Development of self-pollinated maize lines based on the teosinte collection of the N.I. Vavilov institute of plant industry (VIR)

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Abstract. The decline in the genetic polymorphism in maize is a cause of concern for many breeders. VIR maize collection represents the world's maize variety over the past 100 years. The results of the study of maize quantitative properties based on 169 samples from the VIR collection created with the teosinte are shown. KB 595 hybrid, which belongs to the late-season group and is prone to multi-cob was used as a standard. Sowing and evaluation of phenotypic traits were carried out for 2 years in the foothills of Kabardino-Balkaria, in conditions of sufficient soil moisture, in the optimal time. All measurements were carried out on 10 plants with average values of 2 years and an LSD0.05. The results of the research allocated a core collection of 21 samples that promising for hybrid maize breeding and are characterized by significant height and leafiness of the stem, as well as a tendency to form 2 or more cobs on one stem. It has been suggested that the involvement of the selected core collection of 21 samples in thybrid maize breeding programs will significantly expand its genetic polymorphism and increase grain yield in hybrid combinations.

1 Introduction

Maize is one of the most common crops in world agriculture. Among the main grains, maize is the second largest crop, second only to wheat [1].

The state of and prospects for the development of modern crop production are evaluated by the degree to which the objective of providing food to the world's population has been achieved. Agricultural production will have to produce as much food as it has produced during the entire period of human existence [2]. Taking into account the evolution of maize from teosinte for more than 6,000 years, it should be noted that maize has achieved great genetic diversity through its genome selection and has become one of the food sources for many peoples on our planet [3.4].

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The challenge of increasing food production directly depends on an increase in gross food grain and feed grains. Maize as the most productive grain fodder crop has an important role in the solution of the grain problem. The level and quality of maize grains largely depend on the implementation of new high-yield varieties and hybrids into production, as well as the use of research-based technology for their cultivation [5]. In the Russian Federation, technologies for the deep processing of grains are becoming increasingly common, with more end products, including starches with different thermodynamic properties [6.7].

All this indicates that the expansion of maize cultivation is an obvious need, that maize should be given special attention, as a crop that produces high yields and enables the full provision of livestock with succulent and concentrated feed, and industry with raw material for processing [8].

The development of high-yield hybrids is possible only if there are inbred lines that meet the requirements of the modern commercial maize grain and seed production market. Therefore, it is important to develop and study the source material for a number of economic attributes, such as: grain and green mass yield, speed of moisture recovery during grain maturation, resistance to the lodging and overmature of the root in the field, quantity characteristics of plant and cob, resistance to diseases and pests [9].

The trend in the reduction of genetic polymorphism of hybrid maize is currently a matter of concern [10, 11, 12]. It is known that the vast majority of inbred maize lines widespread among breeders are from only three American varieties [13, 14, 15]. The narrowing of the genetic base and the use of closely related genotypes contributes to the rapid spread of diseases to which varieties, lines and hybrids are susceptible, reducing the growth rate of crop yields. In this regard, there is an urgent need to find and involve in breeding programs new source material that concentrates on favorable characteristics. With the widespread use of interline hybrids, teosinte is a repository of germplasm and can serve as a starting material for the development of self-pollinated lines. One of the best opportunities for breeders to expand the genetic polymorphism of the initial material is to involve in the breeding process the sources and donors of valuable maize characteristics, concentrated in the VIR maize collection, which represents the world's maize diversity over the last 100 years [11].

Selecting the source material by origin and maturity group, reaction to the CMS, grain type, its biochemical composition and physiological characteristics during its maturation, structure of quantitative characteristics of plant and cob, resistance to various stress factors of the environment, the breeder can quickly develop a valuable starting material for the hybrid maize breeding. The use of haploinduction techniques can accelerate the production of inbred dihaploid lines within 2 years. For example, plant height is one of the most important morphological characteristics correlated with other indicators - cob initiation height, leafiness, lodging and productivity. Furthermore, plant height and cob attachment height are important in industrial maize technology, as well as in the selection of parental pairs at hybridization sites. The hybrid plants height often significantly depends on the parental plants height [16]. The number of leaves on a plant can be used to indicate the early or late maturity of hybrids, and to specify the ways in which the lines and the hybrids obtained by crossing them can be used.

The purpose of the research is to study the economically valuable morphological characteristics of the maize lines obtained using the Chalco teosinte from the VIR collection as the starting material for hybrid maize breeding.

