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EVALUATION OF INTERSPECIFIC WHEAT HYBRIDS (*T. DURUM* × *T. AESTIVUM*) FOR SPIKE-RELATED TRAITS

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SUMMARY

The presented study analyzed the inheritance via heterosis of interspecific F_1 hybrids between durum and bread wheat over better parents and ratios of dominance for spike-related traits affecting their productivity and transmission to future segregating populations. The research transpired in the crop seasons of 2017–-2019 at the Institute of Molecular Biology and Biotechnologies, Azerbaijan National Academy of Sciences, Baku, Azerbaijan. The hybridization program used eight durum wheat (*Triticum durum* Desf) genotypes, i.e., Shark, Karabagh, Barakatli-95, Tartar, Garagilcııg-2, Vugar, Mirbashir-50, and Shiraslan-23, and 13 bread wheat (*T. aestivum* L.) cultivars, viz., Mirbashir-128, Kyrmyzygul-1, Gobustan, Layaqatli, Kyzyl Bughda, Gunashli, Taleh-38, Sheki-1, Murov, Nurlu-99, Aran, and two foreign cultivars Bezostaya-1 (Russia) and Dagdash (Turkey) to generate 24 interspecific F_1 hybrids. Studying the heterosis over better parents and degree of dominance in these interspecific F_1 hybrids compared their performance with parental genotypes for spike-related traits, i.e., spike length, spikelets per spike, grains per spike, and grain weight per spike. In the F_1 interspecific hybrids' evaluation, the recorded desirable positive heterosis over better parents and dominance ratios appeared in cross combinations, i.e., Barakatli-95 × Gobustan, Karabagh × Mirbashir-128, Karabagh × Shark, Sheki-1 × Gobustan, Murov × Daghdash, Nurlu-99 × Layaqatli, Gobustan × Sheki-1, and Mirbashir-50 × Shiraslan-23 for spike-related traits. However, the F_1 hybrid Garabagh × Gobustan revealed negative heterosis and depression for yield-related traits.

Keywords: Interspecific wheat hybrids (*T. durum* × *T. aestivum*), parental genotypes, heterosis, dominance, spike-related traits, productivity

Key findings: The study identified the promising durum by bread wheat F_1 hybrids in terms of heterotic and dominance effects over better parents for yield indicators that can benefit future breeding work to obtain high-yielding wheat genotypes.

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INTRODUCTION

Genetic analysis and further selection for promising genotypes require various methods of integrated assessment of the breeding material. Hybrids' characteristics are often numerous vital features gathered from two diverse parental genotypes through hybridization. These methods also include evaluating the breeding material with their related traits and dependency on each other (Fonseca, 1965; Rustamov *et al*., 2017). In

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this regard, studying the genetic potential of durum and bread wheat hybrids and their comparison with parental genotypes is an eminent step for developing highly productive cultivars.

Durum (*Triticum durum* Desf.) and bread wheat (*Triticum aestivum* L.) are the oldest and most valuable plant species on earth that are very influential and strategic also in the present era. These two types of wheat differ in their biological and biochemical properties, as well as, technological qualities. In the early 80s of the last century, the academician 'Dr. Jalal Aliyev' developed the tests of the 'Ideal wheat' plant model (Aliyev, 1982; Aliyev and Akperov, 2002; Swelam *et al*., 2022). These tests have also accelerated the selection of breeding material and the creation of valuable forms. The results of these studies then developed several worthwhile wheat hybrids, with ecological tests conducted at various Agricultural Experimental Stations in different regions (Abdullaev, 2012; Rustamov *et al*., 2017; Khan *et al*., 2023).

Total productivity decline links with climate change, which is one of the major causes at present. The salinization of 25% of the earth's dry land triggers decreasing plant productivity, affecting biodiversity and plant genetic resources, which is ultimately an economic loss. The fact that ~48%–50% of Azerbaijan's land is arid, an increased area of salinized land from 521,700 ha to 661,900 ha (46.6% of the total area) shows that this problem is also relevant in the country (Azizov, 2002).

