ISSN : 0974 - 7435 Volume 7 Issue 11

BioTechnology
An Indian Journal

FULL PAPER

BTAIJ, 7(11), 2013 [459-465]

Technical process for crop grey breeding

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ABSTRACT

In this paper, applying the idea of system theory, combining the theory of conventional breeding, crop grey breeding theory and the crop genetic law of main quantitative traits, the technical process of crop grey breeding were summarized, including six core technology innovations such as formulation, match, selection, comparison, approval and utilization. It has important guiding significance to put forward the technology process, for overcoming limitations of the traditional experience breeding such as long cycle, big blindness, improvident and low selection efficiency, and realizing the informalization, quantification and scientization of crop breeding. At present, 24 new crop varieties has been developed using the technology process, which verify the feasibility of the technology process from the perspective of breeding practice.

KEYWORDS

Crop;
Grey breeding;
Technology;
Process.

INTRODUCTION

The technical process of crop grey breeding is a new effective technology route for breeding crop new varieties proposed by author engaging in the grey breeding research for years, applying system theory thought, combining the crop conventional breeding theory[1-5] with the grey breeding theory[6-8] and the genetic rules of main quantitative traits for crops, which can make up for the shortage of the traditional experience breeding to some extent, and can realize informalization, quantification and scientization of crop breeding. After sharpening, filling in articles or in discussion, or summing up in theories or putting into practice, this technical course or process has achieved good results since it was proposed, and has a certain guiding significance for crop breeding. For this reason, we briefly introduce it, and expect to provide a new way for breeding crop new varieties.

TECHNICAL PROCESS FOR CROP GREY BREEDING

Technical process for crop grey breeding can be summed up in six words: that is formation, match, selection, comparison, approval and utilization, representing six different key links of crop breeding process respectively. These six links are one indivisible entirety, neither can exist effectively without the other.

Formation: that is setting breeding targets.

Set the breeding targets and selection criteria applying the ecology theory and the theory of market demand. analyze on breeding target characters by grey relativity analysis method[9], clear relationships between them, and lay the foundation for later selection. Breed-

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ing targets have dynamic nature, as the increasing of level of the yield, quality and other characters, the corresponding changes of them should also be followed, and constantly be adapted to meet the multifaceted growing needs of peoples.

Match: that is to produce hybrid combinations.

After a preliminary observation of better breeding materials, their combining ability and genetic distance are determined in a planned way, purposefully and systematically. Connecting with the breeding targets, applying the method of grey classification for parents[10], screen out better parents based on the principles of selecting parents[4], produce the high quality hybrid combinations.

