International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 6, No. 3, p. 132-138, 2015

INNSPUB

RESEARCH PAPER OPEN ACCESS

Results of fodder and semi-sugar beet breeding in Bulgaria

Georgi Kikindonov*, Tzvetan Kikindonov

Plant Breeding Department, Agricultural Institute, Shumen, Bulgaria

Article published on March 21, 2015

Key words: Root yield, Dry matter, Inheritance, Heterosis

Abstract

They have been discussed the results of tests of fodder beet origins and their semi-sugar beet hybrids, carried out in 2003-2013. The character of inheritance of the quantitative traits root yield and dry matter content has been established. The variability of the parental characteristics and the differences in the agroclimatic conditions during the vegetation affect the degree of heterosis manifestation in the semi-sugar beet hybrids. Various high productivity fodder beet origins are available, which do not fall back the already certified commercial varieties. Their heritage factors dominate in their hybrids with male sterile sugar beet lines. All the semi-sugar beet hybrids realize proven heterosis in the dry matter yield from a unit of area, no matter the climatic conditions of the vegetation, and meet the requirements of the modern intensive technologies of growing.

* **Corresponding Author:** Georgi Kikindonov ✉ gkikindonov@mail.bg

Introduction

The high yields and concentrations of nutritive substances and vitamines, and the good taste qualities (De Vliegher *et al.*, 1994; Stosic *et al.*, 1999), determine the use of fodder beet and semi-sugar beet hybrids for rich forages. These root crops are valuable components in the rations of the ruminant beasts (Albayrak and Yuksel, 2010) in the autumn-winter period - for the maintenance of the normal exchange of matters in the animal organism, improving the digestibility and the assimilation of the rough and concentrated forages. The mass growing of semi-sugar beet hybrids in Europe (Orlov and Yatsenko, 1999) is due to the favorable combination of the positive economical qualities of the sugar beet with the high yield potential of the fodder beet (Turk, 2010) in the crosses between them (Van Bockstaele, 1990). The monogermity, the resistance to diseases, the increased dry matter content, the uniformity of roots by form and position in the ground (Badawi *et al.*, 2000) are preconditions for the application of intensive technologies for growing, conservation and nourishing feeding of beasts. These facts made us start a project for breeding perspective semi-sugar beet hybrids starting from 1994. The reasons for that were the increased interest of the Bulgarian private farmers in fodder beet's rich forages, and the huge demand of high yielding and quality crops in our country.We had the basis for such a breeding program - rich gene fund of monogerm sugar beet male sterile lines, and some very productive fodder beet origins.

The testing of parental components of sugar and fodder beet and the hybrids obtained by crosses between them allows specifying the way of inheritance of some quantitative traits. Such researches have big scientific and applied significance with a view to the receipt of maximum yield of dry matters from a unit of area and high economical effect of growing semi-sugar beet hybrids. And we should say that for 20 years these researches have brought to the success of our breeding program and now our hybrids are preffered source of rich forages for the Bulgarian farmers.

The aim of the present study is to show the summarized results of our tests of fodder beet origins and their semi-sugar beet hybrids during the last decade. The variety of agro-climatic conditions during this period allowed the assessment of the ecological plasticity of the tested materials, and the inclusion of the parental components in the tests give possibility to determine the character of inheritance of the yield and the dry matter content, as well as the manifestations of heterosis in the semi-sugar beet hybrids.

Materials and methods

Materials

The tested semi-sugar beet hybrids are obtainedby crosses between 4 monogerm male sterile lines (MS lines) of sugar beet (MS27a, MS30, MS66 and MS142) and multigerm fodder beet pollinators (diploid – BR, SR, SK2 and tetraploid – SKR, TR, VG). The multigerm fodder beet populations differ significantly by form and colour of roots, and by dry matters content. The monogerm sugar beet lines have very good combining ability. The fully sterile plants of the sugar beet lines are over 95%, and their monogermity is over 98%.

Hybridization

The crosses between the monogerm sugar beet male sterile lines and the multigerm fodder beet pollinators have been made in 2001-2002, in sunflower isolation belt, 4:2 ratio between the plants of the MS line and the pollinator. The simultaneous flowering of the maternal and the paternal components brought to excellent hybridization between them. The monogermity of the hybrid seeds is over 98%, and the germination of all the tested semi-sugar beet hybrid combinations is over 90%.

