

Breeding Importance of the Hybrid Depression Problem and Possible Ways of its Overcoming

Ruzanna Robert Sadoyan

Scientific Center of Agriculture, Ministry of Agriculture, Echmiadzin, Republic of Armenia

Email address:

ruzannasad@mail.ru

To cite this article:

Ruzanna Robert Sadoyan. Breeding Importance of the Hybrid Depression Problem and Possible Ways of Its Overcoming. *American Journal of Agriculture and Forestry*. Vol. 3, No. 3, 2015, pp. 116-119. doi: 10.11648/j.ajaf.20150303.19

Abstract: Widely spread natural negative mutations in the Triticum genus, the divergence of members of the complementary systems of depression, their concentration in different eco-geographical zones, depending on their biotype and variety leading to the appearance of depressive hybrid plants cause serious difficulties in breeding process. To overcome hybrid dwarfism, the impact of mineral fertilizers (N90P90K75) on the growth and development of Dwarf I and Dwarf II wheat hybrids was studied. Creation of suitable growing conditions revealed, that contrary the increase in vegetative mass of hybrid Dwarf I (plant height, number of leaves, weight per plant) and elements of productivity of hybrid Dwarf II (plant height, productive tillering, the length of the main ear, grain yield per plant) in none of the hybrids the overcoming of depression was registered.

Keywords: Wheat, Hybrid Depression, Breeding, Mineral Fertilizers, Vegetative Mass

1. Introduction

On purpose to enrich the hybrid population genetically and to obtain a wide range of variability, the breeders often use the methods of distant eco-geographical, interspecific and intergeneric hybridization. In breeding program the hybrid depression is presented as serious problem. In the research of genes lethality in the Triticum genus three main aspects of breeding and genetic importance problem were identified. The first aspect is the prevalence of genes lethality at a certain combination originated in the case of disturbance of regulatory mechanisms of vitality. The second aspect is the diversity of lethality types and multiple alleles of genes determining this phenomenon. The third aspect is the

extensive polymorphism of complementary genes of hybrid depression of some species in different eco-geographical zones [1, 2, 3].

In the breeding aspect it is important also the linkage of depression genes not only among themselves but also with the genes controlling the immune system and economically important traits as weight and size of grain and rust resistance [4]. According to Austin [5], the adoption of wheat cultivars of shorter stature was one of the important factors for obtaining greater yields, due to resistance to lodging and earlier ripening. The introgression of dwarfing (Rht) genes greatly promoted the partitioning of wheat biomass to grains [6]. The scheme of linkage of depression genes and economically important traits is presented on the Figure 1.

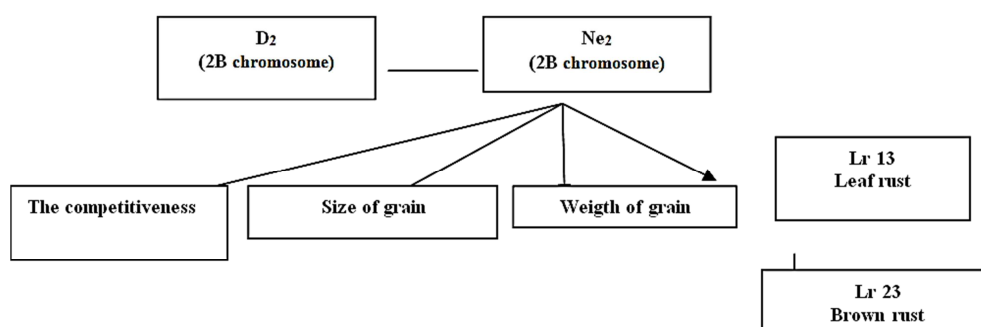


Fig. 1. The scheme of linkage of depression genes and economically important traits.

Significance of the hybrid depression problem is increasing due to the requirements of modern breeding of intensive forms of wheat. The simultaneous presence in one genotype of few dominant genes leads to the manifestation of different types of depression, which undoubtedly affects the efficiency of the selection process. Expression of the gene alleles individually determining each type of hybrid depression can cause different levels of depression of hybrid generation up to the plants lethality [7]. Naturally, when the genes of depression lead to the essential decrease of viability, the possibility of heterosis is minimized [8].

