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ESTIMATION OF MID PARENT HETEROSIS AND HETEROBELTIOSIS FOR YIELD AND YIELD CONTRIBUTING TRAITS IN WHEAT CROSSES

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Abstract:

This study was conducted to estimate heterosis for the yield and yield contributing traits of 3 different cross combinations involving 6 diverse genotypes obtained from CIMMYT at the experimental field of Hazara University, Mansehra in 2016-2017 growing season. The experiment was designed in a Randomized Complete Block Design (RCBD). All three cross combinations showed desirable negative better parent heterosis for days to 50%heading and days to maturity. Highest positive significant mid parent hetersosis in plant height is exhibited by cross C (7.17*). Biological yield is one of the important yield attributing trait, all 3 crosses showed nonsignificant but positive values in MPH for this trait (7.02, 8.89 and 1.85 respectively). Crosses A and B resulted in positive significant heterosis over mid parent for trait of plant yield and cross C showed positive but nonsignificant MPH (13.45*, 18.07* and 6.93). Heterotic hybrids with maximum number of studied desirable yield contributing traits (3) identified only one cross B. The present study suggests ample scope for exploitation of heterosis for commercial production of hybrid wheat by involving early maturity trait for getting further breakthrough in wheat yields.

Keywords: Heterosis, Heterobeltiosis, Yield Component, Wheat, Cross

INTRODUCTION:

Heterosis or hybrid vigour has taken a significant part in the improvement of crops (Morojele & Labuschagne, 2013). In a specific cross, it illustrates improved performance of F1 hybrids over their parents respective of hybrid plant agro morphological traits, increased biomass, plant growth, its yield, resistance to biotic and biotic factors and

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fertility rate (Lippman and Zamir, 2007; Fu et al., 2014; Ji et al., 2014). Heterosis is generally accomplished due to increase in cell number rather than increase in cell size (Birchler et al., 2010). The phenomenon of heterosis arose when Charles Darwin in 1876 analyzed progenies of maize crosses which were significantly taller than its parents. Since the discovery of heterosis by Shull (1908), a remarkable progress was observed in the development of potential hybrids in wheat due to its autogamous nature so the hybrids are highly expected with improved production rate (Whitford et al., 2013; Jaiswal et al., 2010).

In plant breeding programs besides development of many refined approaches to elevate wheat production still heterosis is significantly used for accelerating the crop yield as a conventional breeding technique. First heterotic studies in wheat was made by Freeman (1919) and then Briggle (1963), who examined significant heterosis for grain yield and yield attributes in various wheat hybrids. Heterotic performance of hybrids is evaluated in terms of the percent increase or decrease over the mid and better parent (Inamullah et al., 2006; Hochholdinger and Hoecker, 2007).

Two main ways of expressing hybrid performance have been used. First, it has been expressed as mid-parent heterosis, the increase in yield or other character of the hybrid compared to the mean of the parents, and is an estimate of the mean directional dominance (potence) of the alleles for a given character. Second, it has been measured as heterobeltiosis, the increase in yield or other character of the hybrid compared to that of the better-parent for the character. Heterobeltiosis implies that there is dispersion for dominant alleles between the parents which may increase or decrease the character. Zhang et al. (1985) have showed that more diverse parents would result more heterotic hybrid, he proved his study that heterosis in wheat is positively correlated with the genetic diversity of the parents.

The present study specifically carried out to estimate the heterosis (%) over mid-parent (MP), and better-parent (BP) for thirteen agro morphological traits of bread wheat in three different crosses, to determine the probable direction of heterosis and to identify parental lines that could be used for commercial production of hybrid wheat for further betterment of grain yield in bread wheat.

MATERIAL AND METHODS:

The experiment was conducted in the research field of Department of Biotechnology and Genetic engineering, Hazara University Mansehra during the winter season of 2016-2017. The experiment was laid out in Randomized Complete Block Design with 30cm gap between rows, while length of row was kept about 3 meters.

