**Estimation of Heterotic Performance and Inbreeding Depression for grain yield and**

**contributing traits in bread wheat (*Triticum aestivum* L.)**

**ABSTRACT**

In breeding programme for the development of wheat varieties, indigenous, exotic and wild species germplasms are the backbone of successful breeding programme for improving yield and yield contributing characters. The experimental material comprised of 10 diverse wheat cultivars *viz.,* DBW 88, K 9006, DBW 187, WH 1142, HI 1563, HD 3326, K 9423, K 1317, KRL 210 and KRL 19. These cultivars were cultivated in a randomized block design (RBD) with three replications at the Student Instruction Farm, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, during the Rabi season of 2022-23. Geographically, this place is located between 250 28’ and 260 58’ N latitude, 790 31’ and 800 34’ E longitudes and an altitude of 125.9 m above from mean sea level. This falls in sub-tropical climatic zone. The soil type is sandy loam. The climate of district Kanpur is semiarid with hot summer and cold winter. Each parent and F1 were planted in single row while each F2 was planted in two rows of three meter length with inter and intra-row spacing of 22.5 cm and 10 cm, respectively. The recommended agricultural practices and techniques were followed to ensure proper crop growth. Recommended cultural practices were applied to raise good crop. The minimum and maximum value of economic heterosis for grain yield per plant varied from -36.53 to 16.31 (HI 1563 x K 9423 to DBW 187 x K 1317) per cent. Eight crosses showed positive and significant heterosis, out of these, five in order of merits were, DBW 187 x K 1317, DBW 88 x DBW 187, K 1317 x KRL 210, DBW 187 x KRL 19 and DBW 187 x HI 1563. Grain yield per plant noted inbreeding depression from -0.10 to 19.24 (DBW 187 x KRL 210 to K 9423 x KRL 19) per cent. 31 crosses observed positive and significant while 14 crosses observed positive and non-significant inbreeding depression.

***Keywords:*** *Heterotic performance; bread wheat; inbreeding depression; grain yield.* **INTRODUCTION**

Wheat is the staple food crop of about two billion people (36% of the world population) and an important commodity on the world grain commerce. The wheat grown in India is a spring variety of the *Triticum aestivum* species (bread wheat). Wheat is higher in nutrients than other cereals. It has a strong nutritional profile, with 12.1% protein, 1.8 percent lipids, 1.8 percent ash, 2.0 percent reducing sugars, 6.7 percent pentosans, 59.2% starch, and 70% total carbohydrates, and 314 calories per 100 gram of food. Calcium (37 mg/100g), iron (4.1 mg/100g), thiamine (0.45 mg/100g), riboflavin (0.13 mg/100g), and nicotinic acid (5.4 mg/100mg) are all good sources of minerals and vitamins. It is consumed a variety of ways such as bread, chapatti, porridge, flour and suji *etc*. and has relatively higher content of niacin and thiamine which are principally concerned in providing the special protein called ‘Glutin’. Wheat proteins are of special significance because glutin provides the framework of spongy cellular texture of bread and baked products. India`s share in world wheat area is about 12.5%, whereas it also contributes 12% in total world wheat production. In India, wheat crop is cultivated to an area of 31.83 million hectares and production amounting to 113.29 million tons with productivity of 35.59 q ha-1 (IIW&BR, 2023). Wheat is largely grown in Indian states *like* Uttar Pradesh, Madhya Pradesh, Punjab, Haryana, Rajasthan, Bihar, Gujarat, Maharashtra, West Bengal, Uttarakhand and Himanchal Pradesh. These states contribute about 98% of total wheat production in the country and play an appreciable role of supplying carbohydrates, proteins and minerals. Uttar Pradesh ranks first with an area of 9.85 million hectare and production of 35.51 million tonnes with an average productivity of 36.04 (q ha-1). Punjab state has achieved the productivity level of 48.68 q ha-1 (Agricultural statistics at a glance 2022).

In breeding programme for development of wheat varieties, indigenous, exotic and wild species germplasms are the backbone of successful breeding programme for improving yield and yield contributing characters. The nature always favours the plant populations having much variability in terms of adaptation across the years and locations. It is true that greater plant diversity provides more diverse plants, greater chance of obtaining high heterotic crosses and broad spectrum of variability in segregating generation during genetic improvement. Various biometrical tools help plant breeders in ascertaining the information explained above for a successful breeding programme. Diallel cross technique, line x tester and partial cross technique are used in breeding programme. Diallel analysis has been widely used because it provides maximum genetic information, which is helpful in formulation of effective breeding programme. Diallel mating system studies the parental material by all mean particularly in term of genetic component of variance for different characters, general and specific combining ability, gene effects, heterosis, inbreeding depression, heritability, genetic advance and other useful parameters. In addition, this study is also helpful in developing high yielding varieties coupled with better quality.

In the analysis of combining ability, one of the objectives is to identify the best parent/cross combination and these objectives fulfil by exploitation of heterosis. The exploitation of heterosis is a milestone innovation in modern agriculture and it is considered to be one of the pillars of global food security. In a self-pollinated crop like wheat, the utilization of heterosis depends mainly upon the direction and magnitude of heterosis. The study of heterosis and inbreeding depression has a direct impact on the breeding methods used for varietal improvement. Heterosis which is measured as the mean superiority of F1 mid parent, over better and economic parent is thus, an important parameter in such studies. It is the allelic or non-allelic interaction of genes under the influence of specific environment. Heterosis breeding has come to play a pivotal role in crop improvement programme for obtaining higher production. The first important step in the exploitation of heterosis is to know its magnitude and direction. Hybrid vigour has not largely been exploited in self-pollinated crops like wheat or often cross-pollinated ones, due to non-availability of stable male sterile line on commercial scale. However, heterosis as a mean of increasing productivity has been an object of considerable study in wheat. The estimates of heterosis over F1 hybrids in real sense, decides whether. Though, the production (Briggle, 1963), yet the practical approach of this concept needs further exploration and perfection (Willson, 1967). Bailey *et al* 1980 observed that F2 performance was a good indication of predicting F2 hybrids in wheat with this objective inbreeding depression in F2 generation has also been studied. The present study has been carried out to estimate the heterosis (%) over mid parent, better parent, economic parent and inbreeding depression for quantitative and qualitative traits in a 10 x 10 diallel set in bread wheat to identify parental lines that could be used for commercial production of hybrid wheat as well as isolation of pure lines among the progenies of heterotic F1 for further amelioration of grain yield in bread wheat.

**MATERIALS AND METHODS**

The basic material for the present investigation comprised of ten parental lines viz., DBW 88, K 9006, DBW 187, WH 1142, HI 1563, HD 3326, K 9423, K 1317, KRL 210 and KRL 19. These parental lines were crossed to develop 45 F1s and F2s using half diallel mating design. A total of 100 treatments (10 parents + 45 F1s + 45 F2s) were evaluated for the study of genetically analysis for fourteen quantitative characters in wheat. During Rabi 2020-21, all possible single crosses excluding reciprocals were made among the 10 widely diversed selected genotypes in order to complete a 10 parental diallel set. More than 100 seeds of each cross were produced, resultant seeds of 45 hybrids and parental genotypes were harvested separately. During Rabi season 2022-23, ten parents, 45 F1s and 45 F2s were sown on 25 November, 2022 in Randomized Block Design (RBD) with three replications at Student Instruction Farm, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, (U.P.). Each parent and F1 were planted in single row while each F2 was planted in two rows of three-meter length with inter and intra-row spacing of 22.5 cm and 10 cm, respectively. Recommended cultural practices were applied to raise good crop. Observations were recorded on plot basis for days to 75% flowering and days to maturity while plant height, number of effective tillers per plant, spike length, number of spikelets per spike, number of grains per spike, Biological yield per plant, grain weight per spike, grain yield per plant, 1000-grain weight, Harvest index, Protein content and Seed hardness were recorded on 5 randomly selected plants for parents, 45 f1’sand 45 F2’s plants. The term heterosis, first coined by shull (1914), refers to the phenomenon in which the F1, population obtained by crossing of the two genetically dissimilar gametes or individuals show increased or decreased vigour over the better parent or over the mid-parental value. Jinks (1955) considered that non-allelic interactions might be a cause of heterosis rather than special relation between the genes at the same lines. Mather (1955) suggested heterosis to be an expression of the additive, dominance and interaction of homozygous/ homozygous and homozygous/ heterozygous components as well as on the distribution of genes in the parental lines. The term useful heterosis was used by Meredith and Bridge (1972). It refers to the superiority of F1 over the standard commercial check variety. It is also called as economic heterosis. This type of heterosis is of direct practical value in plant breeding. Inbreeding depression refers to decrease in fitness and vigour due to inbreeding. The degree of inbreeding is measured by the inbreeding coefficient. Heterosis leads to increase in yield, reproductive ability, adaptability, disease and insect resistance, general vigour, quality, but for some traits for earliness, height in cereals, micronaire value in cotton and toxic substance like neurotoxin in *Lathyrus sativus,* *etc.* negative heterosis is important.

**RESULT AND DISCUSSION**

Heterosis was calculated per cent over economic parents in F1s and inbreeding depression in F2s for all the fourteen characters. Estimates of heterosis and inbreeding depression are presented in (Table-1). Negative and significant values of heterosis were considered desirable for days to 75% flowering, days to maturity and plant height. On the other hand, positive and significant values were considered desirable for other characters.

**Days 75% flowering:**

The observed heterosis over economic parent for days to 75% flowering ranged between 11.51 to -13.57 (HD 3326 x KRL 19 to HI 1563 to K 9423) per cent. 31 crosses showed positive and significant while 2 were showed positive and non-significant. 10 crosses showed negative and significant while 2 were showed negative and non-significant. 10 combinations were containing negative and significant heterosis for earliness, out of these, five in order of merits were, HI 1563 × K 9423, K 9006 × K 9423, DBW 187 × K 9423, DBW 88 × HI 1563 and WH 1142 × K 9423. Inbreeding depression for days to flower (75%) ranged from 7.04 to - 6.02 (DBW 88 x WH 1142 to HD 3326 x K 1317). Out of 45 crosses, 16 crosses showed positive and significant while 10 was showed positive and non-significant. 19 cross showed negative and significant, namely top five crosses HD 3326 x K 1317, K 9423 x K 1317 DBW 187 x HI 1563, DBW 88 x K 9423 and K 9006 x HI 1563 while no any found for negative and non-significant.

