experiments conducted in different countries reveal that the appropriate combinations of genotypes of cereals, if are carefully made, show better performance in terms of yield, disease resistance, quality, yield stability etc. So if the performance of different wheat varieties is tested in pure stand and in mixture, it can improve per acre yield without any cost and can save crop damage by disease. The experiment under report was conducted on wheat genotypes to obtain information on the performance of binary mixtures, to evaluate mixtures which most efficiently utilize the environmental resources to increase the yield on per unit area basis. Eisenberg (1980) got 4 out of 17 mixtures which yielded higher than the pure stands. An increase in biological yield of the genotypes was observed when grown in mixtures (Rao and Prasad, 1982; Kuzmin and Molokostova, 1985). Over-compensation by blends have been reported by many workers (Cheema *et al*., 1988; Dziamba and Styk, 1992). Chowdhry *et al*. (1992) conducted an experiment on inter-genotypic competition in wheat and found that four out of ten blends were higher yielding than the average of their components giving yield advantage ranging from 2.35 to 12.55 percent. Two blends gave 2.01 and 5.60 percent higher yield than their higher yielding components.

Materials and Methods
The experiment was sown in the experimental area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. The research material consisted of five wheat varieties/lines viz, LU265, 6500, Chakwal 86, Pasban 90 and Rohtas 90. The experiment was laid out in a randomized complete block design with three replications. There were 15 plots each of 1x3 m size, randomly assigned to 5 pure stands and 10 biblends in each replication. Inter-row and inter-plant distance was kept at 15 cm. Regularity of spacing and uniformity of sowing depth was achieved by sowing with the help of a template. Seeds were sown at a depth of 3-4 cm. Two seeds per hill were sown to ensure full crop stand. Seedlings were thinned to one plant per site after germination. Five guarded plants were taken at random from each component genotype. Data recorded on biomass and grain yield per plant were subjected to the analysis of variance technique (Steel and Torrie, 1980). Least significant differences were calculated by DMR-test. Land Equivalent Ratio (LER) was calculated by using the concept of Relative Yield Total

(RYT) of De Wit and Van den Berg (1965) as:

$$LER = 1/2[(Y_{ab}/Y_{aa}) + (Y_{ba}/Y_{bb})]$$

where,

Y_{aa} = Pure stand yield of genotype 'a'.
Y_{bb} = Pure stand yield of genotype 'b'.
Y_{ab} = Yield of genotype 'a' in mixed stand with genotype 'b'.
Y_{ba} = Yield of genotype 'b' in mixed stand with genotype 'a'.

Results and Discussion

Analysis of variance for biomass and grain yield per plant and their statistical significance are presented in Table 1 and 2.

Biomass per plant: The biomass in pure stands ranged from 65.33 to 90.66 gm (Table 2). Genotypes showed differential behavior in mixed stands producing heavier plants in some mixtures and lighter in other combinations over their pure cultures (Table 3). The genotype Pasban 90 reduced its biomass by 3.71, 12.97 and 18.53 percent when grown with genotypes Rohtas 90, LU265 and Chakwal 86, respectively. On the other hand increased its biomass by 5.56 percent in association with 6500. Genotype LU26S produced heavier biomass in pure stand but reduced it's biomass ranging from 20.58 to 33.82 percent with other associates. Genotype Rohtas 90 showed a reduction in biomass in all combinations. The decrease ranged from 1.61 to 27.41 percent. The strain 6500 has the lowest biomass in monoculture but increased its biomass by 16.33 and 18.37 percent when it was grown in combination with Chakwal 86 and Pasban 90, respectively. But it gained less by 16.33 and 18.37 percent in association with Rohtas 90 and LU26S. The genotype Chakwal 86 showed a positive response when sown .in mixtures. Three out of four combinations showed an increase in biomass. The increase ranged from 16.36 to 21.82 percent. Only in combination i.e., with LU26S, it showed a decrease of 5.45 percent over its pure stand.