2 Materials and methods

The material for the study was 169 middle-late (FAO 400-550) maize lines developed using Chalco teosinte from the VIR collection. For estimating plant height and cob fixation height, number of leaves and cobs a hybrid of the KBNIISH selection - KB 595 st from the FAO late maturity group was chosen as a standard.

The selection estimation of the VIR maize collection was carried out in 2018-2019. in accordance with the following methods: Dospekhov B.A. “The methodology of field experience” [17], Guidelines for the study and maintenance of corn collection samples, approved by the VASKhNIL VIR [18]. The description of morphological characteristics was performed according to “A wide unified classifier of CMEA and the international classifier of CMEA of the species *ZEA MAYS* L.” [19].

The research was carried out at the research and production site NPU No.1 (village Nartan, foothill zone) of the Institute of Agriculture of the Kabardino-Balkarian Scientific Center of the Russian Academy of Sciences. The NPU (research and production site) No.1 territory is located within the foothill zone of the North Caucasus and lies on the Urvan-Nalchik watershed.

The soil of the experimental site is represented by ordinary carbonate chernozem of a heavy loamy variety. The agrochemical composition of the soil of the experimental site (according to Chirikov) is represented by the following indicators: pH-7.2; labile P_2O_5 - 9.8 mg/100 g of soil; exchangeable K_2O -7.2 mg/100 g of soil; humus (according to Tyurin) - 4.4%. The arable horizon contains 3.9-4.2% humus, 18-27 mg of nitrogen, 27-34 mg of labile phosphorus and 230-250 mg of exchange potassium.

During the years of research the climate of the zone was moderately hot. The amount of active temperatures was 3000-3200^{0}C with moderate moisture (moisture coefficient - 0.5-0.9), hydrothermal coefficient 0.9-1.2. In early April, the average daily air temperature passed through + 10^{0}C. On average, the frost stopped at the end of the second decade of April. The frost-free period lasted until the end of October and amounted 190 days. Up to 17.5 days with strong winds were recorded per year. The amount of precipitation for the year was 615 mm, of which 75.8% (416 mm) were for the growing season.

The site area was 7.84m^2, the location of the sites was systematic. The row spacing was 0.7 m, the plant density was 50-60 thousand plants per 1 ha. According to the breeding program, all the necessary phenological observations for all the main phases of plant development were carried out on the studied samples during the growing season. The morphological characteristics of maize (plant height and attachment of economically suitable cobs, number of leaves on the main stem, number of cobs on a plant) were measured on 10 typical plants of each sample.

3 Research results

The analysis of the research results showed that all of the studied lines belong to the middle-late and late maturity groups according to FAO 400-550. From the studied 169 samples of the VIR collection, a selection of 21 best biometric genotypes was formed (Table 1). The main estimation criteria were: plants height, cob fixation height, number of leaves and number of cobs on a stem. None of the samples showed any tillering at standard planting density, despite the fact that the lines were developed on the basis of teosinte, which is characterized by a high degree of tillering. It should be noted that the selection of 21 samples included all samples with a multi-cob tendency. Indicator variation ranged from 1.0 to 2.45 cobs on average over 2 years (Fig. 1).

Table 1. Biometric characteristics of the matured maize plants of the VIR collection (2019-2020, foothill zone).

