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Estimation the extent of inbreeding depression in F_2 hybrids of hexaploid bread wheat

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Abstract
The present study was conducted to quantify the inbreeding depression in six F_2 hybrids. The genotypes (parents and F_2 populations) of bread wheat differed significantly ($P \leq 0.01$) for yield and its components, signifying that ample genetic diversity is presented in evaluated genotypes for studied characters. Considering inbreeding depression, the F_2 progeny Anmol-91 x SKD-1 displayed low extent of inbreeding depression for tillers plant^{-1} (-0.7.41%), spike length (-15.82%), grains spike^{-1} (-3.58%) and seed index (-0.21%); while, F_2 progeny Anmol-91 x Khirman for grain yield plant^{-1} (-3.62%). Of the particular note, these above mentioned F_2 progenies may be proved useful F_2 hybrids for commercial cultivation.

Keywords: inbreeding depression, f_2 hybrids, bread wheat, grain yield

1. Introduction
Wheat is the principal food grain of Pakistan, growing at the largest area of the country under single crop. It accounts for 9.9 and 2.0% of the value added in agriculture and GDP of Pakistan, respectively. During 2015-16, wheat production of the country stood at 25.482 million tonnes, displaying an increase of 1.6% over the previous year's production (25.086 million tonnes). The improvement in yield was due to that crop was grown at proper time, and showed a required amount of moisture particularly in Barani Track, which was good enough for better germination and growth; while availability and use of inputs remained adequate [1]. Information about genetics of yield and its components is of great worth for breeders to select the parents so as to evolve new and potential crop varieties. Therefore, breeding skills and an improved genetic makeup involved for expression of various characters under selection has received great significance [2]. The potentiality of the crosses may be assessed through the comparison of the per se performance of parents, combining ability effects and inbreeding depression. The reduction in performance in advanced generation was not basically due to poor initial identification but could be because of inbreeding depression. Inbreeding depression is resulted by in the reduction of heterozygosity, which shows over-dominance [3]. Therefore, the objectives of this study was to estimate inbreeding depression in F_2 intra-aestivum hybrids and to identify promising crosses for yield potential in subsequent generations.

2. Materials and methods
The present study was conducted on wheat at Southern Wheat Research Station Tandojam. In this study, F_2 population raised from intra-specific crossing between two cultivated wheat varieties viz., Anmol-91 and Kiran-95 with three promising breeding lines viz., Imdad-05, SKD-1 and Khirman. These five wheat varieties were crossed in a line x tester design; consequently, six F_2 hybrids were obtained. The characters were analysed, including tillers plant^{-1}, spike length (cm), grains spike^{-1}, grain yield plant^{-1} (g) and seed index (1000-grain weight g). The analysis of variance was conducted after Gomez and Gomez [4]. Inbreeding depression of all F_2 hybrids was computed according to Falconer [5].

3. Results and Discussion
3.1 Analysis of variances
Analysis of variances (Table-1) exhibited that mean squares for all traits were highly significant differences ($P \leq 0.01$) among the assessed genetic resources. This reveals that used plant materials tend to possess potential genetic assets, therefore may be preferred in future breeding programs. Baloch *et al.* [6] also reported that all the cultivars performed significantly different for a range of quantitative traits.

3.2 Tillers plant^{-1}
The inbreeding depression in F_2 progenies for tillers plant^1 is given in Table-2. All F_2 progenies demonstrated inbreeding depression ranging from -7.41 to – 29.36%, the maximum inbreeding depression (-29.36%) was calculated from the cross Kiran-95×Imdad-05, followed by Kiran-95×Khirman (-24.69). Whereas, the minimum inbreeding depression (-7.41%) was observed in the crosses of Anmol-91× SKD-1. In view of the small extent of inbreeding depression, several researchers, including Singh *et al.* [7], Al-Hamadadi [8] and Bao *et al.* [9] have proposed that less reductions in F_2 populations describes gene action that involves additive x additive and additive x dominance, indicating a possible reason of smaller amount of inbreeding depression.

