*УДК 575.22:631.52:636.03*

*DOI:****10.35330/****1991-6639-2020-4-96-40-48*

**CYTOPLASMIC MALE STERILITY.**

**RESTORING GENES IN CORN**

**K.R. KANUKOVA1, Z.I. BOGOTOVA1,2,**

**I.Kh. GAZAEV1, S.P. APPAEV1**

1FSBSI " Federal scientific center

"Kabardino-Balkar scientific center of the Russian academy of sciences"

360002, KBR, Nalchik, 2 Balkarova st.

E-mail: kbncran@mail.ru

2 Kabardino-Balkarian State University n.a. H.M. Berbekov

360000, KBR, Nalchik, street Chernishevskaya, 173

E-mail: [yka@kbsu.ru](mailto:yka@kbsu.ru)

*Cytoplasmic male infertility (sterility) is common in higher plants and is characterized by maternal inheritance, pollen infertility, and normal development of the pistil.*

*CMS is widely used for the production of hybrid corn seeds. However, the genetic mechanisms underlying the restoration of fertility, is very complicated.*

*This review is devoted to the study and practical application of the sign of cytoplasmic male sterility in the selection and seed production of hybrid corn seeds. Scientific materials and research on the history of the discovery and origin of the phenomenon of CMS in higher plants are summarized. The mechanisms of restoring the fertility of CMS types T, M and S are described. The susceptibility of maize hybrids to southern helminthosporiosis depending on the type of CMS is shown. The expediency of application and practical significance of the CMS system in breeding and seed production in maize is indicated. Valuable genomic resources are presented for understanding the molecular mechanism underlying the restoration of fertility of CMS types.*