**Days to maturity:**

The estimated heterosis over economic parent for days to maturity varied from -6.43 to 8.45 (HI 1563 x K 9423 to K 9006 x WH 1142) per cent. 26 crosses observed positive and significant while 10 crosses observed negative and significant heterosis. 7 crosses witnessed positive and non significant while 2 crosses were negative and non-significant heterosis in out of 45 crosses for economic heterosis. Desirable and significant heterosis for 10 crosses, out of these, five in order of merits were, HI 1563 × K 9423, DBW 187 × K 9423, DBW 88 × K 9423, K 9423 × K 1317 , DBW 187 X HI 1563. Inbreeding depression for days to maturity ranged from -5.39 to 4.27 (DBW 88 x DBW 187 to DBW 88 x KRL 210) per cent. 13 crosses observed positive and significant whereas 4 crosses observed positive and non-significant for inbreeding depression. 2 crosses observed negative and non-significant while 26 crosses observed desirable negative and significant inbreeding depression, out of these, five in order of merits were, DBW 88 × DBW 187, DBW 88 × HI 1563, HI 1563 × HD 3326, K 9006 × KRL 210 and DBW 88 × K 9423.

**Plant height:**

Heterosis over economic parent for plant height varied from -13.87 to 1.43 (K 9006 x KRL 210 to DBW 88 x WH 1142) per cent. Negative and significant heterosis recorded for 25 crosses. Positive and non-significant were receded for one cross whereas negative and non-significant 96 observed for 19 crosses. Heterosis over economic parent showed desirable and significant heterosis for 25 crosses, out of these, five in order of merits were, K 9006 × KRL 210, HI 1563 × KRL 19, KRL 210 × KRL 19, K 9423 × KRL 210 and WH 1142 × KRL 210. Inbreeding depression for plant height varied from -7.17 to 11.96 (HD 3326 x KRL 19 to DBW 187 x KRL 210) per cent. 7 crosses estimated positive significant while 10 crosses negative significant for inbreeding depression. 7 cross positive non-significant and 21 crosses negative non significant was recorded for inbreeding depression. Among 10 crosses observe negative significant inbreeding depression, five in order of merits were, HD 3326 × KRL 19, K 9006 × KRL 19, WH 1142 × KRL 210, WH 1142 × K 9423 and HI 1563 × K 9423.

**Number of effective tillers per plant:**

The minimum to maximum value of heterosis over economic parent for number of productive tiller plant-1 varied from -33.33 to 10.42 (K 9006 x KRL 210 to DBW 187 x KRL 210) per cent. In case of economic parent, positive significant observed in 4 crosses while negative significant recorded in 34 crosses. Positive non-significant observed in 5 crosses while negative non significant observed in 2 cross. Out of 45, 4 crosses namely, DBW 187 x KRL 210, DBW 187 x K 1317, DBW 187 x HD 3326 and DBW 88 x DBW 187 recorded for significant economic heterosis.The magnitude of inbreeding depression for number of productive tiller plant-1 ranged from - 4.83 to 13.79 (K 1317 × KRL 19 to K 9423 × KRL 19) per cent. Positive significant observed for 11 crosses while Positive and non-significant observed for 29 crosses. Negative and non-significant observed for 4 while no anyone cross recorded for negative and significant inbreeding depression. Out of 45, 4 crosses observed positive and non-significant economic heterosis, among these, order of merits, were, K 1317 × KRL 19 and DBW 187 × KRL 19.

**Spike length:**

The minimum to maximum value of heterosis over economic parent for spike length varied from -26.03 to 13.73 (WH 1142 x K 9423 to K 9006 x DBW 187) per cent. Positive and significant heterosis were estimated in 2 crosses, namely, K 9006 x DBW 187 and K 9006 x K 9423 while positive non-significant values were observed in 9 crosses. Negative significant values recorded in 29 crosses while negative non-significant values recorded in 5 crosses out of 45 crosses.The range of inbreeding depression for spike length varied from -28.81 to 13.37 (HD 3326 x KRL 210 to K 9423 × KRL 19) per cent. Among the positive inbreeding depression, 7 recorded significant; while 17 was non-significant. Similarly for negative inbreeding depression, 12 crosses recorded significant, namely, HD 3326 × KRL 210, DBW 88 × KRL 19, HI 1563 × K 9423, DBW 88 x K 9423 and K 9423 x KRL 210 whereas 9 crosses recorded non-significant.

**Number of spikelets per spike:**

The extent of heterosis over economic parent for number of spikelets spike-1 ranged from - 19.12 to -1.59 (HI 1563 x HD 3326 to K 9423 x K 1317) per cent. No anyone cross observed for positive significant and positive non-significant economic heterosis. 33 crosses showed negative significant while 12 crosses showed negative non-significant. The lowest to highest magnitude of inbreeding depression varied from -9.90 to 11.88 (K 9006 x DBW 187 to DBW 187 x K 9423) per cent. 4 crosses showed positive and significant value while 29 showed positive and non-significant value. Negative and significant were recorded in 2 while 9 crosses showed negative and non-significant value, out of these order of merits were, K 9006 x DBW 187, K 1317 x KRL 19.

**Number of grains per spike:**

The heterosis over economic parent for number of grains spike-1 ranged from -20.17 to 8.99 (WH 1142 x KRL 19 to DBW 187 x KRL 210) per cent. Positive and significant heterosis were observed in 4 crosses, viz., DBW 187 x KRL 210, DBW 187 x KRL 19, DBW 187 x K 1317 and DBW 187 x HD 3326 while 3 crosses showed positive and non-significant. Thirteen 32 showed negative and significant heterosis while 6 crosses showed negative and non-significant heterosis. Number of grains spike-1 indicated inbreeding depression from -16.13 to 14.81 (K 9006 x DBW 187 to DBW 187 x K 1317) per cent. Out of 45 crosses, 4 crosses showed positive and significant while 26 crosses showed positive and non-significant inbreeding depression. 9 cross showed negative and non-significant inbreeding depression while negative significant was recorded in 6 crosses, out of these, five in order of merits viz., K 9006 × DBW 187, K 9006 x WH 1142, WH 1142 x K 9423, K 1317 x KRL 19 and HI 1563 x K 9423 for inbreeding depression.

**Grain weight per spike:**

The heterosis over economic parent for grain weight spike-1 ranged from -15.01 to 11.47 (K 9423 x K 1317 to DBW 187 x KRL 19) per cent. Positive and significant heterosis were observed 100 in 6 crosses, top five crosses viz., DBW 187 x KRL 19, K 1317 x KRL 210, K 1317 x KRL 19, DBW 88 x DBW 187 and DBW 187 x HI 1563 while 5 crosses showed positive and non-significant. Thirteen 13 showed negative and significant heterosis while 21 crosses showed negative and non-significant heterosis. Grain weight spike-1 indicated inbreeding depression from -5.83 to 18.66 (DBW 187 x KRL 210 to K 9006 x KRL 19) per cent. Out of 45 crosses, 14 crosses showed positive and significant while 26 crosses showed positive and non-significant inbreeding depression. 5 cross showed negative and non-significant inbreeding depression while negative significant crosses not found.

**Biological yield per plant:**

Heterosis over economic parent for biological yield plant-1 ranged between -30.68 (HI 1563 x K 9423) to 16.28 (DBW 187 x K 1317) per cent. Significant and positive heterosis were observed in 8 crosses, out of these, five in order of merits were, DBW 187 × K 1317, DBW 187 × HI 1563, K 1317 × KRL 19, DBW 187 × KRL 19 and DBW 88 × DBW 187. Negative and significant value was recorded in 34 crosses while negative and non-significant values were observed in 3 crosses for economic heterosis. Inbreeding depression for biological yield plant-1 varied from -4.80 to 29.07 (HI 1563 x KRL 19 to HD 3326 x KRL 210) per cent. Out of 45 crosses, Positive and non-significant in 22 crosses while negative and non-significant in 3 crosses out of these, order of merits viz., K 9006 × K 9423, WH 1142 x K 9423, for inbreeding depression while no anyone recorded for negative significant crosses.

**1000-grain weight:**

The lowest to highest value of heterosis over economic parent for 1000 grain weight ranged from -8.63 to 5.63 (WH 1142 x KRL 19 to DBW 187 x K 1317) per cent. DBW 187 x K 1317 was estimated significant and positive while 22 crosses estimated significant and negative heterosis over economic parent. Non-significant and positive was observed in 4 crosses while Non-significant and negative was observed in 18 crosses. 1000 grain weight indicated inbreeding depression from -1.91 to 13.89 (DBW 187 x KRL 19 to K 9006 x HI 1563) per cent. In case of inbreeding depression, positive and significant value was observed in 10 crosses while positive and non-significant value was observed in 29 crosses. 102 Negative and significant cross was not found while negative and non-significant recorded for 6 crosses namely, DBW 187 x KRL 19 and DBW 187 x WH 1142.

**Harvest index:**

The extreme of heterosis over economic parent for harvest index ranged from -20.05 to 1.65 (HD 3326 x KRL 210 to DBW 88 x K 9423) per cent. Positive significant heterosis value was not found while 5 crosses were recorded non-significant. Similarly for negative inbreeding depression, 32 crosses recorded significant and 8 crosses recorded non-significant. The magnitude of harvest index indicated inbreeding depression from -27.36 to 15.20 (HD 3326 x KRL 210 to HI 1563 x K 9423) per cent. In case of inbreeding depression, positive and significant value was observed in 10 crosses while positive and non-significant value observed in 16 crosses. Negative and significant value was recorded in 6 crosses, out of these, order of merits were, HD 3326 x KRL 210, HI 1563 x KRL 210, DBW 88 x WH 1142, HD 3326 x K 9423 and HD 3326 x K 1317 while negative and non-significant value was recorded in 13 crosses.

**Seed hardness:**

Estimated heterosis over economic parent for seed hardness varied from -7.21 (K 9006 x K 9423) to 47.04 (HI 1563 x KRL 210) per cent. Significant and positive economic heterosis were estimated in 17 nine crosses, out of these, five in order of merits were, HI 1563 × KRL 210, DBW 88 × K 1317, DBW 187 × HI 1563, DBW 187 × K 1317 and K 9423 × K 1317 while significant and negative economic heterosis cross was not recorded. Positive and non-significant heterosis was observed in 18 crosses whereas 10 crosses were recorded negative and non-significant. Seed hardness indicated inbreeding depression ranged from -46.09 to 30.35 (DBW 187 x K 9423 to DBW 187 x HI 1563) per cent. In case of inbreeding depression, positive and significant was observed in 5 crosses while negative and significant was observed in 24 crosses, out of these, five in order of merits were, DBW 187 x K 9423, HD 3326 x K 1317, WH 1142 x K 9423, K 9006 x K 9423 and WH 1142 x K 1317 while 8 crosses were recorded for negative and non-significant while positive and non significant was observed in 8 crosses.