Widely spread natural negative mutations in the *Triticum* genus, their complementary nature, the divergence of members of the complementary systems of depression, their concentration in different eco-geographical zones, depending on their biotype and variety leading to the appearance of depressive hybrid plants cause serious difficulties in breeding process. One of the optimal methods to overcome depression and to get healthy hybrid generation is the application of natural heterogeneous variety on dominant genes of hybrids depression, that exhibit low level of depression in F₁. Another way to overcome hybrid depression is the creation of favorable conditions for cultivation [8]. In particular, it concerns the creation of optimal conditions for the growth and development of hybrids.

Zhang *et al.* [9] discussed the physiological domains in crop drought resistance as a major factor in the stabilization of crop performance in drought prone environments. The tolerance to stress is controlled by many genes, and their simultaneous selection is difficult. At the same time, the semi-dwarf varieties, also tolerant to stress because of their resistance to flustering by wind, rain and effectiveness in converting fertilizer input into higher yield [9], have the genetic basis that can be traced to a small number of genes. The tendency to taller dwarf cultivars with better resource (light, water, minerals) capture efficiency than shorter dwarf cultivars was discussed by Hawkesford [10]. It was revealed, that the genes, responsible for selection dwarfism, are mostly involved in the biosynthesis and signaling pathways of gibberellins [11].

The objective of our research was the application of mineral fertilizers for overcoming the wheat hybrid depression.

2. Materials and Methods

Our research on overcoming the hybrid depression of Dwarf I and Dwarf II was conducted on the basis of the Armenian Scientific Center of Agriculture of Ministry of Agriculture, located in Echmiadzin at Ararat region. The region is characterized by dry and sharply continental climate and the cultivation of agricultural crops is conducted under irrigation.

Considering agrochemical parameters of irrigated meadow-brown soils of the experimental area, under winter seeding of hybrids were introduced by following fertilizers: ammonium nitrate - 34% N, simple powdered superphosphate - 17% P₂O₅, potassium salt - 40% K₂O₄. The norm of fertilizer per 1 ha is N₉₀P₉₀K₇₅, while on 1m² accounted N-26,5g, P-53g, K-18,7g. The fertilizers were applied in the following terms: during basic tillage a full dose of potassium 18,7g and 70% phosphorus (37,1g), during pre tillage 8,8g (33%) N, simultaneously with seeding the rest of phosphorus 15,9g (30%) and in spring 17.7 g (67%) of nitrogen, as feeding after the snow, followed by harrowing the soil. The experiments were carried out in triplicate, the distance between rows was 20 cm, between plants 10 cm, the size of the accounting plots was 1m².

The scheme of experiment was as followed:

1. Dwarf I (♀Frisco x Amby♂) F₁ lethal form, as control
Dwarf I (♀Frisco x Amby♂) F₁ lethal form, with fertilizer
2. Dwarf II (♀Amby x Delfi♂) F₁ semi lethal form, as control
Dwarf II (♀Amby x Delfi♂) F₁ semi lethal form, with fertilizer

Statistical data processing was performed by Student's t-test

3. Results and Discussion

The influence of mineral fertilizers on the hybrid Dwarf I was detected. Based on the obtained data of lethal form of Dwarf I, the mineral fertilizers increased vegetative mass about 1.5-2 times, but the type of depression was not displaced (*Table 1*).

Table 1. The influence of mineral fertilizers (N₉₀P₉₀K₇₅) on the hybrid Dwarf I.

Samples	Height of plants, cm	Quantity of leaves per/plant	Weight per plant, gr
Dwarf I (Frisco x Amby) F ₁ Control	12,70±1,40	8,90±1,50	9,30±0,66
Dwarf I (Frisco x Amby) F ₁ , with fertilizer	23,70±1,0*	18,90±1,20*	14,30±0,8*

Average value ± standard deviation (n=3), * the differences are significant as compared to the control hybrid Dwarf I (p< 0.05).