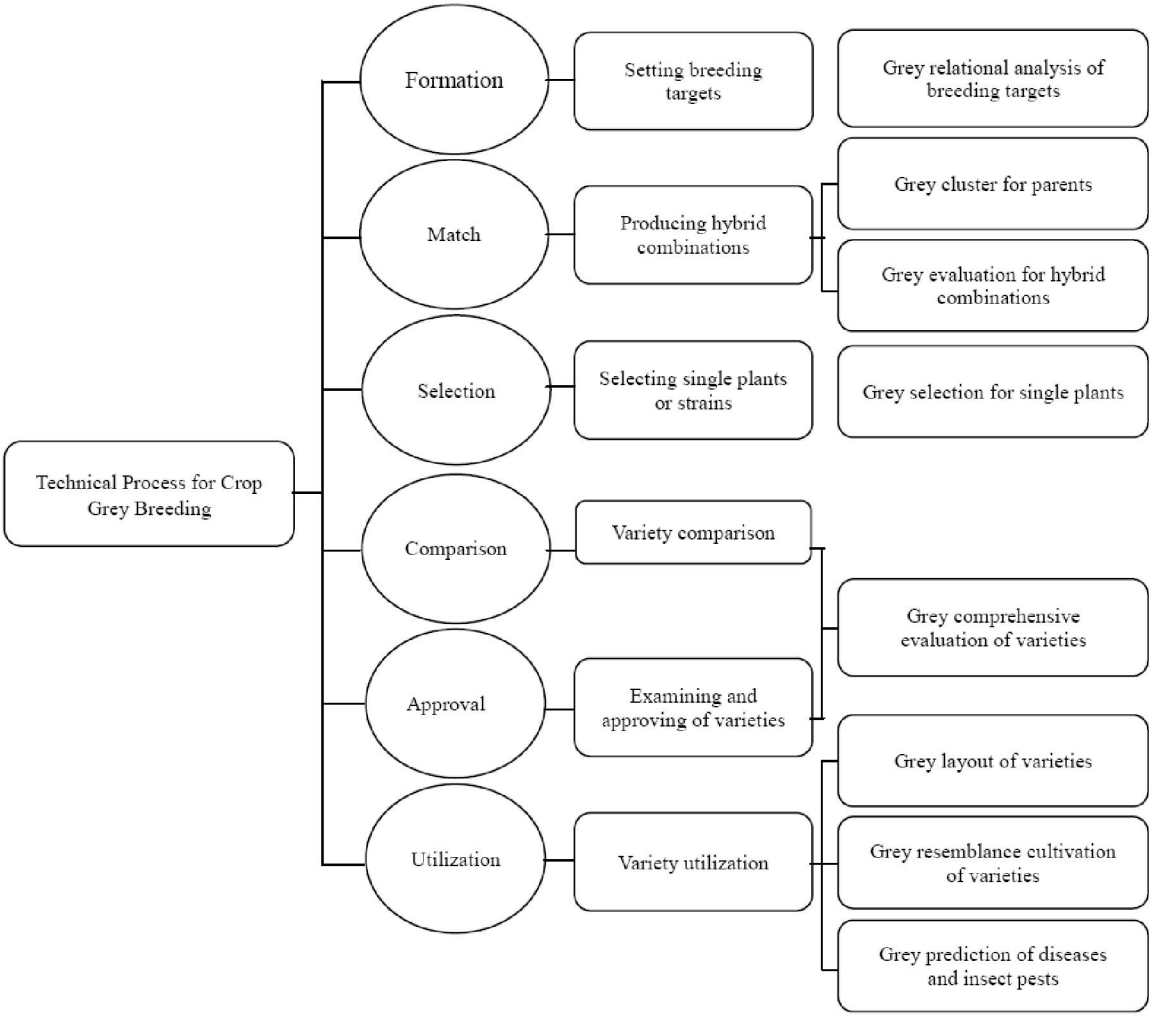

Figure 1 : Technical process for crop grey breeding

To overcome the blindness and improve predictability, using the method of grey evaluation of hybrid combination[11-13], F_1 hybrid combinations are evaluated, and key combinations in early generations are determined, so as to concentrate on the selection of key combinations as early as possible, and improve selection efficiency.

Selection: that is to select single plants or elite strains.

In accordance with the breeding targets, select superior single plants or elite strains. This link, with particular emphasis on synergistic effect of various traits, should select single plants or strains with better integrated traits, not only one with a better trait. Applying single grey selection method[14], evaluate the grade of single plant comprehensively, and decide to accept or reject them. In General, the first-class single plants evaluated are key single plants in the process of single plant selection, should be priority observation and selection in later generations; and the second-class single plants are common ones, should be planted, observed and

selected continuously; and the third-class single plants should be eliminated.

It should be pointed out that, in the process of single plant selection, the appropriate application of molecular marker assisted selection technique can effectively improve the accuracy of selection, and further raise the breeding level.

Comparison: that is varieties (or strains)comparison.

Namely let superior varieties (or strains) join the strain identification, variety comparison test and new varieties demonstration test, evaluate varieties (or strains) objectively and reasonably. For the dynamic management of crop breeding process system, plant breeders should obtain as much information about the gap between the overall level of strains and the breeding expectation value (breeding target value) from the above tests, which is feedback to plant breeders, so as to further adjust the breeding strategies, determine the main direction of breeding in future.

Using multidimensional comprehensive evaluation method[7,16-18], and combining with variance analysis results, comprehensively evaluate varieties (or strains) joined the strain identification, variety comparison test and new varieties demonstration test from multiple traits related to breeding targets, and determine utilization value of new varieties in large area production or in breeding.

Approval: Namely the examination and approval of varieties.

Extend new varieties (or strains) passed through the provincial or national regional test, and production test of new varieties (or new strains) and released from the provincial or national variety certification commission to wide use in the production.

Utilization: namely variety utilization.

Utilize varieties scientifically and reasonably, including identifying appropriate area and scope of varieties, making variety layout decision, realizing matching good varieties with good cultivation method, speeding up the elite seed production, etc., maximizing the potential of the yield and quality of new varieties.

Varieties reasonable layout: Adopting the analysis method of crop variety grey layout[19,20], make the reasonable layout of new better varieties showed in the varieties of regional and demonstration test, determine the most suitable planting area or range of new varieties, and provide the persuasive analysis results for the agricultural decision-making departments to write varieties using opinions. Above analysis method make the ecotype varieties be more consistent with ecological characteristics of the ecological type area, and composition structure of varieties be more reasonable, basically achieving a ecological type area having a variety synusia, avoiding unreasonable layout in the whole province or several ecological areas to unify promotion of several varieties, which can not only give full play to the potential of yield and quality of new strong universality varieties, but also can make some special adaptive varieties play their proper role.