Test field conditions

The tests for technological qualities of the semi-sugar beet hybrids have been carried out during 2003-2013. The soil type of the experimental fields of the Agricultural Institute-Shumen is a carbonate black-earth with a good mechanical structure and weakly alkaline reaction of the soil solution.

Experimental design

The randomization of the field tests is according the two-seated lattice method (Shanin, 1977), in four replications having a plot size of 10.8 m^2 with 3 rows each at a distance of 45 cm. The commercial semi-sugar beet variety Pliska is used as a Standard.

Agroclimatic conditions

The agroclimatic conditions during the test period vary significantly. We could divide the period to years with water deficiency during the vegetation (April-September) – with vegetation rainfalls under the norm for 50-years period, and years with overnorm quantity of the rainfalls during the beets vegetation. So, the quantity of vegetation rainfalls during 2003, 2007, 2008, 2009, 2011 is with 44.6 mm less than the normal vegetation rainfalls quantity, with mean daily temperatures and relative air humidity respectively 19.0^{o}C and 64.8%. And the rainfalls in the remaining years of the test period are over the norm – 129.5 mm more rainfalls for the vegetation period, even unevenly distributed during the vegetation, with mean daily temperatures of 17.8^{o}C and relative air humidity of 70.6%.

Assessment parameters

The assessed parameters are root yield (t.ha^{-1}) and dry matter content (%), measured refractometrically.

Statistical analyses of the test results

Dispersion analysis (Lidanski, 1988) was used for determination of the statistical significance of the differences between the test variants. The type of inheritance is measured by the values of the overdominance ratio (the dominant to additive parameters ratio), according to Genchev *et al.*, (1975). The effect of heterosis is calculated according to Abramova (1985).

Results and Discussion

The basic economical indices of fodder beet are the root yield, the dry matter content in the roots and the yield of dry matters from a unit of area. In Table 1 are given the summarized results of our tests for these indices. It is obvious that the root yield of the diploid fodder beet populations is significantly lower than the yield from the tetraploid fodder beet origins. This reflects the productivity of their hybrids with sugar beet MS lines – the diploid semi-sugar beet hybrids have significantly lower yield than the triploid hybrids. At the other hand, the excess in the root yield of the diploid semi-sugar beet hybrids towards the yield of the relevant fodder beet parents is much more considerable than that of the triploid semi-sugar beet hybrids. The highest percentage of dry matters is measured in the roots of the diploid semi-sugar beet hybrids. This is a result of the proved higher dry matter content in the roots of the diploid fodder beet pollinators, compared to the Standard's one. And in vegetational water deficiency years the concentration of dry matter in the roots exceeds 20%. The tetraploid fodder beet origins are with lower content of dry matters, but by hybridization with sugar beet MS lines the dry matter content in the roots of the relevant triploid semi-sugar beet hybrids increases significantly, i.e. the concentration of dry matters in the triploid semi-sugar beet hybrids is proved higher than that of the relevant fodder beet parents.

The yield of dry matter from a unit of area is the most important economical index. Data of our continuous tests show, that we have a good collection of variable fodder beet origins, allowing realization of semi-sugar beet hybrids with good qualities and high productivity. The tested fodder beet origins do not fall back the already certified semi-sugar beet varieties regarding the dry matter yield. The yields of dry matter, realized by the semi-sugar beet hybrids are significantly higher if compared to the yields of the relevant fodder beet parents. This excess is proved for the triploid semi-sugar beet hybrids, no matter the agro-climatic conditions of their testing.

And what is more, the triploid hybrids realize proved higher yield of dry matter that the yield of the Standard variety Pliska. The diploid semi-sugar beet hybrids as a whole do not fall back the Standard regarding this index, and in conditions of summer droughts some of them form even higher than the Standard's yield of dry matter.

Table 1. Productivity of fodder beet origins and semi-sugar beet hybrids /Agricultural Institute– Shumen, 2003 – 2013.