The impact of these abiotic stressors is likely to intensify in the future. Therefore, an urgent need to develop new wheat cultivars resistant to stress conditions with high productivity requires action. Knowingly, the development of agriculture in the future will take place mainly through developing new cultivars that better adapt to the ever-changing environment, with the continuous creation of new plant models (Guliyev, 1993; Bome *et al*., 2022). Simultaneously, several studies also showed that the disturbance of the ecological balance and the presence of abiotic stress factors in nature requires the creation of more flexible wheat cultivars suitable for the republic's regions (Abdullaev, 2012; Rustamov *et al*., 2017).

The role of the basic breeding material in developing new productive cultivars is highly relevant. According to N.I. Vavilov, to obtain hybrids with high heterosis, correctly selecting the types of parental genotypes should take place (Vavilov, 1967). The past study conducted on 422 interspecific F_2 populations of *T. polonicum* x *T. spelta* revealed that the grains per spike enhanced as the chromosome number approached 28 to 42, while the lowest in F_2 hybrids with 31 chromosomes and the genotypes with 35 chromosomes showed only 50% fertility (Kihara, 1982).

According to other researchers, the recorded lowest number of grains per spike and mass emerged in the interspecies F_2 populations of *Triticum aestivum* × *Triticum durum* with 2n = 33, 32, and 34 chromosomes, while the highest grains were in the populations with 2n = 28 chromosomes. Researchers have also specifically noted that various types of populations obtained in interspecific hybrids revealed the chromosome number of these forms when reaching a stable level, the intermediate types disappear over time for several reasons, with their findings also indicating that 50% of these hybrids were sterile (Dorofeev *et al*., 1987; Ozkan and Genj, 1998).

Based on the above discussion and past literature, a conclusion is that it is possible to obtain new wheat cultivars with high productivity and good quality traits by using individual high-characteristic cultivars in a hybridization program. Nowadays, breeders in different countries worldwide create appropriate plant models and use them in breeding programs, not just as novelty and fashion but as a requirement of breeding programs considering all possible biotic and abiotic factors (Aliyev and Akperov, 2002). The presented study aimed to determine the degree of dominance and the effects of heterosis in F_1 hybrids obtained by using durum and bread wheat cultivars.

MATERIALS AND METHODS

The latest research program used eight durum wheat (*T. durum* Desf.), viz., Shark, Karabagh, Barakatli-95, Tartar, Garagilciıg-2, Vugar, Mirbashir-50, and Shiraslan-23, and 13 bread wheat (*T. aestivum* L.), Mirbashir-128, Kyrmyzygul-1, Gobustan, Layaqatli, Kyzyl Bughda, Gunashli, Taleh-38, Sheki-1, Murov, Nurlu-99, Aran, Bezostaya, and Dagdash. After hybridization, obtaining 24 F_1 cross combinations (hybrids) resulted during the study. Planting all the F_1 hybrids along with their durum and bread wheat parental cultivars in irrigated conditions ensued in 2017–2019 for their evaluation at the Institute of Molecular Biology and Biotechnologies, Azerbaijan National Academy of Sciences, Baku, Azerbaijan. Organic manure application at the rate of 0.5 kg proceeded on every m^2 of soil. Irrigating the wheat genotypes at the stages of tube opening (20.4), spike formation (19.5), and especially at the grain formation stage (04.6) continued, with the recommended cultural practices for maintenance of the crop in the said region carried out in the experimental area.