Forming a complete set of fine variety and good cultivation measures: Using theory and method of varieties grey resemblance cultivation[21], obtain the grey resemblance degree in cultivation characteristics among new varieties (to be recommended varieties) and the large area commercial varieties, thus determine the cultivation type of the new varieties. Unique feature of this method is able to conduct similarity analysis using the data from variety regional test, seek the most similar large area commercial varieties to new varieties without cultivation experiment, and make cultivation technical measures of these large area commercial varieties for its use, in the year when the new varieties is extending directly form a complete set of fine variety and good cultivation measures, which overcomes the disjointed phenomenon between the good variety and the good cultivation measures for a long time, being of great significance to give full play to the potential of yield and quality of new varieties.

Forecast and control of diseases and pests: Under the current breeding level, it is almost impossible to expect all crop varieties resistant to pests and diseases, therefore, timely predict crop diseases and insect pests is very necessary. Consequently, we should adopt theory and method of grey prediction of plant diseases and insect pests[7,8], timely predicting diseases and insect pests of main crops, enabling farmers to make sufficient mental preparation and physical preparation, preventing from occurence of diseases and insect pests, so as to give full play to the production potential of varieties.

Now that the technical process of crop grey breeding have completed a cycle (period). Then go round and

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round, stepwise cycle for the second cycle, the third cycle and multiple cycles. It should be noted that each cycle is not simple repetition of original cycle. Especially the breeding targets, with the unceasing change of agricultural production and ecological condition, need breeding workers standing at a higher level, adjusting and improving them continuously. In this way, each new cycle is more advanced than the original cycle, promoting constantly advancing to the new and higher level of crop breeding.

APPLICATION OF TECHNICAL PROCESS OF CROP GREY BREEDING IN CROP BREEDING

At present, the technical process of the crop grey breeding has been widely used in crop breeding, using this technical process, we have bred 24 new varieties such as wheat, mung bean, cotton, black-eyed peas, sweet corn, pumpkin, mulberry, high quality silkworm and 3 new ryegrass strains (TABLE 1), which has a

TABLE 1 : Crop new varieties bred by the technical process of crop grey breeding

Crop type	Variety Name	Breeding Organization	Examining and Approving Department (Years)	Awards situation
Wheat	Anmai No.1	Anyang City Academy of Agricultural Sciences	Crop Variety Certification Committee of Henan Province (2001)	Second prize of scientific and technological achievements of Henan agricultural sciences system (2006)
	Anmai No.7	Anyang City Academy of Agricultural Sciences	Crop Variety Certification Committee of Henan Province (2004)	Second prize of scientific and technological achievements of Henan agricultural sciences system (2008)
	Yumai No.35	Neixiang County Institute of Agricultural Sciences	Crop Variety Certification Committee of Henan Province (1995)	First prize of scientific and technological progress of Henan province (1999)
	Yumai NO.57	Luohe City Academy of Agricultural Sciences, Anyang City Academy of Agricultural Sciences	National Crop Variety Certification Committee (2003)	Second prize of scientific and technological achievements of Henan agricultural sciences system (2001)
Mung bean	Yulv No.3	Anyang City Academy of Agricultural Sciences	Crop Variety Certification Committee of Henan Province (1999)	First prize of scientific and technological achievements of Henan agricultural sciences system (2002)
	Anyan black mung bean No.1	Anyang City Academy of Agricultural Sciences	—	Second prize of scientific and technological achievements of Henan agricultural sciences system (2006)
	Anyan black mung bean No.2	Anyang City Academy of Agricultural Sciences	—	Second prize of scientific and technological achievements of Henan agricultural sciences system (2009)
Millet	Yugu No.12	Anyang City Academy of Agricultural Sciences	National Millet Variety Identification Committee (2006)	—
	Yugu No.13	Anyang City Academy of Agricultural Sciences	National Millet Variety Identification Committee (2007)	—
	Yugu No.14	Anyang City Academy of Agricultural Sciences	National Millet Variety Identification Committee (2008)	—
	Yugu No.15	Anyang City Academy of Agricultural Sciences	National Millet Variety Identification Committee (2009)	—