3.3 Spike length (cm)
Inbreeding depression for spike length is presented in Table-3. All F_2 progenies exhibited inbreeding depression, which range from -15.82 to -43.53%. Table-3 shows that cross Kiran-95 × Imdad-05 expressed maximum inbreeding depression (-43.53%), followed by Kiran-95 × Khirman (-

42.26%) and Anmol-91 × Imdad-05 (39.96%); while crosses Amnol-91 × SKD-1, Kiran-95 × SKD-1 and Anmol-91 × Khirman revealed minimum inbreeding depression with value of -15.82, -18.14 and -36.77%, respectively. Similarly, Larik *et al.* [10] and Singh *et al.* [11] also observed high reductions in performance due to inbreeding depression for all the studied traits, and advocated that reduction was predominantly related with linkage disequilibrium, epistasis and irregular segregation at the stage of meiosis due to greater ploidy level.

3.4 Grains spike^{-1}

The reductions due to inbreeding depression of grains spike^{-1} is given in Table-4. All F_2 progenies showed reduction in performance; though the witnessed reduction for grains spike^{-1} was not as high as found for other traits in the current study, showing a range between -3.58 and 14.14%. The maximum inbreeding depression (-14.14%) was observed in cross combination Kiran-95 × SKD-1, followed by Anmol-91 × Imdad-05 (-8.53) and Anmol-91 × Khirman (-6.69), while the minimum inbreeding depression of -3.58 and -3.95% was demonstrated by the cross combinations of Anmol-91 × SKD-1 and Kiran-95 × Khirman, respectively. It was noted that inbreeding depression occurred in all F_2 hybrids for grains spike^{-1}, ranging from -3.58 to -14.14%. Nevertheless, reduction in fitness of F_2 generations was found up to moderate level and some F_2 generations also indicated even fewer amount of inbreeding depression, signifying that it is worth to select high yielding F_2 hybrids for further use.

3.5 Grain yield plant^{-1}

The reduction in fitness of F_2 generations for grain yield plant^{-1} is described in Table-5. All F_2 progenies exhibited inbreeding depression, ranging from -7.02 to -31.60%. The cross-combination Kira-91 × Khirman showed maximum (-31.60%) inbreeding depression, followed by Kiran-95 × SKD-1 and Kiran-95 × Imdad-05 which demonstrated -20.73 and 15.03% reduction in performance, respectively. Whereas, the minimum inbreeding depression (-7.07%) for grain yield plant^{-1} among the F_2 progeny populations were shown by cross Anmol-91 × Khirman followed by Anmol-91 × SKD-1 (-8.88%). Abd-Allah *et al.* [12], Herefold [13] and Baloch *et al.* [6] also witnessed a great extent of reduction due to homozygosity resulted from inbreeding depression for grain yield in different F_2 hybrids, however, it is further exceeded in polyploids what is imagined by the extent. The response of such type is attributed in decrease of favourable interactions between numerous alleles triggered by inbreeding and irregular segregation during meiosis.

3.6 Seed index (1000-grain weight, g)

Inbreeding depression for the trait seed index is present in Table-6. It is observed that seed index showed inbreeding depression was low to moderate in all F_2 progenies, ranging from -0.21 to -3.46%. The maximum inbreeding depression (-3.46%) was observed in the cross combination Anmol-91 × Khirman, followed by Kiran-95 × Khirman (-3.37%) and Anmol-91 × Imdad-05 (-3.11%), while minimum inbreeding depression was found in F_2 progeny Anmol-91 × SKD-1 (-0.21%), followed by Kiran-95 × Imdad-05 (-0.38%) and Kiran-95 × SKD-01 (-0.88). Since the observed inbreeding depression was not too high in the used F_2 crosses; of special note, the findings support the idea that advantage of F_2 generations may be used as possible hybrid crop if parental materials are documented via their promising performance in segregating materials.

4. Conclusions

It is concluded that F_2 progeny Anmol-91 × SKD-1 exhibited low amount of inbreeding depression for tillers plant^{-1}, spike length, grains spike^{-1} and seed index; thus could be choice F_2 hybrids for further utilization in breeding programs.