Variant	Root yield t.ha^{-1}	% of St.	Dry matter content %	% of St.	Dry matter yield t.ha^{-1}	% of St.
Pliska (3x) Standard	61.86	100.0	14.67	100.0	9.07	100.0
2x fodder beet origins	53.70	86.8	15.87	108.2	8.52	93.9
4x fodder beet origins	64.96	105.0	13.99	95.4	9.09	100.2
2x semi-sugar beet hybrids	56.83	91.9	16.54	112.7	9.40	103.6
3x semi-sugar beet hybrids	66.39	107.3	15.22	103.7	10.10	111.4
GD 5%	6.29	10.1	0.84	6.0	0.91	10.3
P%	3.48		2.06		3.49	

The parallel tests of parental components and semi-sugar beet hybrids, obtained by the crosses between them, give possibility to determine the way of inheritance of some quantitative traits (Table 2).

Table 2. Inheritance of the root yield and the dry matter content in semi-sugar beet hybrids.

Hybrids	P_1	P_2	MP	F_1	d	a	d/a
Root yield t.ha^{-1}							
Diploid hybrids	40.52	53.70	47.11	56.83	9.72	6.59	1.47
Triploid hybrids	40.52	64.96	52.74	66.39	13.65	12.22	1.12
Dry matter content %							
Diploid hybrids	18.98	15.87	17.43	16.54	- 0.89	1.55	- 0.57
Triploid hybrids	18.98	13.99	16.49	15.22	- 1.27	2.49	- 0.51

The MS lines of sugar beet, participating in the hybridization are with significantly lower root yield than the fodder beet pollinators – for the period of study the MS lines have 13.18 t.ha^{-1} lower root yield than that of the diploid, and 24.44 t.ha^{-1} lower than that of the tetraploid fodder beet parents. Let us note that in vegetational water deficiency years the differences between the values of the index of the parental components are not as big. All the semi-sugar beet hybrids F_1 have higher yield values than the mean of the relevant parents (MP) values, and than the relevant fodder beet pollinators (parents with higher value of the index). The review of the values of dominant to additive parameters ratio show

an overdominance of the higher yield of the fodder beet pollinators in the diploid semi-sugar beet hybrids (d/a=1.47), and dominance of the higher yield of the tetraploid fodder beet pollinators in their semi-sugar beet hybrids. It is confirmed also the clear tendency to overdominant inheritance of the higher yield of the fodder beet pollinators in conditions of vegetational humidity deficiency, and for dominant inheritance of the significantly higher yield of the fodder beet pollinators in the semi-sugar beet hybrids in conditions of overnorm vegetation rainfalls.

It is well known the negative correlation between the root yield and the dry matters content in the roots (Dalke, 1996), as well as the positive correlation between the sugar content and the percentage of dry matters in the root (Kajiyama *et al., 1*992).

The tested fodder beet pollinators are with lower values of the dry matter content than those of the maternal components. And the semi-sugar beet hybrids are with lower values than the mean parents' values. That is why the d/a ratio is negative and shows incomplete dominance of the lower dry matter content of the fodder beet pollinators in the hybrids.

The extent of the heterosis effect depends on the nature of the components in the hybridization, on their genetical heterogeneity and combining ability (Yankulov *et al.*, 1993). The concentration of genes in the parents, expressing valuable traits, is a precondition for the higher productivity, quality and uniformity of the semi-sugar beet hybrids (Shevtzov, 1996). The results of the calculations for real, hypothetical and competitive heterosis effect in the tested semi-sugar beet hybrids are given in Table 3.

Table 3. Heterosis effect in diploid and triploid semi-sugar beet hybrids.

Hybrid	Root yield t.ha^{-1}			Dry matter %			Dry matter yield t.ha^{-1}		
	HP	MP	CHE	HP	MP	CHE	HP	MP	CHE
Diploid hybrids	+5.1	+15.7	-8.1	-16.7	+4.5	+12.7	+9.7	+14.7	+3.6
Triploid hybrids	+2.3	+22.0	+7.3	-25.7	+8.3	+3.7	+11.2	+19.3	+11.4
Pliska– St (abs.value)	61.86 t.ha^{-1}= 100.0%			14.67% = 100.0%			9.07 t.ha^{-1}=100.0%		
GD 5%	10.1			6.0			10.3		

Because of the huge differences between the root yields from the sugar beet MS lines and the fodder beet pollinators there are no proved values of the real heterosis HP (difference towards the parent with the higher value). The values of the hypothetical heterosis MP (the difference from the mean of the relevant parents' value) are proved positive for both ploidy levels of tested semi-sugar beet hybrids.