Crop type	Variety Name	Breeding Organization	Examining and Approving Department (Years)	Awards situation
Cotton	Zhongmiansuo No.41	Cotton Reaserch Institute, Chinese academy of agricultural sciences	National Crop Variety Certification Committee (2002)	Second prize of national scientific and technological progress (2009)
	Zhongmiansuo No.45	Cotton Reaserch Institute, Chinese academy of agricultural sciences	National Crop Variety Certification Committee (2003)	Second prize of Xinjiang scientific and technological progress (2009)
	Fumian No. 289	Qi County Stock Seed Farm, Henan Province	Crop Variety Certification Committee of Henan Province (2008)	
	Fuza No.5	Qi County Stock Seed Farm, Henan Province	Crop Variety Certification Committee of Shanxi Province (2010)	
	Fuza No.3	Qi County Stock Seed Farm, Henan Province	Crop Variety Certification Committee of Henan Province (2011)	
	Daiza No. 2	Qi County Stock Seed Farm, Henan Province	Crop Variety Certification Committee of Henan Province (2011)	
Soybean	Andou No.1	Anyang City Academy of Agricultural Sciences	Crop Variety Certification Committee of Henan Province (2009)	—
Cowpea	Zaocuic cowpea	Department of Agronomy, Jianghan University	Crop Variety Certification Committee of Hubei Province (2000)	—
Silkworm	Ecan No.3 (895×892)	Fruit Tea, Sericultural and mulberry Research Institute, Hubei academy of agricultural sciences	Crop Variety Certification Committee of Hubei Province (2003)	First prize of scientific and technological progress of Hubei province (2005)
High quality Mulberry	Eyou No. 1	Fruit Tea, Sericultural and mulberry Research Institute, Hubei academy of agricultural sciences	Crop Variety Certification Committee of Hubei Province (2003)	—
	Esan No.1	Fruit Tea, Sericultural and mulberry Research Institute, Hubei academy of agricultural sciences	Crop Variety Certification Committee of Hubei Province (2003)	—
Pumpkin	Jinli	Hunan Institute of Melon	Crop Variety Certification Committee of Hunan Province (2000)	
Sweet corn	Huanmei No. 168	South China Agricultural University	Crop Variety Certification Committee of Guangdong Province (2008)	

huge social and economic benefits[22]. Thus, the feasibility and application value of the technological process has been proved from the angle of breeding practice.

DISCUSSION

Compared with the traditional qualitative experience breeding, the technology process has the following distinctive features:

Technical route having a unique style:

In accordance with the technical process of crop grey breeding, formulate breeding targets using principle of grey relationship analysis of breeding targets, select parents and prepares hybrid combinations using the principle of the parents grey classification, determines the F_1 key combinations using principle of grey evaluation for hybrid combinations, accept or reject single plants using principle of single plant grey selection, evaluate new varieties comprehensively using principle of grey multidimensional comprehensive evaluation, seek the optimal ecological type for new varieties using principle of grey layout, guide a complete set of good varieties with good cultivation measures using the principle of grey resemblance cultivation; predict crop diseases and insect pests using the principle of the grey forecasting. The technology route is obviously a step forward compared with the traditional experience breeding.

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Combining the qualitative with the quantitative

Application of grey breeding theory and method is an effective supplement to the traditional experience breeding. It both borrows from precious experiences of breeders which have been accumulated for many years, and overcomes some shortages of the traditional experience breeding in some ways, makes the crop breeding rise to the stage of combining qualitative with quantitative from the stage of qualitative experience, which makes it possible for crop breeding developing to more sophisticated discipline from qualitative descriptive discipline.

Selection being more accurate and reliable

Application of grey breeding theory in crop breeding has achieved the quantification and standardization of various key links of breeding process, so its processing results are relatively reliable, avoiding the decision-making errors of traditional breeding caused by inexperienced breeder, effectively improving the utilization of hybrid combinations, enhancing the selection effect and selection efficiency.

Intelligent degree to get a significant boosting

In order to put the technical process of crop grey breeding into practice in the process of breeding, and to get effective application, we have developed a computer decision-making system for crop grey breeding[7]. Development and utilization of the system make the intelligent degree of crop breeding be greatly increased, which provides a convenient and fast technology platform for breeding workers. The operation of the system is simple, easy to be grasped, even the green hand can also gain the decision-making level as breeding expert. Also it can make breeders liberate from busy data processing tasks, effectively improving the breeding efficiency. Therefore, it has a broad application prospect.

Of course, as with any new theories and methods, the technical process of crop grey breeding also needs to continuously improve and update. Combining with molecular marker assisted selection technology will be an important research direction in the research of technical process of crop grey breeding in future. At the same time, many experts and scholars have achieved plenty of fruits in the research area of crop breeding, therefore, mixing the technical process of crop grey breeding and their research fruits together and making its more perfect also will be an important work to has to do in the future for a long time.

ACKNOWLEDGMENTS

The authors express their thanks to the following projects: Basic and Forward Technology Foundation in Henan Province under Grant No. 092300410; Key scientific and technological project of Henan province under Grant No. 112102110001.

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