**Protein content:**

The minimum to maximum heterosis over economic parent for protein content varied from - 9.64 (HD 3326 x KRL 19) to 7.21 (DBW 88 x K 9006) per cent. Positive and significant economic heterosis was recorded in 5 crosses, five in order of merits were, DBW 88 x K 9006, DBW 88 x 104 DBW 187, K9006 x DBW 187, K 9006 x KRL 210 and K 9006 x K 1317 whereas 7 crosses negative and significant economic heterosis was estimated. 12 crosses showed positive and non significant whereas 21 crosses showed negative and non-significant. Inbreeding depression for protein content varied from -16.48 (HD 3326 x KRL 19) to 8.25 (DBW 88 x K 9423) per cent. Positive and significant showed in 8 crosses while positive and non significant showed in 24 crosses were recorded inbreeding depression. Negative and significant were recorded for single cross, viz., HD 3326 x KRL 19 while negative and non-significant were recorded in 12 crosses for inbreeding depression.

**Grain yield per plant:**

The minimum and maximum value of economic heterosis for grain yield plant-1 varied from -36.53 to 16.31 (HI 1563 x K 9423 to DBW 187 x K 1317) per cent. 8 crosses showed positive and significant heterosis, out of these, five in order of merits were, DBW 187 x K 1317, DBW 88 x DBW 187, K 1317 x KRL 210, DBW 187 x KRL 19 and DBW 187 x HI 1563 while 37 crosses showed negative and significant; no any crosses found positive or negative and non significant in economic heterosis for grain yield per plant. Grain yield plant-1 noted inbreeding depression from -0.10 to 19.24 (DBW 187 x KRL 210 to K 9423 x KRL 19) per cent. 31 crosses observed positive and significant while 14 crosses observed positive and non-significant inbreeding depression. No any cross found for negative and significant or negative and non-significant for grain yield plant-1.

HI 1563 × K 9423 and DBW 187 × K 9423, exhibited significant negative heterosis over economic parent for the traits like days to 75% flowering, day to maturity, Plant height and Grain yield per plant (Table 1). This two cross could be used for developing early maturity and short statured hybrids. DBW 88 x DBW 187, exhibited significant positive heterosis over economic parent for the traits *like* Protein contain, Biological yield, grain weight per spike, No. of grain per spike and no. of productive tiller per plant; DBW 187 x K 13174, exhibited significant positive heterosis over economic parent for the traits like Biological yield, grain weight per spike, No. of grain per spike and no. of productive tiller per plant; DBW 187 x KRL 19 and DBW 187 x HI 1563,exhibited significant positive heterosis over economic parent for the traits like Seed hardness, Biological yield, grain weight per spike and No. of grain per spike (Table 1). This cross could be used for developing height yielding verities and as a parent in crop improvements. Similar finding also observed by Upadhyay *et al.* (2017), Saren *et al.* (2018) and Nagar *et al.* (2019).