According to the obtained data, the differences between control plants of hybrid Dwarf I and hybrid Dwarf I treated with fertilizer, for all morphological parameters of studied traits were revealed. For hybrid Dwarf I treated with fertilizer

in comparison with the control plants significantly higher parameters of height of plants, quantity of leaves and weight per plant were detected.

Semi lethal form of dwarfness was undergone to certain,

but small changes. All parameters of investigated traits with fertilizer increased by 1.2 - 1.6 times. The hybrid depression

type semi lethal form of Dwarf II was not changed (Table 2).

Table 2. The influence of mineral fertilizers ($N_{90}P_{90}K_{75}$) on elements of productivity of hybrid Dwarf II.

Samples	Height of plants, cm	Product. tillering per/plant	The length of the ear, cm	Grain yield per plant, gr
Dwarf II (Amby x Delfi) F1 Control	25,3±0,9	4,0±0,2	6,7±0,3	0,75±0,09
Dwarf II (Amby x Delfi) F1 with fertilizer	31,0±1,44*	5,0±0,17**	8,6±0,3*	1,1±0,10*

Average value ± standard deviation (n=3), * the differences are significant as compared to the control hybrid Dwarf II ($p < 0.05$), ** the differences are insignificant as compared to the control hybrid Dwarf II ($p > 0.05$).

On the base of obtained results, the differences between control plants of hybrid Dwarf II and hybrid Dwarf II treated with fertilizer, for all morphological parameters of studied traits were revealed. Regarding to the parameters of height of plants, length of ear and yield per plant significantly higher level in comparison with control plants was detected. In contrast, for productive tillering, the detected difference was insignificant. The results obtained support the statement, that the yields of both genetic and environmental manipulations are important for advanced crop production to maximize growth rate and yield [12].

Laghari et al. [13] compared three wheat varieties (TD-1, T.J-83 and Mehran-89) treated with nine levels of NPK fertilizer (0-0-0, 60-60-00, 60-60-30, 120-60-00, 120-60-60, 180-60-00, 180-60-90, 240-60-00 and 240-60-120 kg/ha-1), that significantly enhanced growth, yield and nutrient uptake traits of wheat. Optimal was application of 120-60-60 NPK kg/ha-1 to TD-1 variety that induced maximum of investigated parameters.

According to the Jan et al. [14] nitrogen presents major element of the fertilizer for a good yield, being closely linked to the vegetative growth and hence determining the fate of reproductive cycle. It was demonstrated, that the each increment of nitrogen fertilizer responded better to growth and yield of cultivars [12]. Laghari et al. [13] state, that most favorable nitrogen efficiency in wheat can be reached by optimal fertilizer rate application and management techniques. Data for various parameters of the crops were collected and analyzed by them to determine the influence of varying nitrogen levels (zero, 70, 140 and 210 kg N ha-1) applied to wheat cultivars. By Loddo and Gooding [15] the modern shorter varieties of wheat justify, economically, a greater use of N fertilizers due to increase of land-use efficiency (yield/ha). The introduction of dwarfing genes by breeders allowed the production of varieties with high leaf N content and enhanced sink capacity [16].

Physiological and genotypic differences in K efficiency (the capacity of a genotype to grow and yield well in soils low in available K), and their application in breeding programs to enhance K efficiency were discussed in review by Rengel and Damon [17].

Not less important is the problem of enhancing the P efficiency for wheat growth and yield due to genotypic differences. By Ortiz-Monasterio et al. [18] “many soils have large reserves of total phosphorus, but low levels of

“available” phosphorus”. Authors cite the paper of Al-Abbas and Barber [19] that total soil P is often 100 times higher than the fraction of soil P available to crop plants.

4. Conclusion

We have studied the influence of mineral fertilizers ($N_{90}P_{90}K_{75}$) on the growth and development of hybrids Dwarf I (lethal form) and Dwarf II (semi lethal form) wheat hybrids as possible way to overcome the hybrid depression. It has been shown that the application of mineral fertilizers ($N_{90}P_{90}K_{75}$), in the case of hybrid Dwarf I (lethal form) lead to the increase in vegetative mass, but the type of depression was not changed. The semi lethal form of Dwarf II although has undergone some changes, but retained the hybrid type of dwarfism. We suppose that this is the result of strong allelic complementation of hybrid depression genes that lead to blocking of endogenous active substances and disturbance of several physiological processes.