No.	Line name	Plant height, m			Attachment height of economically suitable cob, m			The number of leaves on the main stem, pcs.			Number of economically suitable cobs on one plant, pcs.		
		2019	2020	2-year average	2019	2020	2-year average	2019	2020	2-year average	2019	2020	2-year average
1	KB 595 st	2.21	2.15	2.18	0.88	0.82	0.86	15.4	16.0	15.5	1.4	1.6	1.5
2	MP 151 A yellow	2.42	2.37	2.40	1.18	1.08	1.13	17.0	17.0	17.0	2.1	1.9	2.0
3	MP 153 V yellow	2.67	2.64	2.66	1.43	1.35	1.39	16.0	16.5	16.25	1.9	2.2	2.15
4	MP 75 B yellow	3.01	2.88	2.95	1.61	1.54	1.58	16.2	15.4	15.9	2.3	2.6	2.45
5	MR 16616-5	2.79	2.75	2.77	1.11	1.08	1.10	15.0	16.0	15.5	1.1	1.3	1.25
6	MR 16616-8	2.41	2.44	2.42	1.29	1.22	1.26	14.8	15.6	15.2	2.2	2.3	2.25
7	MR 16616-24	2.71	2.63	2.67	1.23	1.25	1.24	15.8	16.4	16.1	2.2	2.1	2.15
8	MRxArg1	2.51	2.57	2.54	1.17	1.14	1.16	14.5	14.8	14.7	2.2	2.3	2.25
9	1120 MP-213	2.79	2.77	2.78	1.59	1.49	1.55	16.4	16.8	16.6	2.4	2.3	2.35
10	MP 135 D	2.55	2.52	2.54	1.08	1.10	1.09	14.9	15.3	15.1	1.1	1.1	1.1
11	MR 16616-17	2.61	2.56	2.59	1.21	1.15	1.18	16.1	15.9	16.0	1.0	1.0	1.0
12	MR 16616-25 yellow	2.53	2.56	2.55	1.01	1.08	1.05	15.2	15.7	15.5	1.1	1.4	1.25
13	MP 16616-33 yellow	2.89	2.77	2.83	1.37	1.29	1.33	16.2	16.8	16.6	1.1	1.1	1.1
14	I 627401	2.63	2.54	2.59	1.09	1.15	1.12	15.5	16.3	15.9	1.4	1.7	1.55
15	I 627403	2.79	2.69	2.74	1.31	1.25	1.28	16.3	16.8	16.6	1.5	1.3	1.4
16	KBN 16-93-1	2.91	2.88	2.90	1.21	1.18	1.20	15.5	15.9	15.7	1.3	1.3	1.3
17	102AMP x Nart37	2.91	2.85	2.88	1.51	1.44	1.48	15.8	16.3	16.1	1.5	1.8	1.65
18	1084 MP-71	2.59	2.56	2.58	1.18	1.19	1.19	15.8	16.7	16.3	1.3	1.6	1.45
19	1087 MP-76	2.79	2.74	2.77	1.19	1.17	1.18	16.0	16.5	16.3	1.2	1.4	1.3
20	1103 MP-113	2.78	2.74	2.76	1.17	1.12	1.15	15.8	16.3	16.1	1.5	1.4	1.45
21	1105 MP-121	2.91	2.85	2.88	1.57	1.47	1.52	16.2	16.7	16.5	2.0	2.3	2.15
22	1113MP-150	2.69	2.65	2.67	1.17	1.24	1.21	15.7	16.5	16.4	1.5	1.7	1.6
22	Average			2.68			1.25			16.01			1.54
LCD_{05}				0.21			0.17			1.1			0.11

Biometric measurements of the quantitative characteristics of maize lines showed that plant height allocated such lines as: MP 153 V yellow, MP 75 B yellow, MR 16616-5, MR16616-24, 1120 MP-213, MR 16616-17, MR 16616-33 yellow, I 627401, I 627403, KBN 16-93-1102A, MP x Nart37, 1084MP-71, 1087MP-76, 1103MP-113, 1105MP-121, 1113MP-150. The variation ranged from 2.40 to 2.95m, which is higher than the LCD=0.21cm.

On average for 2 years in the selection (without a standard), the number of samples with a multi-cob value above 2.0 was 8 samples (MP 151 A yellow, MP 153 V yellow, MP 75 B yellow, MR 16616-8, M 16616-24, MPxArg, 11120 MP-213, 1105 MP-121) and according to the number of leaves on the stem, the sample MP 151 A yellow. showed a significant excess over the standard.

Fig. 1. Polymorphism based on the phenotypic trait of multi-cob in some of the studied maize lines from the VIR collection (the leftmost is hybrid KB 595 - standart).

4 Conclusions

The breeding material of maize samples developed on the basis of teosinte from the VIR collection is of practical interest and makes it possible to expand the genetic polymorphism of the starting material for the breeding of hybrid maize. Based on the studied material presented by the VIR maize collection, a selection of 21 samples was created that represent a breeding value as a starting material for improving maize for a number of economically valuable characteristics. Valuable genotypes characterized by a high stem (MP 153 V yellow, MP 75 B yellow, MR 16616-5, MR 16616-24, 1120 MP-213, MR 16616-17, MR 16616-33 yellow, I 627401, I 627403, KBN 16-93-1102A, MP x Nart37, 1084MP-71, 1087MP-76, 1103MP-113, 1105MP-121, 1113MP-150), a large number of leaves on the stem (MP 151 A yellow) and a tendency to multi-cob (MP 151 A yellow, MP 153 V yellow, MP 75 B yellow, MP 16616-8, MR 16616-24, MPxArg, 11120 MP-213, 1105 MP-121), which will later be used in the breeding programs of Institute of Agriculture of the Kabardino-Balkarian Scientific Center of the Russian Academy of Sciences, on the creation of maize hybrids with high grain yield were allocated.

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