Table 1: Mean squares for the analysis of variance for biomass and grain yield per plant in hexaploid wheat

Source of variation	Df	Biomass per plant	Grain yield per plant
Replications	2	266.46^{NS}	108.42^{NS}
Treatments	24	346.10*	85.08*
Error	48	176.23	46.85

* = Significant, NS = Non-significant

Out of ten, three binary mixtures namely Rohtas 90-Chakwal 86, Pasban 90-6500 and 6500-Chakwal 86 showed yield advantage of 9.40, 11.64 and 16.36 percent in biomass over their mid parents. In all other mixtures there was a decrease in biomass ranging from 0.01 to 27.34 percent over their respective mid parents. LER value of binary mixtures Rohtas 90-Chakwal 86, Pasban 90-6500 and 6500-Chakwal 86 were 1.10, 1.12 and 1.16 which also indicated 10, 12 and 16 percent increase in biomass over mid parents. Similar findings were reported by Rao and Prasad (1982) and Kuzmin and Molokostova (1985).

Table 2: Mean performance and statistical significance for biomass and grain yield per plant

Treatments	Statistical significance	
	Biomass per plant	Grain yield per plant
LU26S	90.66 a	39.79 a
Chakwal 86 with Rohtas 90	89.33 ab	39.70 a
Chakwal 86 with Pasban 90	86.66 abc	37.03 ab
Chakwal 86 with 6500	85.33 abcd	36.90 ab
Rohtas 90	82.66 abcde	36.37 abc
Rohtas 90 with Chakwal 86	81.33 abcde	37.05 ab
6500 with Pasban 90	77.33 abcdef	30.55 abcd
Pasban 90 with 6500	76.00 abcdef	31.35 abcd
6500 with Chakwal 86	76.00 abcdef	34.59 abc
Chakwal 86	73.33 abcdef	30.80 abcd
Pasban 90	72.00 abcdef	32.91 abcd
LU26S with Pasban 90	72.00 abcdef	26.16 abcd
LU26S with Chakwal 86	70.66 abcdef	29.69 abcd
Pasban 90 with Rohtas 90	69.33 abcdef	36.78 ab
Chakwal 86 with LU26S	69.33 abcdef	28.1'9 abcd
6500	65.33 abcdef	29.41 abcd
LU26S with RohtaS 90	65.33 abcdet	29.86 abcd
Rohtas 90 with LU26S	64.00 bcdef	31.72 abcd
Pasban 90 with LU265	62.66 cdef	29.76 abcd
Rohtas 90 with 6500	61.33 cdef	27.05 abcd
Rohtas 90 with Pasban 90	60.00 def	26.30 abcd
LU26S with 65Q0	60.00 def	23.92 bcd
Pasban 90 with Chakwal 86	58.66 ef	25.13 bcd
6500 with Rohtas 90	54.66 f	22.99 cd
6500 with LU265	53.33 f	20.26 d

Means followed by similar letters are not statistically different from each other

Grain yield per plant: The yield data revealed that the genotypes showed differential behavior when grown in association with other genotypes (Table 4). The genotype Pasban 90 showed reduction in yield when grown with 6500, LU26S and Chakwal 86. The decrease was 4.74, 9.57 and 23.64 percent, respectively whereas Pasban 90 when associated with Rohtas 90 showed an increase of 11.76 percent over its monoculture. The high yielding genotype LU265 responded negatively in mixtures and reduction of 24.96 to 39.90 percent was observed. The genotype Rohtas 90 in association with Chakwal 86 showed an increase of 1.87 percent while in other combinations reduction of 12.80 to 27.69 percent was bserved. The low yielding genotype 6500 showed an increase of 3.88 and 17.61 percent when planted with Pasban 90 and Chakwal 86 while a reduction of 21.83 and 31.11 percent was observed when grown with Rohtas 90 and LU265. The genotype Chakwal 86 responded positively in mixtures and showed an increase of 19.81, 20.23 and 28.90 percent when combined with 6500, Pasban 90 and Rohtas 90, respectively. But a reduction of 8.47 percent was observed when planted with LU26S.