Data recorded and statistical analyses

Observations for various traits on all the wheat genotypes went according to the existing methodology (Musayev *et al*., 2008). In the F_1 hybrids, assessment of the transmission of heredity progressed through heterotic effects and degree of dominance. In F_1 hybrids, the better parent heterosis (Heterobeltiosis) estimation was in terms of the percent increase or decrease of the F_1 hybrid over its better parent in various quantitative traits (Fonseca, 1965; Omarov, 1975).

$$Heterobeltiosis\ (\%) = \frac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$$

The degree of dominance (hp) calculation used the formula according to Beil and Atkins (1965).

$$\text{Degree of Dominance} = \frac{\overline{F_1} - \overline{MP}}{\overline{BP} - \overline{MP}}$$

Where:
F_1: Average value of F_1 hybrid
BP: Better-parent value in the particular F_1 cross
MP: Mid-parent value of the particular F_1 cross

RESULTS AND DISCUSSION

According to present results, the inheritance of the various quantitative traits has a varied expression and mainly depends upon the genetic makeup of the parental genotypes and environmental conditions. In the F_1 hybrid combinations, according to the formation of various quantitative traits, the diversity occurred in the transmission of heredity, heterosis over better parents, and dominance to depression. Several studies also reported significant variations in wheat genotypes for various morphological and yield-related traits (Azizov, 2002; Abdullaev, 2012; Rustamov *et al*., 2017). The results, the genetic parameters and the transmission of quantitative traits, i.e., spike length, spikelets per spike, grains per spike, and grain weight per spike from parents to offspring, appear in Tables 1 and 2, with their discussion as follows.

Spike length

Overall, for spike length, the F_1 hybrids ranged from 6.3 to 15.4 cm (Figure 1, Table 1). According to mean performance, the maximum spike length observed was in F_1 hybrid Vugar × Barakatli-95 (15.4 cm), followed by three others with at par spike length, i.e., Barakatli-95 × Vugar (13.4 cm), Mirbashir-50 × Shiraslan-23 (13.3 cm), and Kyrmyzygul-1 × Tale-38 (13.2 cm). Inversely, the minimum spike length showed in F_1 hybrid Dagdash × Murov (6.3 cm). Out of 24 durum by bread wheat F_1 hybrids, 19 revealed positive values for better parent heterosis, ranging from 1.11% to 52.47%, while five F_1 crosses provided negative heterobeltiosis, ranging from -6.31% to -24.09% (Table 1).

For spike length, the recorded highest positive heterotic effects over better parents were in the F_1 hybrid Vugar × Barakatli-95 (52.47%), followed by two others, Karabagh × Mirbashir-128 (45.71%) and Barakatli-95 × Vugar (45.65%). However, the highest negative heterosis over better parents occurred in three F_1 hybrids, viz., Dagdash × Murov (-24.09%), Karabagh × Garagilciıg-2 (-21.56%), and Aran × Kyrmyzygul-1 (-20.38%). For spike length, the degree of dominance ranged from -3.40 to 10.33. Further, the noted highest positive values of degree of dominance resulted in F_1 hybrids Barakatli-95 × Vugar (10.33), followed by three others, Kyrmyzygul-1 × Tale-38 (9.57%), Vugar × Barakatli-95 (8.33), and Karabagh × Mirbashir-128 (7.16). Past studies also enunciated that the significant heterotic effects and positive dominance values emerged for spike length and other yield-related traits in wheat hybrids by comparing with parental genotypes (Aliyev and Akperov, 2002, Abdullaev, 2012; Rustamov *et al*., 2017).

Spikelets per spike

Overall, in F_1 hybrids, the spikelets per spike ranged from 18.4 to 28.4 (Figure 1, Table 1). The highest and same number of spikelets per spike (28.4) came from two F_1 hybrids, Layaqatli × Mirbashir-128 and Kyzyl Bugda × Gunashli, followed by Tartar × Karabagh (26.0) and Karabagh × Shark (25.1). However, the acquired least number of spikelets per spike was in F_1 hybrids Barakatli-95 × Vugar