For all three crosses six different parental genotypes of wheat consisting of effective or partially effective rust resistant genes (Bibi, et al 2022) were obtained from CIMMYT. Cross A was made between YR24/3*AOC and 1055, cross B was made between 1121 and AOC-YR*3/3/ALTAR84/AE.SQ//OPATA (-3Y) while cross C was made between 1018, AOC-YR*3//LALBMONO1*4/PVN (-37Y). Parental genotypes and their F1

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generations were evaluated under natural growing conditions. Data was recorded for days to 50% heading (50%h), spikes per plant (spk/p), spike length (SL), spikelets per spike (spklt/spk), peduncle length (PL), flag leaf area (FLA), grains per spike (G/S), plant height (PH), days to maturity (DTM), 1000 grains weight (1000GW), yield per plant (Y/P), harvest index (HI).

Falconer (1996) proposed a formula to calculate average (mid parent) heterosis and better parent (Heterobeltiosis).

Mid parent heterosis (MPH) = (F1 – MP) / MP x 100

MP = [Female parent (♀) + Male parent (♂)] / 2

Better parent heterosis (BPH) = 100 * (F1 – BP) / BP

Estimation of the significance of heterosis is tested by t-test (wynne et al., 1970).

t (Static) for MPH= (F1 – MP) / (3/8 σ2E)1/2

t (Static) for heterobeltiosis = (F1 – BP) / (1/2 σ2E)1/2

RESULTS AND DISCUSSIONS:

Data of table 1 shows results of the study. It revealed that all three crosses showed negative better parent heterosis for trait of 50%heading and days to maturity. Hybrids of only cross A showed highly negatively significant heterosis over mid and better parent. This negative heterosis is more demanding and effective in wheat breeding programs. Negative heterosis for days to 50%heading and days to maturity is also reported by (Mahajan and Nagarajan, 2001; Akbar et al., 2010, Gawande and Dhumale, 2002; Wu et al., 2001; Inamullah et al., 2006).

One of the vital traits for assuring better yield of a plant is flag leaf area, it has direct impact on crop yield as larger flag leaf area provides larger quantities of photosynthetic products which are essential for best quality seeds. In present studies positive but non-significant heterosis over mid parent is exhibited by hybrids of all three crosses. Work of other scientists (Khan et al., 1995; Chowdhry et al., 2005) regarding positive heterosis for flag leave area is also studied, while (Bao et al., 2009) reported negative heterosis for this trait.

For trait of plant height current studies revealed that F1 hybrids of cross C have positive significant heterosis over mid parent, while cross A and C exhibited nonsignificant negative heterosis over better parent. It is assumed that taller plants have more risk for lodging in storms ultimately reducing yield. Taller plants may have low weight kernals as more energy is consumed to translocate salutes from soil to seed. Negative heterosis and heterobiltoises was recorded in work of many researcher Ahmad et al., (2006) and Akbar et al., (2010) have also found same results.

Improvement in spike length of hybrid plants is a sign of increased plant production (Iqbal and Khan, 2006). Current studies revealed positive nonsignificant mid parent heterosis for spike length which is in agreement with research work of Akbar et al., (2010), Batool et al., (2013) and Fellahi et al., (2013).

Highly positive significant Heterosis (HMP) by F1 plants of cross B for trait of grains per spike is in accordance with the work of Kobiljski and Denčić, (2002) who crossed wheat Verities of diverse spike characters consequently got significant heterosis.

Yield is not under influence of single specific gene hence it is a polygenic trait (Grafius, 1959). Increase in yield of a plant positive heterosis must be achieved in crosses. In this studies cross A and B showed significant positive heterosis over mid parent. Singh et al., (2004) and Kumar et al., (2011) also reported positive substantial heterosis for plant yield. While few plant breeders including Dreisigacker et al., (2005) and Morgan (1998) conveyed negative heterosis over mid parent for above discussed wheat trait.

CONCLUSION AND RECOMMENDATIONS:

Heterosis in autogamous plants would help to develop better hybrids with high yield potential acceptable to the consumers. Results of the study revealed that all three crosses done in this research showed negative better parent heterosis for trait of 50%heading and days to maturity, which was desired to achieve and should be focused in crop improvement programs. The research findings of this study would also help the researcher to find out the critical areas for the development of wheat hybrids.