**Table-1: Estimation of heterosis over economic parent and inbreeding depression in percent with mean for 14 characters in a 10 parent diallel cross in wheat (*Triticum aestivum* L.).**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S.**  **No.** | **Crosses** | **Days to 75% flowering** | | | | **Days to maturity** | | | |
| **F1 Mean** | **EP** | **F2 Mean** | **ID** | **F1 Mean** | **EP** | **F2 Mean** | **ID** |
| **1** | DBW 88 × K 9006 | 87.07 | 7.40 \*\* | 84.53 | 2.91\* | 128.20 | 7.55 \*\* | 131.40 | -2.5\*\* |
| **2** | DBW 88 × DBW 187 | 85.13 | 5.02 \*\* | 87.67 | -2.98\* | 121.20 | 1.68 \* | 127.73 | -5.39\*\* |
| **3** | DBW 88 × WH 1142 | 89.00 | 9.79 \*\* | 82.73 | 7.04\*\* | 125.60 | 5.37 \*\* | 122.20 | 2.71\*\* |
| **4** | DBW 88 × HI 1563 | 73.73 | -9.05 \*\* | 72.73 | 1.36 | 117.27 | -1.62 \* | 122.80 | -4.72\*\* |
| **5** | DBW 88 × HD 3326 | 87.20 | 7.57 \*\* | 84.53 | 3.06\* | 127.33 | 6.82 \*\* | 129.33 | -1.57\* |
| **6** | DBW 88 × K 9423 | 79.40 | -2.06 \* | 83.53 | -5.21\*\* | 114.33 | -4.08 \*\* | 119.20 | -4.26\*\* |
| **7** | DBW 88 × K 1317 | 83.60 | 3.12 \*\* | 86.40 | -3.35\*\* | 121.53 | 1.95 \*\* | 118.40 | 2.58\*\* |
| **8** | DBW 88 × KRL 210 | 90.20 | 11.27 \*\* | 88.47 | 1.92 | 126.60 | 6.21 \*\* | 121.20 | 4.27\*\* |
| **9** | DBW 88 × KRL 19 | 89.33 | 10.20 \*\* | 91.53 | -2.46\* | 127.40 | 6.88 \*\* | 129.33 | -1.52\* |
| **10** | K 9006 × DBW 187 | 83.27 | 2.72 \*\* | 80.40 | 3.44\*\* | 123.47 | 3.58 \*\* | 120.20 | 2.65\*\* |
| **11** | K 9006 × WH 1142 | 89.40 | 10.28 \*\* | 91.47 | -2.31\* | 129.27 | 8.45 \*\* | 126.47 | 2.17\* |
| **12** | K 9006 × HI 1563 | 76.67 | -5.43 \*\* | 79.80 | -4.09\*\* | 119.20 | 0.01 | 124.07 | -4.08\*\* |
| **13** | K 9006 × HD 3326 | 85.27 | 5.18 \*\* | 82.20 | 3.6\*\* | 123.47 | 3.58 \*\* | 120.67 | 2.27\*\* |
| **14** | K 9006 × K 9423 | 71.40 | -11.92 \*\* | 74.40 | -4.2\*\* | 116.47 | -2.29 \*\* | 121.00 | -3.89\*\* |
| **15** | K 9006 × K 1317 | 85.27 | 5.18 \*\* | 89.07 | -4.46\*\* | 123.27 | 3.41 \*\* | 127.27 | -3.24\*\* |
| **16** | K 9006 × KRL 210 | 89.20 | 10.03 \*\* | 88.47 | 0.82 | 123.40 | 3.52 \*\* | 128.73 | -4.32\*\* |
| **17** | K 9006 × KRL 19 | 85.60 | 5.59 \*\* | 82.47 | 3.66\*\* | 125.47 | 5.26 \*\* | 127.40 | -1.54\* |
| **18** | DBW 187 × WH 1142 | 85.20 | 5.10 \*\* | 82.47 | 3.21\* | 123.47 | 3.58 \*\* | 127.40 | -3.19\*\* |
| **19** | DBW 187 × HI 1563 | 78.33 | -3.38 \*\* | 82.47 | -5.28\*\* | 115.53 | -3.08 \*\* | 119.40 | -3.35\*\* |
| **20** | DBW 187 × HD 3326 | 83.73 | 3.28\*\* | 80.27 | 4.14\*\* | 125.07 | 4.92 \*\* | 123.53 | 1.23 |
| **21** | DBW 187 × K 9423 | 73.40 | -9.46 \*\* | 71.20 | 3.00\* | 112.87 | -5.31 \*\* | 113.27 | -0.35 |
| **22** | DBW 187 × K 1317 | 86.07 | 6.17 \*\* | 82.47 | 4.18\*\* | 120.47 | 1.06 | 117.53 | 2.43\*\* |
| **23** | DBW 187 × KRL210 | 85.20 | 5.10 \*\* | 84.33 | 1.02 | 119.47 | 0.22 | 122.40 | -2.46\*\* |
| **24** | DBW 187 × KRL 19 | 88.20 | 8.80 \*\* | 90.40 | -2.49\* | 120.47 | 1.06 | 123.53 | -2.55\*\* |
| **25** | WH 1142 × HI 1563 | 80.07 | -1.23 | 77.80 | 2.83\*\* | 118.27 | -0.78 | 118.27 | 0.00 |
| **26** | WH 1142 × HD 3326 | 90.40 | 11.51 \*\* | 89.87 | 0.59 | 128.27 | 7.61 \*\* | 124.40 | 3.01\*\* |
| **27** | WH 1142 × K 9423 | 76.00 | -6.25 \*\* | 73.27 | 3.60 | 117.40 | -1.51 \* | 116.53 | 0.74 |
| **28** | WH 1142 × K 1317 | 86.27 | 6.41 \*\* | 89.27 | -3.48\*\* | 124.60 | 4.53 \*\* | 126.93 | -1.87\* |
| **29** | WH 1142 × KRL 210 | 85.40 | 5.35 \*\* | 89.40 | -4.68\*\* | 125.47 | 5.26 \*\* | 127.53 | -1.65\* |
| **30** | WH 1142 × KRL 19 | 85.27 | 5.18 \*\* | 87.20 | -2.27\* | 123.27 | 3.41 \*\* | 128.40 | -4.16\*\* |
| **31** | HI 1563 × HD 3326 | 82.73 | 2.06 \* | 85.73 | -3.63\*\* | 117.07 | -1.79 \* | 122.40 | -4.56\*\* |
| **32** | HI 1563 × K 9423 | 70.07 | -13.57 \*\* | 72.20 | -3.04\* | 111.53 | -6.43 \*\* | 114.93 | -3.05\*\* |
| **33** | HI 1563 × K 1317 | 84.60 | 4.36 \*\* | 82.60 | 2.36\* | 116.53 | -2.24 \*\* | 120.53 | -3.43\*\* |
| **34** | HI 1563 × KRL 210 | 82.27 | 1.48 | 80.87 | 1.70 | 119.27 | 0.06 | 122.47 | -2.68\*\* |
| **35** | HI 1563 × KRL 19 | 83.53 | 3.04 \*\* | 81.53 | 2.39\* | 122.27 | 2.57 \*\* | 120.27 | 1.64\* |
| **36** | HD 3326 × K 9423 | 79.20 | -2.30 \* | 78.47 | 0.93 | 119.40 | 0.17 | 116.40 | 2.51\*\* |
| **37** | HD 3326 × K 1317 | 85.27 | 5.18 \*\* | 90.40 | -6.02\*\* | 121.33 | 1.79 \* | 118.40 | 2.42\*\* |
| **38** | HD 3326 × KRL 210 | 89.40 | 10.28 \*\* | 87.20 | 2.46\* | 127.07 | 6.60 \*\* | 130.87 | -2.99\*\* |
| **39** | HD 3326 × KRL 19 | 90.40 | 11.51 \*\* | 87.20 | 3.54\*\* | 128.47 | 7.77 \*\* | 126.80 | 1.30 |
| **40** | K 9423 × K 1317 | 77.87 | -3.94 \*\* | 82.27 | -5.65\*\* | 115.27 | -3.30 \*\* | 119.60 | -3.76\*\* |
| **41** | K 9423 × KRL 210 | 81.40 | 0.41 | 84.13 | -3.36\*\* | 118.07 | -0.95 | 116.40 | 1.41\* |
| **42** | K 9423 × KRL 19 | 80.27 | -0.99 | 78.80 | 1.83 | 121.53 | 1.96 \*\* | 118.27 | 2.69\*\* |
| **43** | K 1317 × KRL 210 | 85.40 | 5.35 \*\* | 85.07 | 0.39 | 120.53 | 1.12 | 123.40 | -2.38\*\* |
| **44** | K 1317 × KRL 19 | 88.20 | 8.80 \*\* | 90.40 | -2.49\* | 124.53 | 4.47 \*\* | 125.87 | -1.07 |
| **45** | KRL 210 × KRL 19 | 84.40 | 4.11 \*\* | 82.47 | 2.29\* | 126.93 | 6.49 \*\* | 129.27 | -1.84\* |
|  | **SE±** |  | 0.82 |  | 0.66 |  | 0.72 |  | 0.75 |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S.**  **No.** | **Crosses** | **Plant height (cm)** | | | | **No. of effective tillers per plant** | | | |
| **F1 Mean** | **EP** | **F2 Mean** | **ID** | **F1 Mean** | **EP** | **F2 Mean** | **ID** |
| **1** | DBW 88 × K 9006 | 93.08 | -0.43 | 94.43 | -1.45 | 7.73 | -19.47 \*\* | 7.00 | 9.48\*\* |
| **2** | DBW 88 × DBW 187 | 89.91 | -3.82 | 87.90 | 2.23 | 10.20 | 6.25 \* | 9.47 | 7.19\* |
| **3** | DBW 88 × WH 1142 | 94.82 | 1.43 | 91.06 | 3.97\* | 7.93 | -17.40 \*\* | 7.60 | 4.20 |
| **4** | DBW 88 × HI 1563 | 90.00 | -3.73 | 92.20 | -2.45 | 7.73 | -19.48 \*\* | 7.60 | 1.72 |
| **5** | DBW 88 × HD 3326 | 89.07 | -4.72 \* | 83.76 | 5.96\*\* | 8.20 | -14.58 \*\* | 7.20 | 12.20\*\* |
| **6** | DBW 88 × K 9423 | 87.36 | -6.55 \*\* | 90.55 | -3.64\* | 7.00 | -27.08 \*\* | 7.07 | -0.95 |
| **7** | DBW 88 × K 1317 | 92.02 | -1.57 | 89.13 | 3.14 | 8.00 | -16.67 \*\* | 7.67 | 4.17 |
| **8** | DBW 88 × KRL 210 | 87.24 | -6.68 \*\* | 88.17 | -1.06 | 7.20 | -25.00 \*\* | 7.07 | 1.85 |
| **9** | DBW 88 × KRL 19 | 88.79 | -5.02 \* | 89.28 | -0.55 | 9.27 | -3.44 | 8.73 | 5.76 |
| **10** | K 9006 × DBW 187 | 86.71 | -7.25 \*\* | 90.52 | -4.4\* | 8.53 | -11.14 \*\* | 8.07 | 5.47 |
| **11** | K 9006 × WH 1142 | 89.68 | -4.06 | 91.90 | -2.47 | 7.13 | -25.73 \*\* | 6.73 | 5.61 |
| **12** | K 9006 × HI 1563 | 93.17 | -0.33 | 90.69 | 2.66 | 7.30 | -23.96 \*\* | 6.80 | 6.85\* |
| **13** | K 9006 × HD 3326 | 90.10 | -3.62 | 87.99 | 2.33 | 8.00 | -16.67 \*\* | 7.80 | 2.50 |
| **14** | K 9006 × K 9423 | 91.75 | -1.85 | 88.22 | 3.85\* | 6.93 | -27.81 \*\* | 7.13 | -2.88 |
| **15** | K 9006 × K 1317 | 87.86 | -6.01 \*\* | 91.28 | -3.89\* | 8.73 | -9.06 \*\* | 8.20 | 6.11\* |
| **16** | K 9006 × KRL 210 | 80.51 | -13.87 \*\* | 82.97 | -3.05 | 6.40 | -33.33 \*\* | 6.20 | 3.13 |
| **17** | K 9006 × KRL 19 | 85.40 | -8.65 \*\* | 90.90 | -6.44\*\* | 7.20 | -25.00 \*\* | 6.93 | 3.70 |
| **18** | DBW 187 × WH 1142 | 86.25 | -7.74 \*\* | 88.78 | -2.94 | 9.20 | -4.17 | 8.47 | 7.97\* |
| **19** | DBW 187 × HI 1563 | 91.27 | -2.37 | 93.48 | -2.42 | 10.00 | 4.17 | 9.13 | 8.67\*\* |
| **20** | DBW 187 × HD 3326 | 82.73 | -11.50 \*\* | 86.64 | -4.72\* | 10.20 | 6.25 \* | 10.07 | 1.31 |
| **21** | DBW 187 × K 9423 | 84.37 | -9.75 \*\* | 87.26 | -3.43 | 9.80 | 2.08 | 8.80 | 10.20\*\* |
| **22** | DBW 187 × K 1317 | 90.27 | -3.44 | 86.99 | 3.63 | 10.33 | 7.64 \* | 9.13 | 11.61\*\* |
| **23** | DBW 187 × KRL210 | 92.68 | -0.86 | 81.60 | 11.96\*\* | 10.60 | 10.42 \*\* | 10.00 | 5.66 |
| **24** | DBW 187 × KRL 19 | 84.70 | -9.39 \*\* | 86.23 | -1.80 | 9.87 | 2.81 | 10.13 | -2.70 |
| **25** | WH 1142 × HI 1563 | 85.40 | -8.65 \*\* | 88.14 | -3.21 | 6.93 | -27.81 \*\* | 6.73 | 2.88 |
| **26** | WH 1142 × HD 3326 | 90.79 | -2.88 | 91.84 | -1.15 | 8.13 | -15.31 \*\* | 7.67 | 5.74 |
| **27** | WH 1142 × K 9423 | 85.69 | -8.34 \*\* | 89.82 | -4.83\* | 7.00 | -27.08 \*\* | 7.07 | -0.95 |
| **28** | WH 1142 × K 1317 | 82.35 | -11.91 \*\* | 85.61 | -3.95 | 8.07 | -15.94 \*\* | 7.40 | 8.26\* |
| **29** | WH 1142 × KRL 210 | 81.45 | -12.87 \*\* | 85.54 | -5.02\* | 7.27 | -24.31 \*\* | 7.27 | 0.00 |
| **30** | WH 1142 × KRL 19 | 87.02 | -6.91 \*\* | 89.62 | -2.99 | 7.53 | -21.56 \*\* | 7.20 | 4.42 |
| **31** | HI 1563 × HD 3326 | 89.91 | -3.82 | 87.08 | 3.14 | 8.60 | -10.42 \*\* | 8.27 | 3.88 |
| **32** | HI 1563 × K 9423 | 88.28 | -5.57 \* | 92.50 | -4.78\* | 6.93 | -27.81 \*\* | 6.53 | 5.77 |
| **33** | HI 1563 × K 1317 | 87.12 | -6.81 \*\* | 90.04 | -3.35 | 7.20 | -25.00 \*\* | 6.73 | 6.48 |
| **34** | HI 1563 × KRL 210 | 91.34 | -2.30 | 94.14 | -3.07 | 8.20 | -14.58 \*\* | 7.93 | 3.25 |
| **35** | HI 1563 × KRL 19 | 80.56 | -13.83 \*\* | 83.75 | -3.97\* | 7.40 | -22.92 \*\* | 7.20 | 2.70 |
| **36** | HD 3326 × K 9423 | 91.03 | -2.62 | 88.56 | 2.71 | 6.47 | -32.61 \*\* | 6.33 | 2.06 |
| **37** | HD 3326 × K 1317 | 91.48 | -2.14 | 87.94 | 3.87\* | 7.47 | -22.19 \*\* | 7.27 | 2.68 |
| **38** | HD 3326 × KRL 210 | 92.71 | -0.83 | 88.17 | 4.9\* | 8.40 | -12.50 \*\* | 8.07 | 3.97 |
| **39** | HD 3326 × KRL 19 | 85.94 | -8.07 \*\* | 92.10 | -7.17\*\* | 7.07 | -26.35 \*\* | 6.80 | 3.77 |
| **40** | K 9423 × K 1317 | 89.92 | -3.81 | 93.48 | -3.97 | 7.93 | -17.40 \*\* | 7.53 | 5.04 |
| **41** | K 9423 × KRL 210 | 81.36 | -12.97 \*\* | 83.85 | -3.05 | 6.53 | -31.98 \*\* | 6.53 | 0.00 |
| **42** | K 9423 × KRL 19 | 90.66 | -3.02 | 86.53 | 4.55\* | 7.73 | -19.48 \*\* | 6.67 | 13.79\*\* |
| **43** | K 1317 × KRL 210 | 84.29 | -9.83 \*\* | 87.67 | -4.01 | 9.73 | 1.35 | 9.73 | 0.00 |
| **44** | K 1317 × KRL 19 | 86.52 | -7.45 \*\* | 89.34 | -3.25 | 9.67 | 0.72 | 10.13 | -4.83 |
| **45** | KRL 210 × KRL 19 | 80.77 | -13.60 \*\* | 82.75 | -2.46 | 7.00 | -27.08 \*\* | 6.80 | 2.86 |
|  | **SE±** |  | 0.83 |  | 1.08 |  | 0.83 |  | 0.99 |