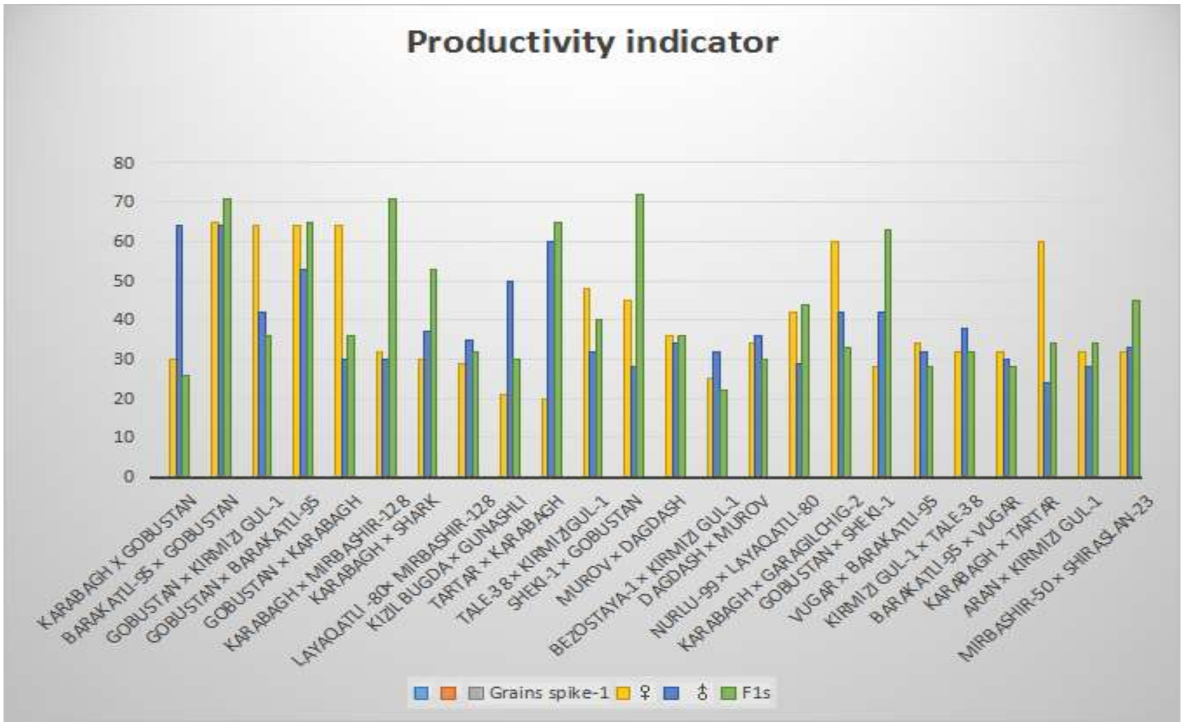

Figure 1. Comparative evaluation of durum and bread wheat cultivars and their F_1 hybrids for spikelets per spike.

Table 1. Inheritance of quantitative traits in the form of heterosis over better parents and degree of dominance in the F_1 hybrids of durum and bread wheat.

