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PHYSIOLOGICAL STRATEGY IN COTTON BREEDING

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Abstract

The results of long-term integrated research work on the design of the physiological tests with reference to breeding of new cotton varieties, correlation analysis of photosynthetic indices with quantity and economic quality of cotton yield, scheme of selection of high-productive cotton forms on the basis of photosynthetic test-traits are reported. The possibility of applying these test-traits in breeding of high-productive cotton varieties and hybrids in combination with traditional methods of breeding is justified and proved.

Introduction

Breeding of high-productive varieties – is a major factor of plant-growing intensification. The agricultural production requires new crop varieties and hybrids with the best combination of valuable properties, resistant to diseases, wreckers and extreme environmental factors. At present it's hard to look forward to successful creation of such varieties if to do no more than to carry out analysis and apply morphological, biological and economically valuable traits, which traditionally were the basis for breeding with the purpose to increase the productivity and improve the quality of agricultural production. Present crop plants' varieties were selected with the help of these traits and classic methods of breeding so, that many from them practically have come nearer to a limit of the biopotential productivity.

Modern breeding of crop plants requires combination of classic methods of selection with both fundamental achievements and methodical approaches of genetics, physiology, biochemistry, phytopathology. According to these requirements the breeding should to carried out on the basis of knowledge of physiology, biochemistry and genetics of the initial breeding material, analysis and registration of components of production process, such, as photosynthesis and photorespiration, dark respiration, transport and partitioning of assimilates, source-sink relations, etc.

These productivity indices were insufficiently taken into account by the majority of breeders and were not introduced into their arsenal of methods and approaches. In particular, the photosynthetic indices as establishing component of yielding process are very seldom taken into consideration in practical selection for increase of plant productivity [1].

During many years the stuff of the Institute of Plant Physiology and Genetics, Academy of Sciences of the Republic of Tajikistan carries out integrated research work on elaboration of photosynthetic test with reference to breeding new varieties of middle staple cotton (*Gossypium hirsutum L.*). Our report is the result of 20 years' research work (from 1982 till 2001) in this field.

Materials and Methods

The material for our experimental work served different genotypes of middle staple cotton (*Gossypium hirsutum L.*): more than 150 varieties, hybrids and original samples, obtained from different selection centers of Central Asia and Azerbaijan, and also from USA, countries of Latin America, Africa and Asia (from the collection of All-Union Scientific Research Institute of Cotton Breeding named after G.S.Zaitsev, Nowadays Uzbek Scientific Research Institute of Cotton Breeding, Uzbekistan), marker inbred lines from genetic collection of middle staple cotton, kindly submitted to our disposal by D.A.Musaev, the academician of Academy of Sciences of Republic of Uzbekistan and professor M.F.Abzalov (Institute of Plant Genetics and Experimental Biology of Academy of Sciences of Republic of Uzbekistan), and also varieties and hybrids available in the collection of the Institute of Plant Physiology and Genetics of the Academy of Sciences of Republic of Tajikistan. The nethods of viual observation as well as quantitative determination of morphological-anatomical and physiological-biochemical parameters of photosynthesis (from rather simple up to most composite, wearing, integral character), equipment, ways and time of sampling are described in details in the paper [2].

Results and Discussion

The results of long-term integrated investigation of the indices of photosynthesis in cotton and their role in the yield formation have proved that the following traits can serve as the tests for estimation of the activity of photosynthetic apparatus in plants with the purpose to pick up the breeding cotton varieties with high crop of high quality: size, colour and growth rates of cotyledons; colour, shape and lobation of the true leaves, angle of the basis of the leaf; number of leaves per plant, length, width and area of the leaf, total leaf area per plant, leaf efficiency (leaf area per one boll, correlation between photosynthesizing leaf mass and number of bolls or mass of seed-cotton); stomatal and mesophyll conductance, or their contrary values stomatal and mesophyll resistance to carbon dioxide transfer; structural and functional leaf mesostructure parameters and specific leaf weight; number of chloroplasts in cells; chlorophyll contents in leaves and aphyllous organs (summary of the chlorophyll in all the green assimilating CO_2 organs), chlorophyll fluorescence characteristics; plant's chlorophyll potential; photoreducing chloroplasts' activity and photosystems [rate of reducig NADP by exogenic ferredoxin (test for activity of photosystem I and photosystem II), and the rate of the reducing $K_4Fe(CN)_6$ (test for the activity of photosystem II)], efficiency of the rate of electrons transport with phosphorylation (photosynthetic control); contents and activity of ribulose-1,5-bisphosphate carboxylase/oxygenase (RUBISCO) enzymes and relation of carboxylase function to oxygenase activity; maximal value of the intensity of apparent and potential photosynthesis in leaves and whole plant.

The above mentioned photosynthetic tests-traits for cotton have broad phenotypical variability and are characterized by high level of heritability (table. 1), they positively correlate with components of economically yield (table 2) and technological qualities of fiber [3-4]. Therefore they are fit for breeding and it is possible to carry out breeding of the best genotypes with high productivity applying these photosynthetic indices.