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| **S.**  **No.** | **Crosses** | **Spike length (cm)** | | | | **No. of spikelets per spike** | | | |
| **F1 Mean** | **EP** | **F2 Mean** | **ID** | **F1 Mean** | **EP** | **F2 Mean** | **ID** |
| **1** | DBW 88 × K 9006 | 12.16 | 1.99 | 11.28 | 7.24\* | 18.27 | -12.72 \*\* | 17.40 | 4.74 |
| **2** | DBW 88 × DBW 187 | 12.31 | 3.25 | 12.29 | 0.19 | 20.47 | -2.22 | 19.73 | 3.58 |
| **3** | DBW 88 × WH 1142 | 9.50 | -20.32 \*\* | 9.30 | 2.11 | 19.53 | -6.70 \* | 19.27 | 1.37 |
| **4** | DBW 88 × HI 1563 | 10.20 | -14.45 \*\* | 11.19 | -9.71\*\* | 20.20 | -3.50 | 18.80 | 6.93\* |
| **5** | DBW 88 × HD 3326 | 10.25 | -14.03 \*\* | 10.21 | 0.36 | 17.80 | -14.97 \*\* | 17.47 | 1.87 |
| **6** | DBW 88 × K 9423 | 9.57 | -19.74 \*\* | 11.04 | -15.29\*\* | 19.07 | -8.90 \*\* | 18.73 | 1.75 |
| **7** | DBW 88 × K 1317 | 10.50 | -11.94 \*\* | 11.75 | -11.94\*\* | 20.40 | -2.55 | 19.33 | 5.23 |
| **8** | DBW 88 × KRL 210 | 9.20 | -22.84 \*\* | 9.00 | 2.14 | 18.20 | -13.06 \*\* | 18.00 | 1.10 |
| **9** | DBW 88 × KRL 19 | 9.20 | -22.84 \*\* | 11.36 | -23.51\*\* | 19.60 | -6.37 \* | 19.33 | 1.36 |
| **10** | K 9006 × DBW 187 | 13.56 | 13.73 \*\* | 13.56 | 0.02 | 19.53 | -6.70 \* | 21.47 | -9.90\*\* |
| **11** | K 9006 × WH 1142 | 12.35 | 3.58 | 11.87 | 3.86 | 18.40 | -12.10 \*\* | 19.00 | -3.26 |
| **12** | K 9006 × HI 1563 | 12.45 | 4.42 | 10.88 | 12.58\*\* | 17.27 | -17.50 \*\* | 17.27 | 0.00 |
| **13** | K 9006 × HD 3326 | 11.50 | -3.55 | 11.68 | -1.54 | 19.00 | -9.23 \*\* | 18.80 | 1.05 |
| **14** | K 9006 × K 9423 | 12.75 | 6.94 \* | 12.31 | 3.42 | 17.87 | -14.63 \*\* | 18.67 | -4.48 |
| **15** | K 9006 × K 1317 | 12.50 | 4.84 | 12.10 | 3.17 | 19.00 | -9.23 \*\* | 18.73 | 1.40 |
| **16** | K 9006 × KRL 210 | 10.80 | -9.42 \*\* | 10.40 | 3.67 | 19.07 | -8.90 \*\* | 18.67 | 2.10 |
| **17** | K 9006 × KRL 19 | 10.80 | -9.42 \*\* | 10.29 | 4.72 | 17.93 | -14.35 \*\* | 18.20 | -1.49 |
| **18** | DBW 187 × WH 1142 | 11.09 | -7.02 \* | 10.33 | 6.83\* | 20.47 | -2.22 | 19.67 | 3.91 |
| **19** | DBW 187 × HI 1563 | 11.60 | -2.71 | 12.47 | -7.44\* | 19.60 | -6.37 \* | 19.27 | 1.70 |
| **20** | DBW 187 × HD 3326 | 12.27 | 2.91 | 11.78 | 4.02 | 20.47 | -2.21 | 20.00 | 2.28 |
| **21** | DBW 187 × K 9423 | 12.50 | 4.84 | 11.53 | 7.76\* | 20.20 | -3.50 | 17.80 | 11.88\*\* |
| **22** | DBW 187 × K 1317 | 11.96 | 0.31 | 11.45 | 4.26 | 20.53 | -1.93 | 20.53 | 0.00 |
| **23** | DBW 187 × KRL210 | 12.25 | 2.74 | 12.59 | -2.80 | 20.40 | -2.55 | 19.53 | 4.25 |
| **24** | DBW 187 × KRL 19 | 11.83 | -0.78 | 12.74 | -7.69\* | 20.40 | -2.55 | 20.53 | -0.65 |
| **25** | WH 1142 × HI 1563 | 10.25 | -14.03 \*\* | 10.15 | 1.01 | 18.33 | -12.44 \*\* | 18.07 | 1.45 |
| **26** | WH 1142 × HD 3326 | 10.00 | -16.13 \*\* | 10.29 | -2.90 | 19.27 | -7.94 \*\* | 18.07 | 6.23\* |
| **27** | WH 1142 × K 9423 | 8.82 | -26.03 \*\* | 9.91 | -12.40\*\* | 19.47 | -7.01 \* | 18.67 | 4.11 |
| **28** | WH 1142 × K 1317 | 10.50 | -11.94 \*\* | 10.82 | -3.02 | 18.60 | -11.15 \*\* | 18.33 | 1.43 |
| **29** | WH 1142 × KRL 210 | 9.70 | -18.65 \*\* | 9.82 | -1.24 | 18.33 | -12.44 \*\* | 18.40 | -0.36 |
| **30** | WH 1142 × KRL 19 | 10.20 | -14.45 \*\* | 10.12 | 0.78 | 17.53 | -16.25 \*\* | 17.67 | -0.76 |
| **31** | HI 1563 × HD 3326 | 9.00 | -24.52 \*\* | 8.77 | 2.59 | 16.93 | -19.12 \*\* | 17.20 | -1.57 |
| **32** | HI 1563 × K 9423 | 9.00 | -24.52 \*\* | 10.79 | -19.93\*\* | 19.27 | -7.94 \*\* | 19.40 | -0.69 |
| **33** | HI 1563 × K 1317 | 10.70 | -10.26 \*\* | 10.30 | 3.71 | 17.53 | -16.26 \*\* | 17.20 | 1.90 |
| **34** | HI 1563 × KRL 210 | 10.20 | -14.45 \*\* | 10.58 | -3.76 | 19.27 | -7.94 \*\* | 19.13 | 0.69 |
| **35** | HI 1563 × KRL 19 | 9.50 | -20.32 \*\* | 10.13 | -6.60 | 17.93 | -14.35 \*\* | 17.53 | 2.23 |
| **36** | HD 3326 × K 9423 | 9.99 | -16.21 \*\* | 10.00 | -0.07 | 19.20 | -8.28 \*\* | 18.80 | 2.08 |
| **37** | HD 3326 × K 1317 | 10.87 | -8.83 \*\* | 9.90 | 8.98\*\* | 19.47 | -7.01 \* | 19.60 | -0.68 |
| **38** | HD 3326 × KRL 210 | 9.50 | -20.32 \*\* | 12.24 | -28.81\*\* | 20.27 | -3.17 | 19.93 | 1.64 |
| **39** | HD 3326 × KRL 19 | 10.50 | -11.94 \*\* | 10.39 | 0.98 | 17.67 | -15.59 \*\* | 17.27 | 2.26 |
| **40** | K 9423 × K 1317 | 10.00 | -16.13 \*\* | 10.75 | -7.47 | 20.60 | -1.59 | 20.13 | 2.27 |
| **41** | K 9423 × KRL 210 | 8.90 | -25.35 \*\* | 10.17 | -14.27\*\* | 20.20 | -3.50 | 19.93 | 1.32 |
| **42** | K 9423 × KRL 19 | 10.72 | -10.09 \*\* | 9.28 | 13.37\*\* | 19.60 | -6.37 \* | 17.53 | 10.54\*\* |
| **43** | K 1317 × KRL 210 | 11.18 | -6.23 | 12.72 | -13.78\*\* | 19.00 | -9.23 \*\* | 19.87 | -4.56 |
| **44** | K 1317 × KRL 19 | 11.00 | -7.74 \* | 12.47 | -13.39\*\* | 19.07 | -8.90 \*\* | 20.33 | -6.64\* |
| **45** | KRL 210 × KRL 19 | 11.68 | -2.04 | 10.30 | 11.84\*\* | 19.53 | -6.70 \* | 18.73 | 4.10 |
|  | **SE±** |  | 0.75 |  | 1.22 |  | 0.81 |  | 0.52 |