No.	Cross Combinations	Spike length (cm)					Spikelets spike^{-1}				
		♀	♂	F_1s	Het. (%)	Hp	♀	♂	F_1s	Het. (%)	Hp
1	Karabagh × Gobustan	8.3	9.5	8.9	-6.31	0.00	22.4	22.8	21.4	-6.14	-6,01
2	Barakatli-95 × Gobustan	7.1	6.3	7.4	4.22	1.75	20.3	22.4	22.5	0.44	1.09
3	Gobustan × Kyrmyzygul-1	6.3	6.9	7.9	14.49	4.33	22.4	20.4	23.1	3.13	1.70
4	Gobustan × Barakatli-95	8.9.	7.1	9.5	6.74	1.66	24.1	20.3	24.4	1.24	1.51
5	Gobustan × Karabagh	9.5	8.3	8.6	-9.47	0.51	20.2	22.4	24.6	9.82	3.01
6	Karabagh × Mirbashir-128	8.3	7.1	12.1	45.71	7.16	24.3	20.2	24.4	0.41	1.04
7	Karabagh × Shark	8.3	7.4	9.2	10.84	2.88	24.4	20.7	25.1	2.86	1.37
8	Layaqatli × Mirbashir-128	9.2	7.1	10.3	11.92	2.04	20.0	22.4	28.4	26.76	6.12
9	Kızıl bugda × Gunashli	8.1	9	9.1	1.11	1.22	22.4	20.4	28.4	26.76	7.21
10	Tartar × Karabagh	8.3	9.0	9.2	2.22	1.57	24.4	22.4	26.0	6.55	2.45
11	Tale-38 × Kyrmyzygul-1	7.1	10	12.4	24.00	2.65	22.3	24.4	24.3	-0.40	0.90
12	Sheki-1 × Gobustan	6.3	9.0	11.2	24.44	2.45	20.4	21.3	22.2	4.22	1.54
13	Murov × Dagdash	9.5	9.1	10.1	6.31	4.00	18.4	20.4	21.2	3.92	1.80
14	Bezostaya-1 × Kyrmyzygul-1	9.5	9.8	10.3	5.10	4.33	20.4	22.2	24.4	9.90	3.44
15	Dagdash × Murov	8.3	7.2	6.3	-24.09	-2.63	22.2	21.4	20.0	-9.90	-4.50
16	Nurlu-99 × Layaqatli	8.3	7.0	10.3	24.09	4.07	18.3	20.4	24.0	17.64	4.42
17	Karabagh × Garagilciıg-2	9.2	10.2	8.0	-21.56	-3.40	19.4	20.4	22.4	9.80	5.01
18	Gobustan × Sheki-1	8.1	9.5	12.3	29.47	5.01	18.4	22.4	24.2	8.03	1.91
19	Vugar × Barakatli-95	9.5	10.1	15.4	52.47	8.33	21.4	19.4	22.4	4.67	2.00
20	Kyrmyzygul-1 × Tale-38	9.5	10.2	13.2	29.41	9.57	18.4	20.4	21.4	4.90	2.00
21	Barakatli-95 × Vugar	8.3	9.2	13.4	45.65	10.33	20.4	20.3	18.4	-9.80	-39.1
22	Karabagh × Tartar	8.3	9.2	11.1	20.65	5.22	22.4	18.6	20.4	-8.92	-0.05
23	Aran × Kyrmyzygul-1	9.2	10.3	8.2	-20.38	-2.81	22.2	20.4	24.4	9.90	3.75
24	Mirbashir-50 × Shiraslan-23	8.1	12.1	13.3	9.91	1.60	22.3	22.4	24.3	8.48	3.91

Note: *Each value represents the mean ±SD (standard deviation) for the mean n = 3 independent experiments p = 0.05, Het. (%): Heterosis over the better parent, Hp: Degree of dominance

(18.4) and Karabagh × Tartar (20.4). Nineteen out of 24 durum by bread wheat F_1 crosses revealed positive heterotic effects over better parents, ranging from 0.41% to 26.76%. The remaining five revealed negative heterosis, ranging from -0.40% to -9.90% (Table 1).

For spikelets per spike, the exhibited highest positive and same heterotic value (26.76%) was in two F_1 hybrids, Layaqatli × Mirbashir-128 and Kyzyl Bugda × Gunashli, followed by F_1 hybrid Nurlu-99 × Layaqatli (17.64%). Inversely, the highest negative heterotic effects over better parents were with three F_1 hybrids, viz., Daghdash × Murov (9.90%), Barakatli-95 × Vugar (9.80%), and Karabagh × Tartar (-8.92%). For spikelets per spike, in F_1 hybrids, the degree of dominance ranged from -39.1 to 7.21. The maximum positive degree of dominance resulted in F_1 hybrids Kyzyl Bugda × Gunashli (7.21), followed by Layaqatli × Mirbashir-128 (6.12), and Karabagh × Garagilciıg-2 (5.01). The same type of heterotic effects over mid- and better-parents and ratios of dominance showed for yield-related traits in various intraspecific hybrids of bread wheat (Fonseca, 1965; Omarov, 1975; Guliyev, 1993; Musayev *et al*., 2008), in durum wheat hybrids (Rustamov *et al*., 2017), and interspecific hybrids (Ozkan and Genj, 1998).