Table 1: Heterosis and heterobeltiosis for thirteen agro morphological characters of three crosses

	50% heading		Spikes per plant		Flag leaf area		Spike length		Grains per spikes	
	MPH	BPH	MPH	BPH	MPH	BPH	MPH	BPH	MPH	BPH
Cross A	-2.87	-2.87	18.52	14.29	3.98	-4.82	2.77	-11.27	6.89	-1.02
Cross B	-5.43*	-6.62*	16.13	-10	12.33	-21.46	17.95	0	37.84**	17.24
Cross C	0.16	-3.43	33.33	23.08	34.84	33.97	10.26	-4.44	8.27	0
	Spikelets per spike		Days to maturity		Peduncle length		Plant height		Biological yield	
	MPH	BPH	MPH	BPH	MPH	BPH	MPH	BPH	MPH	BPH
Cross A	12.98	12.12	-4.55**	-5.19**	1.3	-8.7	1.95	-5.9	7.02	-5.43
Cross B	14.02	10.91	-1.46	-1.75	18.82	16.9	1.85	-1.78	8.89	6.52
Cross C	6.67	1.82	-0.48	-0.96	12.13	5.45	7.17*	0	1.85	-10.57*
	Plant yield		1000 grain weight		Harvest index					
	MPH	BPH	MPH	BPH	MPH	BPH				
Cross A	13.45*	9.67	5.52	2	4.88	-4.47				
Cross B	18.07*	-2	5.57	3.87	5.48	-8.87				
Cross C	6.93	-10	4.29	-2.67	8.28	1.98				

References

❖ Ahmad, I. H, F. Mohammad, S. Ud-Din, G. Hassan and R. Gul. 2006. Evaluation of the heterotic and heterobelthiotic potential of wheat genotypes for improvement yield. Pak. J. Bot. 38(4): 1159-1167.

❖ Akbar, M., J. Anwar, M. Hussain, M. M. Iqbal and W. Sabir. 2010. Heterosis and heterobeltiosis for grain yield improvement in bread wheat. J. Agric. Res. (03681157), 48(1).