References

- [1] Tsunewaki K., Nakai Y. (1967). Distribution of necrosis genes in wheat. I. Common wheat from Central Asia. *Canad. Jour. Genet. and Cytol.*, 9 (1): 69-74.
- [2] Zeven A. C. (1970). Geographical distribution of genes causing hybrid dwarfness in hexaploid wheat of the old world. *Euphytica*, 19: 33-39.
- [3] Pukhalskiy V.A., Martynov S.P., Dobrotvorskaya T.V. (2000). Analysis of geographical and breeding-related distribution of hybrid necrosis genes in bread wheat (*Triticum aestivum* L.). *Euphytica*, 114: 233-240.
- [4] Zeven A. C. (1981). Eight supplementary list of wheat varieties classified according to their genotype for hybrid necrosis. *Euphytica*, 30: 521-539.
- [5] Austin R.B. (1999). Yield of wheat in the United Kingdom: recent advances and prospects. *Crop Science* 39, 6:1604-1610.
- [6] Miralles D. J. and Slafer G. A. (2007). Sink limitations to yield in wheat: how could it be reduced? *The Journal of Agricultural Science*, 145:139-149.
- [7] Hermesen J. G. (1966). Hybrid necrosis and red hybrid chlorosis in wheat. *Hereditas*, suppl., 2: 439-452.

- [8] Hermesen J. G. (1963). Hybrid necrosis as a problem for the wheat breeder. *Euphytica*, 12(1): 1-16.
- [9] Zhang X., Chen X., Wu Z., Zhang X., Huang C., Cao M. (2005). A dwarf wheat mutant is associated with increased drought resistance and altered responses to gravity. *African Journal of Biotechnology*, 4 (10):1054-1057.
- [10] Hawkesford M. J. (2014). Reducing the reliance on nitrogen fertilizer for wheat production. *Journal of Cereal Science*, 59:276-283.
- [11] Claeys H., De Bodt S., Inzé D. (2013). Gibberellins and DELLAs: central nodes in growth regulatory networks. *Trends in Plant Science*, 1–9.
- [12] Ali H., Ahmad S., Ali H., Hassan F. S. (2005). Impact of Nitrogen Application on Growth and Productivity of Wheat (*Triticum aestivum* L.) *J. Agri. Soc. Sci*, 1(3):216–218.
- [13] Laghari G. M., Oad F. C., Tunio S., Gandahi A. W., Siddiqui M. H., Jagirani A. W., Oad S. M. (2010). Growth, yield and nutrient uptake of various wheat cultivars under different fertilizer regimes. *Sarhad J. Agric*, 26 (4):489-497.
- [14] Jan T., Jan M. T., Arif M., Akbar H., Ali S. (2007). Response of wheat to source, type and time of nitrogen application. *Sarhad J. Agric.*, 23(4):871-880.
- [15] Loddo S. and Gooding M.J. (2012). Semi-dwarfing (Rht-B1b) improves nitrogen-use efficiency in wheat, but not at economically optimal levels of nitrogen availability *Cereal Research Communications*, 40(1):116-121.
- [16] Makino A. (2011). Photosynthesis, Grain Yield, and Nitrogen Utilization in Rice and Wheat. *Plant Physiology*, 155(1): 125–129.
- [17] Rengel Z. and Damon P. M. (2008). Crops and genotypes differ in efficiency of potassium uptake and use. *Physiologia Plantarum*, 133: 624–636.
- [18] Ortiz-Monasterio J.I., B.Manske G.G., van Ginkel M. (2001). Nitrogen and Phosphorus Use Efficiency in “Application of Physiology in Wheat Breeding” Reynolds, M.P., J.I. Ortiz-Monasterio, and A. McNab (eds.). Mexico, D.F.: CIMMYT.
- [19] Al-Abbas A.H. and Barber S.A. (1964). A soil test for phosphorus based upon fractionation of soil phosphorus. I. Correlation of soil phosphorus fractions with plant-available phosphorus. *Soil Science Society of America Proceedings*, 28:218-221.