Grains per spike

Generally, for grains per spike, the F_1 hybrids ranged from 22 to 72 (Figure 2, Table 2). The recorded highest number of grains per spike was in the F_1 hybrid Sheki-1 × Gobustan (72), followed by the same number of grains per spike (71) in two F_1 hybrids, Barakatli-95 × Gobustan and Karabagh × Mirbashir-128. In contrast, the least number of grains per spike recorded was in two F_1 hybrids Bezostaya-1 × Kyrmyzygul-1 (22) and Karabagh × Gobustan (26). Twelve durum by bread wheat F_1 hybrids revealed better parents positive heterosis, ranging from 2.77% to 121.87%, while the other 12 enunciated negative heterobeltiosis, ranging from -8.57% to -59.37% (Table 2).

For grains per spike, the gathered highest positive heterosis over better parents was in the F_1 hybrid Karabagh × Mirbashir-128 (121.87%), followed by four F_1 hybrids, viz., Sheki-1 × Gobustan (50.00%) and its reciprocal, Gobustan × Sheki-1 (50.00%), Nurlu-99 × Layaqatli (47.61%), and Karabagh × Shark (43.24%). Contrastingly, the highest negative heterosis over better parents for grains per spike occurred in three F_1 hybrids, Karabagh × Gobustan (-59.37%), followed by Karabagh × Garagilciıg-2 (-45.00%), and the same heterotic value (-43.75%) in two others, Gobustan × Kyrmyzygul-1 and Gobustan × Karabagh. For grains per spike, the degree of dominance ranged from -5.00 to 40.2. The highest positive values of degree of dominance resulted in F_1 hybrids, Gobustan × Sheki-1 (40.2) and Karabagh × Mirbashir-128 (40.1), followed by F_1 hybrid Barakatli-95 × Gobustan (13.2). In past studies, the significant heterosis over mid- and better-parents and positive ratios of dominance also appeared for grains per spike and other yield-contributing parameters in wheat hybrids (Aliyev, 1982; Kihara, 1982; Aliyev and Akperov, 2002).

Grain weight per spike

Wholly, in F_1 hybrids the grain weight per spike ranged from 1.5 to 4.2 g (Figure 2, Table 2). The observed maximum grain weight per spike showed in F_1 hybrid Karabagh × Mirbashir-128 (4.2 g), followed by Tartar × Karabagh (3.5 g), Sheki-1 × Gobustan (3.5 g), Gobustan × Sheki-1 (3.1 g), Karabagh × Shark (2.9 g), and Karabagh × Garagilciıg-2 (2.9 g). However, exhibiting the least grain weight per spike was by the F_1 hybrids Bezostaya-1 × Kyrmyzygul-1, Karabagh × Gobustan, Gobustan × Kyrmyzygul-1, Layaqatli × Mirbashir-128, Kyrmyzygul-1 × Tale-38, and Aran × Kyrmyzygul-1 that ranged from 1.5 to 1.6 g. From 24 durum × bread wheat F_1 hybrids, eight revealed positive values for better parent heterosis, ranging from 3.33% to 162.51%. The rest expressed negative heterosis, ranging from -2.77% to -36.00% for grain weight per spike (Table 2).

For grain weight per spike, the recorded highest positive heterosis over better parents was in the F_1 hybrid Karabagh × Mirbashir-128 (162.51%), followed by two others, i.e., Sheki-1 × Gobustan and Nurlu-99 × Layaqatli with same heterotic effects (16.66%). However, the highest negative and same heterosis over better parents (-36.00%) resulted in three F_1 hybrids, Karabagh × Gobustan and Gobustan × Kyrmyzygul-1, followed by Karabagh × Tartar (-33%). For grain weight per spike, in F_1 hybrids the degree of dominance ranged from -0.20 to 18.01, with the highest positive values observed in F_1 hybrids, viz., Karabagh × Shark (18.01) and Gobustan × Karabagh (13.20). In wheat hybrids, the reported positive dominance values and heterotic effects also occurred for grain weight per spike and yield-related traits in past studies (Fonseca, 1965; Omarov, 1975; Guliyev, 1993).