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- Bao, Y. G., W. Sen, X. Q. Wang, Y. H. Wang, X. F. Li, W. Lin and H. G. Wang. 2009. Heterosis and combining ability for major yield traits of a new wheat germplasm shannong 0095 derived from thinopyrum intermedium. Agric. Sci. in China, 8(6): 753-760.
- Batool, A., I. R. Noorka, M. Afzal and A. H. Syed. 2013. Estimation of heterosis, heterobeltiosis and potence ratio over environments among pre and post green revolution spring wheat in Pakistan. J. Basic & Appl Sci., 9: 36.
- Bibi. S., A. Qayyum, I. Ullah, K. baigum, H. Ali and R. Ullah. 2022. Gene pyramiding for stripe rust resistance in whear (Triticum aestivum). J. Xi,an Shiyou University, natural science edition. 18(12): 1192-1201.
- Birchler, J.A., H. Yao, S. Chudalayandi, D. Vaiman and R.A. Veitia. 2010. Heterosis. Plant Cell. 22: 2105-2112.
- Briggle, L.W. 1963. Heterosis in wheat.A review. Crop Sci. 3: 407-412.
- Chowdhry, M. A., M. S. Saeed, I. Khaliq and M. Ahsan. 2005. Combining ability analysis for some polygenic traits in a 5x5 diallel cross of bread wheat (triticum aestivum l.). Asian J. of Plant Sci., 4 (4): 405-408
- Dreisigacker, S., A. Melchinger, P. Zhang, K. Ammar, C. Flachenecker, D. Hoisington and M. Warburton. 2005. Hybrid performance and heterosis in spring bread wheat, and their relations to ssr-based genetic distances and coefficients of parentage. Euphytica, 144(1): 51-59.
- Falconer, D. S. 1996. Introduction to quantitative genetics. Pearson Education India.
- Fellahi, Z. E. A., A. Hannachi, H. Bouzerzour and A. Boutekrabt. 2013. Line× tester mating design analysis for grain yield and yield related traits in bread wheat (Triticum aestivum l.). Inter. J. Agron.,1-9.
- Freeman, G.F. 1919. Heredity of quantitative characters in wheat.Genetics. 4:1-9.
- Fu, D., M. Xiao, A. Hayward, Y. Fu, G. Liu, G. Jiang and H. Zhang. 2014. Utilization of crop heterosis: rev. Euphytica, 197(2): 161-173.
- Gawande, V. and D. Dhumale. 2002. Heterosis and combining ability studies in durum wheat. J. Maharashtra agric. univ., 27(1): 96-97.
- Grafius, J. 1959. Heterosis in barley 1. Agron. J., 51(9): 551-554.
- Hochholdinger, F. and N. Hoecker. 2007. Towards the molecular basis of heterosis. Trends Plant Sci. 12(9): 427-432.
- Inamullah, H.A., F. Muhammad, Sirajuddin, G. Hassan and R. Gul. 2006. Diallel analysis of the inheritance pattern of agronomic traits of bread wheat. Pak. J. Bot. 38(4): 1169-1175.
- Iqbal, M. and A. Khan, 2006. Analysis of combining ability for spike characteristics in wheat (Triticum aestivum L.). Int J Agric Biol., 8: 684-687.
- Jaiswal, K. K., P. Pandey, S. Marker and P.J. Anurag. 2010. Heterosis studies for improvement in yield potential of wheat (Triticum aestivum L.). Adv. Agric. Botanics-Bioflux. 2(3): 273-278.
- Ji, T., P. Liu and D. Nettleton. 2014. Estimation and testing of gene expression heterosis. J. agr. bio. environ. stat., 19(3): 319-337.
- Khan, N., M. Swati, G. Hassan and Q. Nawaz. 1995. Heterosis exhibited by some morphological traits of diallel crosses in wheat (triticum aestivum l.). Sarhad J. Agric. (Pakistan). 11: 485-489
- Kobiljski, B. Đ. and S. S. Denčic. 2002. Heterosis in crosses between wheat genotypes with different spike architecture. Zbornik Matice srpske za prirodne nauke, (102): 71-75.

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- Kumar, A., V. Mishra, R. Vyas and V. Singh. 2011. Heterosis and combining ability analysis in bread wheat (Triticum aestivum l.). J. Plant Breed. Crop Sci., 3(10): 209-217.
- Lippman, Z. B. and D. Zamir. 2007. Heterosis: Revisiting the magic. Trends in genet., 23(2): 60-66.
- Morgan, C. 1998. Mid-parent advantage and heterosis in f1 hybrids of wheat from crosses among old and modern varieties. J. Agri. Sci., 130(3): 287-295.
- Mahajan, V. and S. Nagarajan. 2001. Hybrid wheat evaluation by raised bed fixed plot drill. ICAR News, 7: 19.
- Morojele, M. and M. Labuschagne. 2013. Heterotic performance of quality characteristics of bread wheat cultivars. Afr. Crop Sci. J., 21(4): 283-289.
- Singh, R. P., H. M. William, J. Huerta-Espino and G. Rosewarne. 2004. Wheat rust in asia: Meeting the challenges with old and new technologies. In: Proceedings of the 4th International Crop Science Congress. Citeseer.
- Shull, G.F. 1908. The composition of a field of maize. Rep. Am. Breed. Assoc. 5: 51-59.
- Whitford, R., D. Fleury, J.C. Reif, M. Garcia, T. Okada, V. Korzun and P. Langridge. 2013. Hybrid breeding in wheat: technologies to improve hybrid wheat seed production. J. Exp. Bot. 64: 5411-5428.
- Wu, L. M., Z. F. Ni, Z. K. Wang, Z. Lin and Q. Sun. 2001. Relationship between differential expression patterns of multigene families and heterosis in a wheat diallel crosses. Yi chuan xue bao= Acta genetica Sinica, 28(3): 256-266.
- Zhang, A.M., J. Huang, M.L. Wang, and T. Huang (1985). The relationship between genetic distance of quantitative characters of parents and heterosis in hybrid wheat with Triticum timmopheevi cytoplasm. Acta Agriculture Universities Pekinensis 11:135-142.