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| **S.**  **No.** | **Crosses** | **No. of grains per spike** | | | | **Grain weight per spike (g)** | | | |
| **F1 Mean** | **EP** | **F2 Mean** | **ID** | **F1 Mean** | **EP** | **F2 Mean** | **ID** |
| **1** | DBW 88 × K 9006 | 50.53 | -6.77 \* | 50.00 | 1.06 | 1.96 | -0.86 | 1.87 | 4.59 |
| **2** | DBW 88 × DBW 187 | 57.53 | 6.14 | 57.60 | -0.12 | 2.14 | 8.42 \* | 2.08 | 2.80 |
| **3** | DBW 88 × WH 1142 | 49.40 | -8.86 \*\* | 49.00 | 0.81 | 1.89 | -4.40 | 1.82 | 3.53 |
| **4** | DBW 88 × HI 1563 | 48.67 | -10.20 \*\* | 47.13 | 3.15 | 1.98 | 0.16 | 1.68 | 15.15\*\* |
| **5** | DBW 88 × HD 3326 | 53.67 | -0.98 | 48.60 | 9.44\*\* | 1.89 | -4.40 | 1.84 | 2.65 |
| **6** | DBW 88 × K 9423 | 50.47 | -6.88 \* | 48.93 | 3.04 | 1.90 | -3.89 | 1.98 | -4.03 |
| **7** | DBW 88 × K 1317 | 51.87 | -4.30 | 49.73 | 4.11 | 1.95 | -1.37 | 1.73 | 11.45\*\* |
| **8** | DBW 88 × KRL 210 | 52.93 | -2.34 | 52.20 | 1.39 | 1.96 | -0.86 | 1.89 | 3.74 |
| **9** | DBW 88 × KRL 19 | 50.00 | -7.75 \* | 49.33 | 1.33 | 1.86 | -5.92 | 1.67 | 10.22\*\* |
| **10** | K 9006 × DBW 187 | 50.00 | -7.75 \* | 58.07 | -16.13\*\* | 1.99 | 0.66 | 1.82 | 8.38\* |
| **11** | K 9006 × WH 1142 | 43.33 | -20.05 \*\* | 49.67 | -14.62\*\* | 1.85 | -6.42 | 1.73 | 6.67 |
| **12** | K 9006 × HI 1563 | 44.73 | -17.47 \*\* | 43.87 | 1.94 | 1.89 | -4.40 | 1.58 | 16.23\*\* |
| **13** | K 9006 × HD 3326 | 46.20 | -14.76 \*\* | 45.80 | 0.87 | 1.80 | -8.95 \* | 1.69 | 5.93 |
| **14** | K 9006 × K 9423 | 47.60 | -12.18 \*\* | 51.53 | -8.26\*\* | 1.82 | -7.94 \* | 1.59 | 12.45\*\* |
| **15** | K 9006 × K 1317 | 49.60 | -8.49 \*\* | 49.07 | 1.08 | 1.89 | -4.40 | 1.75 | 7.41\* |
| **16** | K 9006 × KRL 210 | 47.60 | -12.18 \*\* | 47.20 | 0.84 | 1.93 | -2.38 | 1.81 | 6.39 |
| **17** | K 9006 × KRL 19 | 45.87 | -15.37 \*\* | 45.80 | 0.15 | 1.95 | -1.36 | 1.58 | 18.66\*\* |
| **18** | DBW 187 × WH 1142 | 53.20 | -1.85 | 47.20 | 11.28\*\* | 1.86 | -5.92 | 1.75 | 5.91 |
| **19** | DBW 187 × HI 1563 | 55.07 | 1.61 | 53.07 | 3.63 | 2.13 | 7.74 \* | 2.07 | 2.81 |
| **20** | DBW 187 × HD 3326 | 57.67 | 6.40 \* | 57.93 | -0.46 | 2.06 | 4.20 | 2.07 | -0.32 |
| **21** | DBW 187 × K 9423 | 51.20 | -5.54 | 50.40 | 1.56 | 1.76 | -10.97 \*\* | 1.62 | 8.32\* |
| **22** | DBW 187 × K 1317 | 58.07 | 7.14 \* | 49.47 | 14.81\*\* | 2.13 | 7.74 \* | 2.16 | -1.09 |
| **23** | DBW 187 × KRL210 | 59.07 | 8.99 \*\* | 52.73 | 10.72\*\* | 2.00 | 1.16 | 2.12 | -5.83 |
| **24** | DBW 187 × KRL 19 | 58.33 | 7.62 \* | 54.73 | 6.17 | 2.20 | 11.28 \*\* | 2.11 | 4.24 |
| **25** | WH 1142 × HI 1563 | 46.27 | -14.63 \*\* | 46.40 | -0.29 | 1.80 | -8.95 \* | 1.72 | 4.44 |
| **26** | WH 1142 × HD 3326 | 47.93 | -11.57 \*\* | 46.40 | 3.20 | 1.85 | -6.42 | 1.58 | 14.62\*\* |
| **27** | WH 1142 × K 9423 | 46.80 | -13.65 \*\* | 52.73 | -12.68\*\* | 1.78 | -9.96 \*\* | 1.75 | 1.31 |
| **28** | WH 1142 × K 1317 | 49.53 | -8.62 \*\* | 50.40 | -1.75 | 1.78 | -9.96 \* | 1.63 | 8.43\* |
| **29** | WH 1142 × KRL 210 | 48.47 | -10.57 \*\* | 48.40 | 0.14 | 1.89 | -4.40 | 1.85 | 1.94 |
| **30** | WH 1142 × KRL 19 | 43.27 | -20.17 \*\* | 43.00 | 0.62 | 1.85 | -6.42 | 1.75 | 5.59 |
| **31** | HI 1563 × HD 3326 | 47.27 | -12.79 \*\* | 49.40 | -4.51 | 1.71 | -13.50 \*\* | 1.60 | 6.61 |
| **32** | HI 1563 × K 9423 | 44.67 | -17.58 \*\* | 49.20 | -10.15\*\* | 1.79 | -8.95 \* | 1.72 | 3.91 |
| **33** | HI 1563 × K 1317 | 49.67 | -8.36 \*\* | 49.53 | 0.27 | 1.80 | -9.11 \* | 1.86 | -3.34 |
| **34** | HI 1563 × KRL 210 | 45.27 | -16.48 \*\* | 45.20 | 0.15 | 1.95 | -1.37 | 1.83 | 6.15 |
| **35** | HI 1563 × KRL 19 | 45.60 | -15.87 \*\* | 47.80 | -4.82 | 1.75 | -11.48 \*\* | 1.66 | 4.95 |
| **36** | HD 3326 × K 9423 | 49.67 | -8.36 \*\* | 52.47 | -5.64 | 1.76 | -10.98 \*\* | 1.69 | 4.17 |
| **37** | HD 3326 × K 1317 | 48.00 | -11.44 \*\* | 47.47 | 1.11 | 1.95 | -1.37 | 1.72 | 11.64\*\* |
| **38** | HD 3326 × KRL 210 | 49.80 | -8.12 \* | 49.07 | 1.47 | 1.86 | -5.92 | 1.65 | 11.11\*\* |
| **39** | HD 3326 × KRL 19 | 47.47 | -12.42 \*\* | 47.00 | 0.98 | 1.89 | -4.40 | 1.79 | 5.30 |
| **40** | K 9423 × K 1317 | 51.33 | -5.30 | 51.07 | 0.52 | 1.68 | -15.02 \*\* | 1.56 | 7.34 |
| **41** | K 9423 × KRL 210 | 46.20 | -14.76 \*\* | 45.87 | 0.72 | 1.89 | -4.40 | 1.87 | 0.88 |
| **42** | K 9423 × KRL 19 | 48.60 | -10.33 \*\* | 47.87 | 1.51 | 1.76 | -10.98 \*\* | 1.56 | 11.36\*\* |
| **43** | K 1317 × KRL 210 | 54.67 | 0.87 | 54.80 | -0.24 | 2.20 | 11.28 \*\* | 2.13 | 2.88 |
| **44** | K 1317 × KRL 19 | 50.53 | -6.77 \* | 56.60 | -12.01\*\* | 2.17 | 9.76 \* | 2.04 | 6.13 |
| **45** | KRL 210 × KRL 19 | 49.60 | -8.49 \*\* | 50.33 | -1.48 | 1.98 | 0.15 | 1.95 | 1.52 |
|  | **SE±** |  | 1.87 |  | 0.44 |  | 1.69 |  | 0.50 |