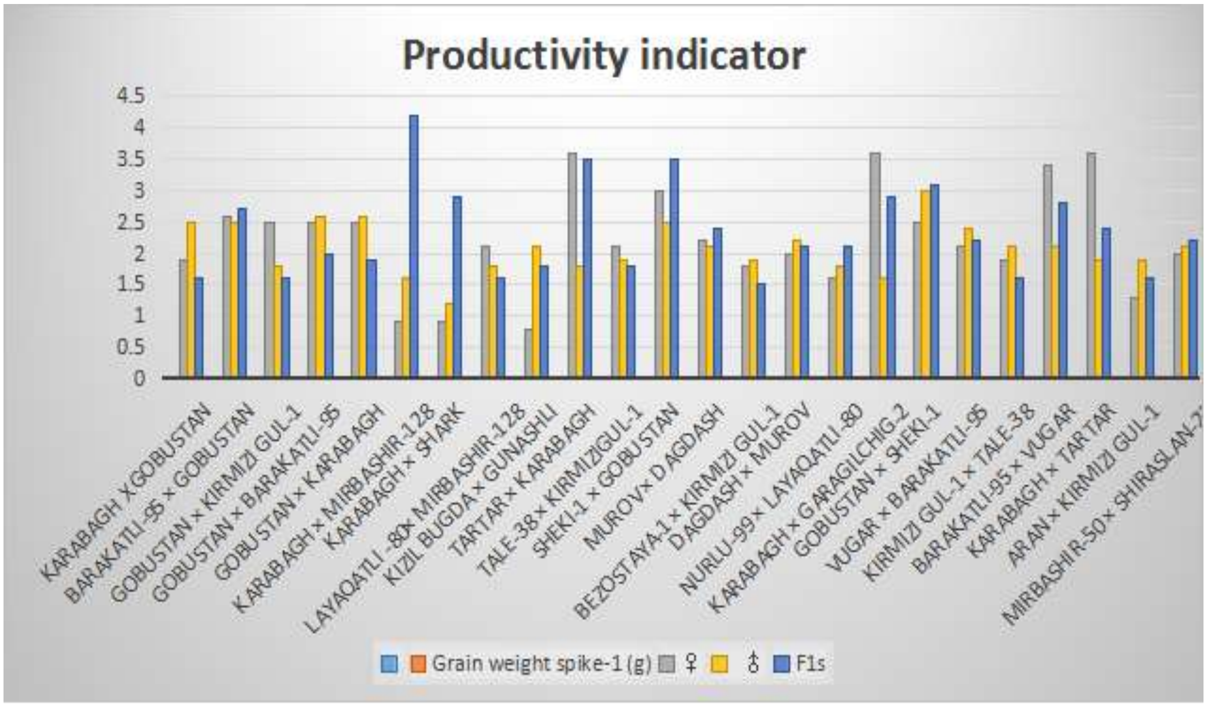

Figure 2. Comparative evaluation of durum and bread wheat cultivars and their F_1 hybrids for grain weight per spike.

Table 2. Inheritance of quantitative traits in the form of heterosis over better parents and degree of dominance in F_1 hybrids of durum and bread wheat.