Breeding according to photosynthetic tests-traits is conducted under the following scheme.

In the first year of the experiment it is necessary from the nursery collection to pick up species with high intensity of photosynthesis and productivity for hibridization on beforehand established "photosynthetic passport" as the maternal form, because these peculiarities are inherited on maternal line [2].

In the second year from a population of F_1 hybrids, according to the nature of inheritance and dominance of traits the best samples with high indices of photosynthesis, productivity and resistance to diseases and wreckers are selected.

In the third year of the experiment, taking into consideration that the intensity of photosynthesis is under control of dominant genes and its heretability both in broad (^{2}), and in narrow (h^2) sense have sufficiently high values (table 1), selection and rejection start in F_2. From the population of F_2 hybrids first of all we selected the plants with high intensity of photosynthesis and productivity (25%), and the individual samples, taken from these groups of plants, are transmitted in breeding nurseries. Plants with low intensity of photosynthesis and productivity (25 %) are rejected and samples from the stayed plants (50 %), which one have intermediate values of the traits close to photosynthesis of F_1 hybrids are transmitted to the breeding nurseries for the subsequent selection.

During the fourth year of the experiment in breeding nursery the careful analysis of isolated of lines to photosynthetic and economically-valuable traits is conducted. Determination of technological qualities of fiber is carried out. The lines with successful combination of photosynthetic and crop indices of better quality are transmitted on stationary and competitive variety trials. After competitive trials the new variety runs last determination of its qualities and the question of its transmission to State variety-trials is decided. The course of the creation of new crop varieties applying photosynthetic traits is 2-3 years shorter.

Breeding according to this scheme applying photosynthetic tests combined with traditional approaches proved to be successful in the creation of new high-productive cotton varieties and hybrids. Burnashev Sh.T. and Abdullaev Kh.A., etc., have created and handed on a State variety-trials new perspective varieties of middle staple cotton – Rokhaty, Guliston, Guliston-2, Ravshan, Somoni (Safedak) and Shavkat-80. Varieties Guliston since 1994 and Guliston-2 since 2001 are widely spread through the fields of the Republic of Tajikistan and sown on the area more than 10000 hectares.

Major physiological features of these varieties are high photosynthetic productivity, effective utilization of photoassimilates for formation of fruiting organs and heightened resistance to diseases, wreckers and unfavorable environmental factors. For example, the variety Guliston has high resistance to verticillous wilt, only 5-10 % of plants is disease, its vegetation period is 120-122 days. The average productivity of Guliston is 4,0-4,5 t per ha, that is 10-15 % above standard varieties(108-F, Tashkent-1,Namangan-77), the ripeness is 6-8 days higher, with large fiber output (2-3 % more) and better quality of a yarn.
Thus, the adduced data testify that the actuation in the arsenal of breeding process of physiological tests-traits and application of the scheme of breeding on photosynthetic indices, alongside with other methods of breeding, enables to speed up creation of new varieties and hybrids with high potential of yield and better quality of commodity.

References

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Table 1. Heritability of Photosynthetic Traits in Cotton.

Photosynthetic traits	Values of heritability	
	Broad-sense (H^2)	**Narrow-sense (h^2)**
Activity of RUBISCO enzymes, Mmol/dm^2 min	0.64-0.95	0.82-0.91
Chlorophyll content, mg/g fresh leaf weight	0.81-0.84	0.77-0.84
Number of chloroplasts in cell	0.68-0.97	0.61-0.64
Carbon exchange rate (CER), mg CO_2/dm^2 h	0.76-0.92	0.70-0.89
Specific leaf weight	0.88-0.96	0.77-0.85
Number of leaves per plant	0.73-0.92	0.29-0.53
Leaf area (LA), dm^2/plant	0.68-0.80	0.42-0.72
Net assimilation rate (NAR), g/m^2 day	0.84-0.94	0.18-0.59
Leaf efficiency (LE)	0.61-0.73	0.19-0.48

Table 2. Correlation Coefficient between Photosynthetic Indices and Yield Components in Cotton.

	Photosynthetic indices					
	leaf area, dm^2/plant			carbon exchange rate, mg CO_2/dm^2·h		
Cotton yield components	**1***	**2**	**3**	**1**	**2**	**3**
Dry matter weight, g/plant	0.84	0.85	0.79	0.56	0.68	0.71
Seed cotton yields, g/plant	0.49	0.48	0.37	0.45	0.38	0.45
Harvest index, Hi	0.65	0.71	0.55	0.73	0.55	0.43
Bolls number, per plant	0.84	0.86	0.79	0.57	0.47	0.30
Bolls weight, g	0.38	0.49	0.31	0.04	0.08	0.18

* - Plant developmental stages: 1 – squaring; 2 – flowering; 3 – fruiting.