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| **S.**  **No.** | **Crosses** | **Biological yield per plant** | | | | **1000-grain weight** | | | |
| **F1 Mean** | **EP** | **F2 Mean** | **ID** | **F1 Mean** | **EP** | **F2 Mean** | **ID** |
| **1** | DBW 88 × K 9006 | 35.63 | -16.44 \*\* | 35.01 | 1.74 | 42.56 | -3.34 | 41.89 | 1.57 |
| **2** | DBW 88 × DBW 187 | 48.15 | 12.92 \*\* | 44.57 | 7.44 | 43.78 | -0.57 | 42.36 | 3.24 |
| **3** | DBW 88 × WH 1142 | 37.97 | -10.95 \*\* | 33.49 | 11.82\*\* | 42.80 | -2.79 | 42.18 | 1.45 |
| **4** | DBW 88 × HI 1563 | 33.44 | -21.58 \*\* | 30.72 | 8.13 | 42.65 | -3.13 | 42.57 | 0.19 |
| **5** | DBW 88 × HD 3326 | 38.42 | -9.90 \*\* | 34.37 | 10.54\* | 42.25 | -4.04 \* | 40.59 | 3.94\* |
| **6** | DBW 88 × K 9423 | 36.54 | -14.31 \*\* | 32.31 | 11.57\*\* | 42.56 | -3.34 | 40.51 | 4.82\* |
| **7** | DBW 88 × K 1317 | 37.08 | -13.04 \*\* | 33.39 | 9.97\* | 43.12 | -2.07 | 43.00 | 0.28 |
| **8** | DBW 88 × KRL 210 | 38.45 | -9.83 \*\* | 32.71 | 14.94\*\* | 43.16 | -1.98 | 42.86 | 0.70 |
| **9** | DBW 88 × KRL 19 | 35.47 | -16.82 \*\* | 35.40 | 0.20 | 41.36 | -6.06 \*\* | 41.10 | 0.63 |
| **10** | K 9006 × DBW 187 | 39.83 | -6.60 | 37.27 | 6.43 | 42.98 | -2.38 | 39.88 | 7.22\*\* |
| **11** | K 9006 × WH 1142 | 31.76 | -25.52 \*\* | 30.01 | 5.53 | 41.89 | -4.86 \*\* | 39.15 | 6.53\*\* |
| **12** | K 9006 × HI 1563 | 31.74 | -25.56 \*\* | 25.82 | 18.66\*\* | 42.56 | -3.34 | 36.65 | 13.89\*\* |
| **13** | K 9006 × HD 3326 | 34.58 | -18.90 \*\* | 34.38 | 0.57 | 41.56 | -5.61 \*\* | 39.26 | 5.53\*\* |
| **14** | K 9006 × K 9423 | 29.77 | -30.18 \*\* | 30.58 | -2.73 | 42.10 | -4.38 \* | 41.58 | 1.24 |
| **15** | K 9006 × K 1317 | 31.76 | -25.52 \*\* | 30.58 | 3.74 | 43.58 | -1.02 | 42.98 | 1.38 |
| **16** | K 9006 × KRL 210 | 34.87 | -18.23 \*\* | 31.71 | 9.06\* | 41.98 | -4.66 \* | 41.27 | 1.69 |
| **17** | K 9006 × KRL 19 | 31.46 | -26.23 \*\* | 29.63 | 5.81 | 41.65 | -5.41 \*\* | 40.85 | 1.90 |
| **18** | DBW 187 × WH 1142 | 40.77 | -4.39 | 38.17 | 6.39 | 43.50 | -1.20 | 43.65 | -0.34 |
| **19** | DBW 187 × HI 1563 | 48.56 | 13.88 \*\* | 41.54 | 14.46\*\* | 43.20 | -1.89 | 42.89 | 0.72 |
| **20** | DBW 187 × HD 3326 | 47.89 | 12.31 \*\* | 46.73 | 2.43 | 43.25 | -1.77 | 43.67 | -0.98 |
| **21** | DBW 187 × K 9423 | 38.04 | -10.79 \*\* | 33.73 | 11.33\*\* | 43.56 | -1.07 | 43.21 | 0.80 |
| **22** | DBW 187 × K 1317 | 49.58 | 16.28 \*\* | 41.52 | 16.25\*\* | 46.51 | 5.63 \*\* | 44.12 | 5.14\*\* |
| **23** | DBW 187 × KRL210 | 47.59 | 11.61 \*\* | 46.40 | 2.49 | 44.61 | 1.32 | 44.08 | 1.20 |
| **24** | DBW 187 × KRL 19 | 48.23 | 13.11 \*\* | 45.17 | 6.34 | 41.41 | -5.95 \*\* | 42.20 | -1.91 |
| **25** | WH 1142 × HI 1563 | 30.66 | -28.10 \*\* | 29.31 | 4.39 | 42.00 | -4.61 \* | 41.64 | 0.86 |
| **26** | WH 1142 × HD 3326 | 34.72 | -18.57 \*\* | 30.51 | 12.13\*\* | 41.90 | -4.84 \*\* | 40.28 | 3.87 |
| **27** | WH 1142 × K 9423 | 30.92 | -27.49 \*\* | 31.34 | -1.37 | 42.65 | -3.13 | 41.68 | 2.27 |
| **28** | WH 1142 × K 1317 | 35.16 | -17.54 \*\* | 30.15 | 14.26\*\* | 42.89 | -2.60 | 42.31 | 1.34 |
| **29** | WH 1142 × KRL 210 | 31.89 | -25.21 \*\* | 31.85 | 0.14 | 41.90 | -4.85 \*\* | 41.31 | 1.40 |
| **30** | WH 1142 × KRL 19 | 31.53 | -26.06 \*\* | 31.12 | 1.31 | 40.23 | -8.63 \*\* | 39.64 | 1.47 |
| **31** | HI 1563 × HD 3326 | 33.00 | -22.61 \*\* | 31.98 | 3.10 | 41.10 | -6.66 \*\* | 41.49 | -0.96 |
| **32** | HI 1563 × K 9423 | 29.56 | -30.68 \*\* | 26.58 | 10.08\*\* | 41.89 | -4.87 \*\* | 42.10 | -0.51 |
| **33** | HI 1563 × K 1317 | 31.66 | -25.75 \*\* | 31.15 | 1.61 | 44.12 | 0.20 | 43.67 | 1.02 |
| **34** | HI 1563 × KRL 210 | 35.49 | -16.77 \*\* | 27.09 | 23.68\*\* | 41.50 | -5.75 \*\* | 40.27 | 2.96 |
| **35** | HI 1563 × KRL 19 | 29.67 | -30.42 \*\* | 31.09 | -4.80 | 41.23 | -6.36 \*\* | 40.37 | 2.09 |
| **36** | HD 3326 × K 9423 | 33.14 | -22.28 \*\* | 25.56 | 22.88\*\* | 42.15 | -4.27 \* | 41.78 | 0.88 |
| **37** | HD 3326 × K 1317 | 36.76 | -13.79 \*\* | 28.60 | 22.19\*\* | 42.68 | -3.07 | 41.39 | 3.02 |
| **38** | HD 3326 × KRL 210 | 40.14 | -5.86 | 28.47 | 29.07\*\* | 41.20 | -6.43 \*\* | 40.10 | 2.68 |
| **39** | HD 3326 × KRL 19 | 35.91 | -15.78 \*\* | 33.47 | 6.80 | 40.98 | -6.93 \*\* | 39.21 | 4.33\* |
| **40** | K 9423 × K 1317 | 32.45 | -23.90 \*\* | 29.54 | 8.96\* | 43.15 | -2.00 | 41.89 | 2.92 |
| **41** | K 9423 × KRL 210 | 31.69 | -25.68 \*\* | 30.66 | 3.24 | 41.23 | -6.36 \*\* | 41.37 | -0.34 |
| **42** | K 9423 × KRL 19 | 31.58 | -25.94 \*\* | 26.68 | 15.52\*\* | 41.95 | -4.72 \* | 41.34 | 1.45 |
| **43** | K 1317 × KRL 210 | 47.23 | 10.76 \*\* | 43.91 | 7.04 | 45.50 | 3.34 | 42.22 | 7.22\*\* |
| **44** | K 1317 × KRL 19 | 48.39 | 13.49 \*\* | 42.53 | 12.12\*\* | 44.94 | 2.07 | 43.28 | 3.70 |
| **45** | KRL 210 × KRL 19 | 36.49 | -14.42 \*\* | 33.42 | 8.42 | 40.98 | -6.93 \*\* | 38.96 | 4.93\* |
|  | **SE±** |  | 2.30 |  | 0.31 |  | 0.30 |  | 0.26 |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S.**  **No.** | **Crosses** | **Harvest index (%)** | | | | **Seed hardness (kg/seed)** | | | |
| **F1 Mean** | **EP** | **F2 Mean** | **ID** | **F1 Mean** | **EP** | **F2 Mean** | **ID** |
| **1** | DBW 88 × K 9006 | 41.78 | -5.75 \* | 37.33 | 10.64\*\* | 9.42 | 17.65 \*\* | 11.74 | -24.63\*\* |
| **2** | DBW 88 × DBW 187 | 44.86 | 1.20 | 42.97 | 4.20 | 8.02 | 0.17 | 9.65 | -20.37\*\* |
| **3** | DBW 88 × WH 1142 | 36.74 | -17.12 \*\* | 41.07 | -11.80\*\* | 8.15 | 1.79 | 8.88 | -9.00\* |
| **4** | DBW 88 × HI 1563 | 42.54 | -4.03 | 41.19 | 3.17 | 8.86 | 10.66 | 9.58 | -8.13 |
| **5** | DBW 88 × HD 3326 | 39.04 | -11.93 \*\* | 38.36 | 1.75 | 8.95 | 11.78 | 9.39 | -4.91 |
| **6** | DBW 88 × K 9423 | 45.06 | 1.65 | 42.59 | 5.49\* | 8.44 | 5.41 | 9.27 | -9.79\* |
| **7** | DBW 88 × K 1317 | 39.30 | -11.34 \*\* | 38.50 | 2.03 | 11.59 | 44.75 \*\* | 8.19 | 29.38\*\* |
| **8** | DBW 88 × KRL 210 | 41.44 | -6.51 \* | 40.00 | 3.47 | 10.66 | 33.13 \*\* | 9.91 | 7.00 |
| **9** | DBW 88 × KRL 19 | 41.06 | -7.38 \*\* | 39.18 | 4.58 | 7.50 | -6.33 | 9.32 | -24.27\*\* |
| **10** | K 9006 × DBW 187 | 39.41 | -11.09 \*\* | 39.48 | -0.19 | 8.36 | 4.41 | 9.73 | -16.35\*\* |
| **11** | K 9006 × WH 1142 | 39.54 | -10.81 \*\* | 38.59 | 2.40 | 9.39 | 17.27 \*\* | 9.64 | -2.63 |
| **12** | K 9006 × HI 1563 | 40.27 | -9.14 \*\* | 41.72 | -3.60 | 8.46 | 5.66 | 9.01 | -6.46 |
| **13** | K 9006 × HD 3326 | 40.99 | -7.53 \*\* | 38.40 | 6.30\* | 10.49 | 31.81 \*\* | 8.73 | 16.72\*\* |
| **14** | K 9006 × K 9423 | 41.14 | -7.19 \*\* | 36.49 | 11.32\*\* | 7.43 | -7.21 | 9.69 | -30.40\*\* |
| **15** | K 9006 × K 1317 | 44.86 | 1.20 | 43.68 | 2.62 | 9.56 | 19.40 \*\* | 10.92 | -14.23\*\* |
| **16** | K 9006 × KRL 210 | 41.39 | -6.63 \* | 40.54 | 2.05 | 8.29 | 3.53 | 9.97 | -20.35\*\* |
| **17** | K 9006 × KRL 19 | 40.97 | -7.57 \*\* | 37.07 | 9.53\*\* | 7.62 | -4.83 | 8.16 | -7.09 |
| **18** | DBW 187 × WH 1142 | 38.67 | -12.80 \*\* | 38.82 | -0.39 | 9.73 | 21.52 \*\* | 8.57 | 11.99\*\* |
| **19** | DBW 187 × HI 1563 | 43.12 | -2.73 | 44.57 | -3.36 | 11.16 | 39.38 \*\* | 7.77 | 30.35\*\* |
| **20** | DBW 187 × HD 3326 | 43.70 | -1.41 | 44.52 | -1.88 | 9.25 | 15.42 \* | 9.51 | -2.81 |
| **21** | DBW 187 × K 9423 | 39.81 | -10.20 \*\* | 40.81 | -2.53 | 7.49 | -6.46 | 10.95 | -46.09\*\* |
| **22** | DBW 187 × K 1317 | 44.34 | 0.03 | 46.78 | -5.51 | 11.16 | 39.38 \*\* | 10.23 | 8.36 |
| **23** | DBW 187 × KRL210 | 43.91 | -0.94 | 44.96 | -2.39 | 7.71 | -3.71 | 8.79 | -13.92\*\* |
| **24** | DBW 187 × KRL 19 | 43.60 | -1.64 | 46.46 | -6.56\* | 10.18 | 27.14 \*\* | 10.05 | 1.31 |
| **25** | WH 1142 × HI 1563 | 39.91 | -9.96 \*\* | 39.57 | 0.87 | 9.47 | 18.27 \*\* | 10.44 | -10.20\* |
| **26** | WH 1142 × HD 3326 | 38.15 | -13.93 \*\* | 39.39 | -3.26 | 9.76 | 21.89 \*\* | 9.63 | 1.37 |