No.	Cross Combinations	Grains spike^{-1}					Grain weight spike^{-1} (g)				
		♀	♂	F_1s	Het. (%)	Hp	♀	♂	F_1s	Het. (%)	Hp
1	Karabagh x Gobustan	30	64	26	-59.37	-1.23	1.9	2.5	1.6	-36.00	-0.53
2	Barakatli-95 × Gobustan	65	64	71	9.23	13.2	2.6	2.5	2.7	3.84	3.42
3	Gobustan × Kyrmyzygul-1	64	42	36	-43.75	-1.54	2.5	1.8	1.6	-36.00	0.64
4	Gobustan × Barakatli-95	64	53	65	1.56	1.18	2.5	2.6	2.0	-23.37	-11.12
5	Gobustan × Karabagh	64	30.1	36	-43.75	0.65	2.5	2.6	1.9	-26.92	13.20
6	Karabagh × Mirbashir-128	32	30.2	71	121.87	40.10	0.9	1.6	4.2	162.51	3.34
7	Karabagh × Shark	30	37	53	43.24	5.57	0.9	1.2	2.9	14.16	18.01
8	Layaqatli × Mirbashir-128	29	35	32	-8.57	0.00	2.1	1.8	1.6	-23.80	-2.33
9	Kızıl bugda × Gunashli	21	50	30	-40.00	-0.38	0.8	2.1	1.8	-14.20	0.53
10	Tartar × Karabagh	20	60.2	65	7.97	1.25	3.6	1.8	3.5	-2.77	1.46
11	Tale-38 × Kyrmyzygul-1	48	32	40	-16.66	0.00	2.1	1.9	1.8	-14.28	-2.21
12	Sheki-1 × Gobustan	45	28	72	50.00	2.20	3.0	2.5	3.5	16.66	3.31
13	Murov × Dagdash	36	34	36	0.00	1.00	2.2	2.1	2.4	9.09	0.25
14	Bezostaya-1 × Kyrmyzygul-1	25	32	22	31.25	-1.85	1.8	1.9	1.5	-21.05	-7.01
15	Dagdash × Murov	34	36	30	-16.66	-1.10	2.0	2.2	2.1	-4.54	0.00
16	Nurlu-99 × Layaqatli	42	29	44	47.61	1.30	1.6	1.8	2.1	16.66	1.31
17	Karabagh × Garagilciıg-2	60	42	33	-45.00	-2.00	3.6	1.6	2.9	-19.44	0.31
18	Gobustan × Sheki-1	28	42	63	50.00	40.20	2.5	3.0	3.1	3.33	-1.01
19	Vugar × Barakatli-95	34	32	28	-17.64	-5.00	2.1	2.4	2.2	-8.33	0.83
20	Kyrmyzygul-1 × Tale-38	32	38	32	-15.78	-1.40	1.9	2.1	1.6	-23.80	-4.0
21	Barakatli-95 × Vugar	32	30	28	-12.50	-3.00	3.4	2.1	2.8	-17.64	0.07
22	Karabagh × Tartar	60	24	34	-43.30	0.62	3.6	1.9	2.4	-33.33	-0.41
23	Aran × Kyrmyzygul-1	32	28	34	6.25	2.00	1.3	1.9	1.6	-15.78	-0.20
24	Mirbashir-50 × Shiraslan-23	35	36	37	2.77	0.42	2.0	2.1	2.2	4.76	3.20

Note: *Each value represents the mean ±SD (standard deviation) for the mean n = 3 independent experiments p = 0.05, Het. (%): Heterosis over the better parent, Hp: Degree of dominance

CONCLUSIONS

The heterotic and dominance analysis of the spike-related traits in the interspecific hybridization of durum and bread wheat helped identify the best sources for these important yield traits and select the most valuable and desirable F_1 hybrids. In assessing 24 F_1 interspecific cross combinations of durum and bread, obtaining the desirable positive heterosis over better parents and dominance values resulted from cross combinations, i.e., Barakatli-95 × Gobustan, Garabagh × Mirbashir-128, Garabagh × Shark, Sheki-1 × Gobustan, Murov × Dagdash, Nurlu -99 × Layagatli-80, Gobustan × Sheki-1, and Mirbashir-50 × Shiraslan-23. However, the F_1 hybrid Garabagh × Gobustan displayed negative effects of heterosis and depression. The above promising interspecific F_1 hybrids can benefit future breeding programs.

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