Table 3: Mean biomass per plant in pure stands and mixtures and Land Equivalent Ratio (LER) for different genotypic combinations of wheat

Genotype combinations	Pure stands			Mixtures			LER	Percent increase or decrease of mixture over mid parent	Percent increase or decrease of genotype 1 in mixture over its pure stand	Percent increase or decrease of genotype 2 in mixture Over its pure stand
	Genotype 1	Genotype 2	Mean	Genotype 1	Genotype 2	Mean				
Pasban 90 - LU26S	72.00	90.66	81.3	62.66	72.00	67.33	0.8	-17.21	-12.97	-20.58
Pasban 90 - Rchtas 90	72.00	82.66	77.3	69.33	60.00	64.67	0.8	-16.37	-3.71	-27.41
Pasban 90 - 6500	72.00	65.33	68.7	76.00	77.33	67.67	1.1	11.64	5.56	18.37
Pasban 90 - Chakwal 86	72.00	73.33	72.7	58.66	86.66	72.66	1.0	-0.01	-18.53	18.18
LU265 - Rohtas 90	90.66	82.66	86.6	65.33	64.00	64.67	0.7	-25.38	-27.94	-22.57
LU26S - 6500	90.66	65.33	78.0	60.00	53.33	56.67	0.7	-27.34	-33.82	-18.37
LU265 - Chakwal 86	90.66	73.33	82.0	70.66	69,33	70.00	0.8	-14.63	-22.06	-5.45
Rchtas 90 - 6500	82.66	65.33	74.0	61.33	54.66	58.00	0.7	-21.62	-25.80	-16.33
Rohtas 90 - Chakwal 86	82.66	73.33	78.0	81,33	89.33	85.33	1.1	9.40	-1.61	21.82
6500 - Chakwal 86	65.33	73.33	69.3	76.00	85,33	80.67	1.1	16.36	16.33	16.36

Table 4: Mean grain yield per plant in pure stands and mixtures and Land Equivalent Ratio (LER) for different genotypic combinations of wheat

Genotype combinations	Pure stands			Mixtures			LER	Percent increase or decrease of mixture over mid parent	Percent increase or decrease of genotype 1 in mixture over its pure stand	Percent increase or decrease of genotype 2 in mixture Over its pure stand
	Genotype 1	Genotype 2	Mean	Genotype 1	Genotype 2	Mean				
Pasban 90 - LU26S	32.91	39.79	36.35	29.76	26.16	27.96	0.78	-23.10	-9.57	-34.25
Pasban 90 - Rohtas 90	32.91	36.37	34.64	36.78	26.30	31.54	0.92	-8.95	11.76	-27.69
Pasban 90 - 6500	32.91	29.41	31.16	31.35	30.55	30.95	0.99	-0.67	-4.74	3.88
Pasban 90 - Chakwal 86	32.91	30.80	31.86	25.13	37.03	31.08	0.98	-2.43	-23.64	20.23
1_11265 - Rohtas 90	39.79	36.37	38.08	29.86	31.72	30.79	0.81	-19.10	-24.96	-12.80
LU265 - 6500	39.79	29.41	34.60	23.92	20.26	22.09	0.65	-36.20	-39.90	-31.11
LU265 - Chakwal 86	39.79	30.80	35.30	29.69	28.19	28.94	0.83	-18.00	-25.38	-8.47
Rohtas 90 - 6500	36.37	29.41	32.89	27.05	22.99	25.02	0.76	-23.90	-25.63	-21.83
Rohtas 90 - Chakwal 86	36.37	30.80	33.59	37.05	39.70	38.38	1.15	14.26	1.87	28.90
6500. Chakwal 86	28.41	30.80	30.11	34.59	36.90	35.75	1.19	18.73	17.61	19.81

LER is a reliable criterion for comparing mixtures and monocultures. Rao and Prasad (1982) obtained a maximum LER of 1.14 in some mixed stands of wheat whereas Cheema *et al*. (1988) reported that one out of ten biblends gave an LER value of 1.188. In present investigations 2 out of 10 mixtures (i.e., Rohtas 90 - Chakwal 86 and 6500-Chakwal 86) gave more yield than mid component showing an increase of 14.26 and 18.73 percent, respectively. LER value was 1.154 and 1.187 for these mixtures indicating an increase of 15.4 and 18.7 percent.

Inter-genotypic competition is a strong force that changes the behavior of heterogenous populations and it is of practical interest to plant breeding and selection programme. Interaction between competing genotypes may be of benefit to plant breeders, if some genotype combinations are found that result in higher yield. Many scientists had observed that the mixtures were some what superior to their pure stands (Eisenberg, 1980; Cheema *et al*., 1988; Chowdhry *et al*., 1992; Dziamba and Styk, 1992).

It is concluded that varietal mixtures do have potential as a means of increasing crop yield but identification of correct genotype combination is essential.

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