**Keywords:** cytoplasmic male sterility, types of CMS, genes that restore fertility, sterility, hybrids, maize.

**REFERENCES**

1. Gorbacheva A.G. *Otkrytiye i geneticheskaya identifikatsiya tipov TSMS u kukuruzy* [Discovery and genetic identification of CMS types in corn] // *Selektsiya i semenovodstvo* [Selection and seed production]. Corn and sorghum. Pyatigorsk, 2019. № 2. P. 22-34.
2. Sotchenko V.S., co-author: Shindin A. P. et al. *Kukuruza. Sovremennaya tekhnologiya voz-delyvaniya* [Maize. Modern technology of cultivation]. 2nd ed., add. M.: NPO "Rosagrohim", 2012. 148 p.
3. Hu J., Huang W., Qi H., Qin X., Yu C., Wang L., Li S., Zhu R., Zhu Y. Mito-chondria and cytoplasmic male sterility in plants // Mitochondrion 19:282–288 2014.
4. Bohra A., Jha U.C., Adhimoolam P., Bisht D., Singh N.P. Cytoplasmic male sterility (CMS) in hybrid breeding in field crops // Plant Cell Reports 35:967-993, 2016.
5. Krupnov V.A. *Gennaya i tsitoplazmaticheskaya muzhskaya steril'nost'* [Gene and cytoplasmic male sterility]. M.: Kolos, 1973. 279 p.
6. Khadzhinov M.I. *Tsitoplazmaticheskaya muzhskaya steril'nost' kukuruzy i ispol'zovaniye yeyo v selektsii i semenovodstve: tsitoplazmaticheskaya muzhskaya steril'nost' v selektsii i semenovodstve kukuruzy* [Cytoplasmic male sterility of corn and its use in selection and seed production: cytoplasmic male sterility in selection and seed production of corn]. Kiev, 1962. 215 p.
7. Duvick D.N. Cytoplasmic pollen sterility in corn // Adv. Genetics. 1965. No. 13. Pp. 1-56.
8. Edwardson J.R. The restoration of fertility to cytoplasmic male-sterile corn // Agron. J. 1955. Vol .47. No. 5. Pp. 475-461.
9. Jones D.F. The correlation of plasmogenes and chromogenes in pollen production in maize // Genetics. 1950. Vol. 35. No. 5.
10. Rogers J.S. Breeding for pollen restores. Proc. Ninth Annual hybrid corn industry Research conf., 1954. 9 p.
11. Blickenstaff J., Thompson D.J., Harvey P.H. Inheritance and linkage of pollen fertility restoration in cytoplasmic male sterile crosses of corn // Agron. J. 1958. Vol. 50. No. 8. Pp. 430-434.
12. Duvick D.N., Snyder R.J., Anderson E.G. The chromosomal location of Rf1 a restorer gene for cytoplasmic pollen sterile maize // Genetics. 1961. Vol. 46. No. 10. Pp. 1245-1252.
13. Snyder R.J., Duvick D.N. Chromosomal location of Rf2 a restorer gene for cytoplasmic pollen sterile maize // Grop Sci. 1969. Vol. 9. No. 2. Pp. 156-157.
14. Beckett J.B. Inheritance of partial male fertility in maize in the presence of Texas sterile cytoplasm // Crop Sci. 1966. No. 6. Pp. 183-184.
15. Duvick D.N. Potential usefulness of new cytoplasmic male steroids and sterility systems // The 27 Ann. Cornand Sorghum Research Corn. Proc. Washington, 1972. Pp. 197-201.
16. Nagy E., CabuIea I., Has I. The role of genotype in zea x Fusariumpathosystem // Cer. Res. Com., Proc.of the European Fusarium, Seminar, Szeged // Hungary. 1997. Vol. 25. № 3/2. Pp. 789-790.
17. Laughnan J.R., Gabay S.J. Nuclear and cytoplasmic mutations ons to fertility in S male sterile maize // In: Maize Breeding and Genetics. New York, 1978. P. 427-446.
18. Weider C., Stamp P., Christov N., Husken A., Foueillassar X., Camp K., Munsch M. Stability of cytoplasmic male sterility in maize under different environmental conditions // Crop Science. 2009. 49:77-84.
19. Gontarovsky V.A. *Geneticheskiye osnovy ispol'zovaniya tsitoplazmaticheskoy muzhskoy steril'nosti v selektsii gibridnoy kukuruzy: avtoref. diss. … dok-ra biol. nauk* [Genetic bases of using cytoplasmic male sterility in hybrid corn breeding: autoref. Diss. Dr. Biol. Sciences]. Kharkov, 1986. 47 p.
20. Beckett J.B. Classification of male sterile cytoplasms in maize (Zea mays L.) // Crop Sci. 1971. No. 11. Pp. 724-726.
21. Stevanovic M., Camdzija Z., Pavlov J., Markovic K., Vancetovic J., Drinic S.M., Filipovic M. The application of protein markers in conversion of maize inbred lines to the cytoplasmic male sterility basis // Genetika. 2016. 48:691-698.
22. Ren R., Nagel B.A., Kumpatla S.P., Zheng P., Cutter G., Greene T.W., Thompson S.A. Maize cytoplasmic male sterility (cms) c-type restorer rf4 gene, molecular markers and their use. // 2012. US Patent 20120090047, April 12. United States Patent and Trademark Office // United States. Available at https: // www.google.com/ patents, US20120090047.
23. Tang J.H., Liu Z.H., Chen W.C., Hu Y.M., Ji H.Q., Ji L.Y. The SSR markers of the main restorer genes for CMS-C cytoplasmic male sterility in maize // Scientia Agricultura Sinica. 2001. 34:592–596.
24. Yongming et al. A preliminary identification of Rf\*-A619, a novel restorer gene for CMS-C in maize (Zea mays L.) // PeerJ 4:e2719 – 2016.
25. Gorbacheva A.G. *Ispol'zovaniye S tipa TSMS v selektsionno-semenovodcheskikh programmakh* [Use of C type CMS in selection and seed programs] // *Selektsiya. Semenovodstvo. Tekhnologiya vozdelyvaniya kukuruzy. Materialy nauchno-prakticheskoy konferentsii, posvyashchennoy 25-letiyu GNU VNII kukuruzy* [Selection. Seed production. Corn cultivation technology. Materials of the scientific and practical conference dedicated to the 25th anniversary of the Scientific Research Institute of Corn]. Pyatigorsk. 2012. Pp. 157-169.

**Information about the authors:**

**Kanukova Kristina Ruslanovna,** Candidate of Agricultural Sciences, researcher, Laboratory of Molecular Selection and Biotechnology, Federal State Budgetary Scientific Institution FSC KBSC RAS.

360002, KBR, Nalchik, st. Balkarova, 2.

Ph. 8-928-712-97-07.

E-mail: [kkp88@mail.ru](mailto:kkp88@mail.ru)

**Bogotova Zalina Ikhsanovna,** Candidate of Biological Sciences, Head of the Laboratory of Molecular Selection and Biotechnology of KBSC RAS, Associate Professor of the Department of Molecular Selection and Biotechnology of KBSU, Head of IBC of KBSU

360000, KBR, Nalchik, Chernishevsky street, 173.

Ph. 8-903-495-88-66.

E-mail: zalina\_bogotova@mail.ru

**Gazaev Ismail Khizirovich,** Candidate of Biological Sciences, senior researcher, Laboratory of Molecular Selection and Biotechnology, Federal State Budgetary Scientific Institution FSC KBSC RAS.

360002, KBR, Nalchik,. Balkarova street, 2.

Ph. 8-938-692-90-46.

E-mail: is.gazaev@yandex.ru

**Appaev Safar Pakhauovich,** Candidate of Agricultural Sciences, Head of the Laboratory of selection and seed production of early maturing maize of KBSC RAS.

360002, KBR, Nalchik, Balkarova street, 2.

Ph. 8-928-709-07-36.

E-mail: appaev-safar@mail.ru