| **27** | WH 1142 × K 9423 | 39.96 | -9.84 \*\* | 39.20 | 1.90 | 7.47 | -6.71 | 9.75 | -30.54\*\* |
| **28** | WH 1142 × K 1317 | 38.63 | -12.90 \*\* | 39.33 | -1.80 | 8.24 | 2.91 | 10.55 | -28.07\*\* |
| **29** | WH 1142 × KRL 210 | 41.54 | -6.29 \* | 41.45 | 0.23 | 9.07 | 13.28 \* | 9.59 | -5.73 |
| **30** | WH 1142 × KRL 19 | 39.19 | -11.60 \*\* | 38.42 | 1.96 | 8.71 | 8.78 | 10.27 | -17.83\*\* |
| **31** | HI 1563 × HD 3326 | 39.84 | -10.13 \*\* | 40.78 | -2.37 | 8.84 | 10.41 | 8.62 | 2.49 |
| **32** | HI 1563 × K 9423 | 40.66 | -8.27 \*\* | 41.31 | -1.62 | 8.15 | 1.79 | 8.92 | -9.49\* |
| **33** | HI 1563 × K 1317 | 41.87 | -5.54 \* | 39.10 | 6.62\* | 8.70 | 8.66 | 10.84 | -24.60\*\* |
| **34** | HI 1563 × KRL 210 | 37.39 | -15.66 \*\* | 44.56 | -19.18\*\* | 11.77 | 47.04 \*\* | 8.87 | 24.63\*\* |
| **35** | HI 1563 × KRL 19 | 43.72 | -1.37 | 37.08 | 15.20\*\* | 8.15 | 1.79 | 7.49 | 8.18 |
| **36** | HD 3326 × K 9423 | 38.04 | -14.20 \*\* | 41.61 | -9.38\*\* | 9.11 | 13.74 \* | 8.94 | 1.83 |
| **37** | HD 3326 × K 1317 | 39.97 | -9.83 \*\* | 42.87 | -7.26\*\* | 7.72 | -3.53 | 10.33 | -33.85\*\* |
| **38** | HD 3326 × KRL 210 | 35.44 | -20.05 \*\* | 45.14 | -27.36\*\* | 8.61 | 7.58 | 9.89 | -14.86\*\* |
| **39** | HD 3326 × KRL 19 | 38.02 | -14.23 \*\* | 35.94 | 5.46\* | 8.48 | 5.91 | 9.04 | -6.60 |
| **40** | K 9423 × K 1317 | 40.84 | -7.87 \*\* | 40.28 | 1.37 | 10.86 | 35.63 \*\* | 10.25 | 5.65 |
| **41** | K 9423 × KRL 210 | 41.81 | -5.68 \* | 38.50 | 7.92\*\* | 7.95 | -0.71 | 10.17 | -27.83\*\* |
| **42** | K 9423 × KRL 19 | 40.13 | -9.47 \*\* | 38.32 | 4.51 | 7.84 | -2.09 | 9.27 | -18.25\*\* |
| **43** | K 1317 × KRL 210 | 44.75 | 0.95 | 44.26 | 1.09 | 7.45 | -6.96 | 9.16 | -23.01\*\* |
| **44** | K 1317 × KRL 19 | 43.02 | -2.95 | 44.79 | -4.11 | 8.39 | 4.78 | 9.27 | -10.49\*\* |
| **45** | KRL 210 × KRL 19 | 42.74 | -3.58 | 39.28 | 8.09\*\* | 8.19 | 2.29 | 10.21 | -24.57\*\* |
|  | **SE±** |  | 0.26 |  | 0.26 |  | 0.29 |  | 0.63 |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S.**  **No.** | **Crosses** | **Protein content (%)** | | | | **Grain yield per plant (g)** | | | |
| **F1 Mean** | **EP** | **F2 Mean** | **ID** | **F1 Mean** | **EP** | **F2 Mean** | **ID** |
| **1** | DBW 88 × K 9006 | 12.98 | 7.21 \*\* | 12.09 | 6.86\* | 14.89 | -21.25 \*\* | 13.07 | 12.20\*\* |
| **2** | DBW 88 × DBW 187 | 12.93 | 6.80\*\* | 12.74 | 1.42 | 21.61 | 14.30 \*\* | 19.16 | 11.32\*\* |
| **3** | DBW 88 × WH 1142 | 12.10 | -0.06 | 11.89 | 1.74 | 13.90 | -26.48 \*\* | 13.76 | 1.03 |
| **4** | DBW 88 × HI 1563 | 11.27 | -6.91 \*\* | 10.96 | 2.69 | 14.21 | -24.84 \*\* | 12.67 | 10.86\*\* |
| **5** | DBW 88 × HD 3326 | 12.07 | -0.31 | 11.36 | 5.83\* | 14.98 | -20.77 \*\* | 13.20 | 11.90\*\* |
| **6** | DBW 88 × K 9423 | 11.96 | -1.21 | 10.97 | 8.25\* | 15.98 | -15.48 \*\* | 13.76 | 13.87\*\* |
| **7** | DBW 88 × K 1317 | 12.24 | 1.10 | 12.00 | 1.93 | 14.56 | -22.99 \*\* | 12.83 | 11.88\*\* |
| **8** | DBW 88 × KRL 210 | 12.00 | -0.88 | 11.73 | 2.22 | 15.90 | -15.90 \*\* | 13.08 | 17.76\*\* |
| **9** | DBW 88 × KRL 19 | 11.87 | -1.96 | 12.02 | -1.29 | 14.56 | -22.99 \*\* | 13.87 | 4.74 |
| **10** | K 9006 × DBW 187 | 12.90 | 6.55 \*\* | 11.97 | 7.18\* | 15.68 | -17.07 \*\* | 14.71 | 6.15 |
| **11** | K 9006 × WH 1142 | 12.00 | -0.88 | 12.47 | -3.92 | 12.56 | -33.57 \*\* | 11.59 | 7.72\* |
| **12** | K 9006 × HI 1563 | 11.30 | -6.67 \*\* | 11.24 | 0.56 | 12.80 | -32.30 \*\* | 10.77 | 15.86\*\* |
| **13** | K 9006 × HD 3326 | 12.50 | 3.25 | 12.10 | 3.23 | 14.00 | -25.95 \*\* | 13.22 | 5.60 |
| **14** | K 9006 × K 9423 | 12.39 | 2.34 | 12.19 | 1.64 | 12.25 | -35.21 \*\* | 11.15 | 8.95\* |
| **15** | K 9006 × K 1317 | 12.68 | 4.73 \* | 12.89 | -1.63 | 14.23 | -24.74 \*\* | 13.36 | 6.09 |
| **16** | K 9006 × KRL 210 | 12.80 | 5.73 \* | 11.97 | 6.51\* | 14.43 | -23.68 \*\* | 12.85 | 10.97\*\* |
| **17** | K 9006 × KRL 19 | 11.20 | -7.49 \*\* | 11.00 | 1.79 | 12.89 | -31.82 \*\* | 10.97 | 14.87\*\* |
| **18** | DBW 187 × WH 1142 | 12.58 | 3.91 | 12.31 | 2.15 | 15.75 | -16.70 \*\* | 15.49 | 1.65 |
| **19** | DBW 187 × HI 1563 | 12.00 | -0.88 | 12.16 | -1.33 | 20.94 | 10.75 \*\* | 18.52 | 11.59\*\* |
| **20** | DBW 187 × HD 3326 | 12.20 | 0.77 | 12.66 | -3.77 | 20.93 | 10.72 \*\* | 20.82 | 0.56 |
| **21** | DBW 187 × K 9423 | 11.99 | -0.97 | 11.79 | 1.70 | 15.12 | -20.03 \*\* | 13.76 | 8.99\*\* |
| **22** | DBW 187 × K 1317 | 12.41 | 2.50 | 12.17 | 1.93 | 21.99 | 16.31 \*\* | 19.43 | 11.64\*\* |
| **23** | DBW 187 × KRL210 | 12.20 | 0.77 | 11.84 | 2.95 | 20.90 | 10.54 \*\* | 20.88 | 0.10 |
| **24** | DBW 187 × KRL 19 | 11.73 | -3.11 | 11.75 | -0.17 | 21.03 | 11.23 \*\* | 21.00 | 0.14 |
| **25** | WH 1142 × HI 1563 | 12.10 | -0.06 | 11.84 | 2.15 | 12.23 | -35.31 \*\* | 11.60 | 5.18 |
| **26** | WH 1142 × HD 3326 | 12.14 | 0.27 | 11.93 | 1.73 | 13.24 | -29.97 \*\* | 12.02 | 9.21\* |
| **27** | WH 1142 × K 9423 | 11.80 | -2.54 | 10.91 | 7.54\* | 12.32 | -34.84 \*\* | 12.29 | 0.22 |
| **28** | WH 1142 × K 1317 | 12.10 | -0.06 | 11.92 | 1.52 | 13.56 | -28.28 \*\* | 11.85 | 12.63\*\* |
| **29** | WH 1142 × KRL 210 | 11.70 | -3.36 | 11.09 | 5.24 | 13.25 | -29.92 \*\* | 13.20 | 0.40 |
| **30** | WH 1142 × KRL 19 | 11.82 | -2.37 | 12.02 | -1.66 | 12.35 | -34.68 \*\* | 11.95 | 3.27 |
| **31** | HI 1563 × HD 3326 | 11.48 | -5.20 \* | 11.57 | -0.81 | 13.12 | -30.61 \*\* | 13.05 | 0.53 |
| **32** | HI 1563 × K 9423 | 11.78 | -2.70 | 10.98 | 6.79\*\* | 12.00 | -36.53 \*\* | 10.99 | 8.44\* |
| **33** | HI 1563 × K 1317 | 11.32 | -6.50 \*\* | 11.18 | 1.24 | 13.25 | -29.92 \*\* | 12.18 | 8.10\* |
| **34** | HI 1563 × KRL 210 | 12.00 | -0.88 | 12.01 | -0.06 | 13.26 | -29.87 \*\* | 12.06 | 9.07\* |
| **35** | HI 1563 × KRL 19 | 12.16 | 0.44 | 11.87 | 2.38 | 12.95 | -31.51 \*\* | 11.53 | 10.97\*\* |
| **36** | HD 3326 × K 9423 | 12.17 | 0.52 | 12.10 | 0.60 | 12.58 | -33.46 \*\* | 10.64 | 15.42\*\* |
| **37** | HD 3326 × K 1317 | 12.12 | 0.11 | 11.97 | 1.29 | 14.68 | -22.36 \*\* | 12.26 | 16.49\*\* |
| **38** | HD 3326 × KRL 210 | 11.98 | -1.05 | 11.08 | 7.51\*\* | 14.23 | -24.74 \*\* | 12.86 | 9.65\* |
| **39** | HD 3326 × KRL 19 | 10.94 | -9.64 \*\* | 12.74 | -16.48\*\* | 13.65 | -27.80 \*\* | 12.03 | 11.87\*\* |
| **40** | K 9423 × K 1317 | 12.57 | 3.82 | 12.19 | 3.00 | 13.24 | -29.97 \*\* | 11.89 | 10.20\*\* |
| **41** | K 9423 × KRL 210 | 12.00 | -0.88 | 11.89 | 0.92 | 13.25 | -29.92 \*\* | 11.81 | 10.87\*\* |
| **42** | K 9423 × KRL 19 | 11.85 | -2.12 | 11.58 | 2.28 | 12.65 | -33.09 \*\* | 10.22 | 19.24\*\* |
| **43** | K 1317 × KRL 210 | 11.90 | -1.71 | 12.14 | -1.99 | 21.14 | 11.81 \*\* | 19.44 | 8.07\* |
| **44** | K 1317 × KRL 19 | 11.91 | -1.63 | 12.00 | -0.76 | 20.82 | 10.12 \*\* | 19.05 | 8.50\* |
| **45** | KRL 210 × KRL 19 | 11.20 | -7.49 \*\* | 11.35 | -1.31 | 15.60 | -17.49 \*\* | 13.13 | 15.85\*\* |
|  | **SE±** |  | 0.39 |  | 0.54 |  | 0.34 |  | 0.62 |

**CONCLUSION**

Diallel analysis serves as a powerful tool in wheat breeding, enabling the identification of promising genotypes and cross combinations for yield enhancement. The strategic exploitation of heterosis, particularly in self-pollinated crops, remains a cornerstone for varietal improvement and global food security. The identified cross combinations hold strong potential for the development of high-yielding wheat varieties and can significantly contribute to future crop improvement efforts. Promising heterosis crosses such as DBW 88 × DBW 187, DBW 187 × K 13174, DBW 187 × KRL 19, and DBW 187 × HI 1563 have shown potential for high yield and can serve as valuable parental lines in future crop improvement programs while HI 1563 × K 9423 and DBW 187 × K 9423 This two cross could be used for developing early maturity and short statured hybrids.

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