Table 1: Mean squares for various yield and its related traits in bread wheat genotypes

Source of variation	Degree of freedom	Tillers plant^{-1}	Spike length	Grains spike^{-1}	Grain yield plant^{-1}	Seed index
Replication	2	1.013	0.023	2.103	16.078	0.332
Genotypes	10	10.24**	4.56**	880.02**	132.84**	104.09**
Error	20	0.53	0.47	0.96	20.39	0.99

** indicates significant level at 1% of probability level

Table 2: Inbreeding depression in F_2 progenies for tillers plant^{-1}

F_2 progenies	Female parent	Male parent	F_1 hybrids	F_2 progenies	Inbreeding depression
Anmol-91 × Imdad-05	5.06	8.66	13.80	12.73	-7.75
Anmol-91 × SKD-1	5.06	8.40	11.60	12.46	-7.41
Anmol-91 × Khirman	5.06	9.00	11.26	9.23	-18.02
Kiran-95 × Imdad	7.93	8.66	12.60	8.9	-29.36
Kiran-95 × SKD-1	7.93	8.40	11.13	9.36	-15.90
Kiran-95 × Khirman	7.93	9.00	11.46	8.63	-24.69

Table 3: Inbreeding depression in F_2 progenies for spike length (cm)

F_2 progenies	Female parent	Male parent	F_1 hybrids	F_2 progenies	Inbreeding depression
Anmol-91 × Imdad-05	10.33	12.06	15.04	9.03	-39.96
Anmol-91 × SKD-1	10.33	11.03	14.53	12.23	-15.82
Anmol-91 × Khirman	10.33	10.86	14.33	9.06	-36.77
Kiran-95 × Imdad-05	11.46	12.46	14.93	8.43	-43.53
Kiran-95 × SKD-1	11.46	11.03	14	11.46	-18.14
Kiran-95 × Khirman	11.46	10.86	14.60	8.43	-42.26

Table 4: Inbreeding depression in F_2 progenies for grains spike^{-1}

F_2 progenies	Female parent	Male parent	F_1 hybrids	F_2 progenies	Inbreeding depression
Anmol-91 × Imdad-05	56.00	63.46	70.33	64.33	-8.53
Anmol-91 × SKD-1	56.00	49.33	65.20	62.86	-3.58
Anmol-91 × Khirman	56.00	66.06	64.66	60.33	-6.69
Kiran-95 × Imdad-05	52.13	63.46	59.00	55.50	-5.93
Kiran-95 × SKD-1	52.13	49.33	63.20	54.26	-14.14
Kiran-95 × Khirman	52.13	66.06	60.73	58.33	-3.95

Table 5: Inbreeding depression in F_2 progenies for grain yield plant^{-1} (g)

F_2 progenies	Female parent	ale parent	F_1 hybrids	F_2 progenies	Inbreeding depression
Anmol-91 × Imdad-05	10.46	15.41	21.48	18.23	-15.13
Anmol-91 × SKD-1	10.46	12.22	22.06	20.1	-8.88
Anmol-91 × Khirman	10.46	16.34	26	24.16	-7.07
Kiran-95 × Imdad-05	15.04	15.41	29.27	23.2	-20.73
Kiran-95 × SKD-1	15.04	13.22	23.76	19.46	-18.09
Kiran-95 × Khirman	15.04	16.34	26.61	18.2	-31.60

Table 6: Inbreeding depression in F_2 progenies for seed index (1000-grain weight, g)

F_2 progenies	Female parent	Male parent	F_1 hybrids	F_2 progenies	Inbreeding depression
Anmol-91 × Imdad-05	44.93	46.86	65.91	63.83	-3.11
Anmol-91 × SKD-1	44.93	42.78	63.81	63.66	-0.21
Anmol-91 × Khirman	44.93	46.57	67.92	66.53	-3.46
Kiran-95 × Imdad-05	43.82	46.80	60.43	60.2	-0.38
Kiran-95 × SKD-1	43.82	42.78	64.59	64.02	-0.88
Kiran-95 × Khirman	43.82	46.57	66.44	64.2	-3.37

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