The semi-sugar beet hybrids fall back the sugar beet MS lines significantly by dry matters content in the roots and that is why the negative values of HP are ver well proved. The positive values of the hypothetical heterosis are proved only for the tested triploid semi-sugar beet hybrids.

The yield of dry matter from a unit of area is a resultative index and to a great extent determines the economical value of the semi-sugar beet hybrids. All the tested hybrid combinations have proved positive values of HP and MP, only for the diploid semi-sugar beet hybrids the positive values of HP are not reliable.

The competitive heterosis effect (CHE) expresses the superiority of the hybrids to one or group of Standard varieties and gives the clearest idea about the breeding value of the tested hybrids. The summarized data of our tests show insignificant differences from the Standard's root yield. But if CHE is with positive values for the triploid semi-sugar beet hybrids the diploid hybrids have lower yield than the Standards. Six of the years of the study period are characterized with summer droughts, and the diploid semi-sugar beet hybrids have lower resistance to such droughts and the negative affect of the leave mass fading on the yield is much stronger. This, together with the definitely higher productivity of the tetraploid fodder beet pollinators, explains the proved higher root yield of the triploid semi-sugar beet hybrids, compared to that of the diploid hybrids. But regarding the dry matter content the diploid hybrids exceed significantly the Standard (triploid semi-sugar beet hybrid variety) and the triploid hybrids. As in the triploid crosses with sugar beet the fodder beet pollinator (the parent with lower dry matter content) participates with two genomes it is normal the triploid semi-sugar beet hybrids to be with lower concentration of dry matters. At the other hand, by application of traditional breeding methods in the years preceding these tests, we have managed to increase significantly the dry matter content in the available tetraploid fodder beet origins and thus we have already the results. The tested semi-sugar beet hybrids are with higher yield of dry matters from a unit of area than the yield of the Standard. The positive values of CHE for the triploid semi-sugar beet hybrids are statistically significant.

Conclusion

We have various and high productivity fodder beet origins, which do not fall back the certified semi-sugar beet varieties, no matter of the agro-climatic conditions they are grown in. The heredity factors for higher productivity of the fodder beet pollinators dominate in their semi-sugar beet hybrids. The lower dry matter content of the fodder beet parent is inherited with incomplete dominance. All the tested triploid semi-sugar beet hybrids manifest high heterosis in the yield of dry matter from a unit of area, no matter what are the agro-climatic conditions during the vegetation.

References

Abramova ZV. 1985. Genetics of Programmed Teaching. Agropromizdat, Moscow, p.259-265.

Albayrak S, Yuksel O. 2010. Effects of Nitrogen fertilization and harvest time on root yield and quality of fodder beet (*Beta vulgaris var. crassa* Mansf). Turkish Journal of Field Crops, **15** (1), 59-64.

Badawi MA, Attia AN, Sultan MS, Aboel-Goud Sh. 2002. Agronomic Studies on Fodder Beet. 1. Yield and its components. Proceedings of 1st Annual SC Animal & Fish Production, Mansoura, 439-460.

Dalke L. 1996. Genetic diversity of fodder beets. International Crop Network Series, **12**, 80-81.

De Vliegher A, Van Bockstaele E, Van Waes J. 1994. Results of fodder beet breeding during 1950-1993. ISHS Acta Horticulturae 355: Plant Breeding for Mankind-Symposium Agribex'94,133-154.

Genchev G, Marinova E, Yovcheva V, Ognyanova A. 1975. Biometrical Methods in Plant Production, Genetics and Breeding. Zemizdat, Sofia, p. 321-333.

Kajiyama T, Yoshizawa A, Yoshida T. 1992. Changes of dry matter percentage in relation to sugar content of sugar beet roots. Proceedings of Japanese Society of Sugar Beet Technologists, **34**, 102-106.

Lidanski T. 1988. Statistical Methods in Biology and Agriculture. Zemizdat, Sofia, p.150-157.

Orlov S, Yatzenko A. 1999. Semi-sugar and fodder beet hybrids. Saharnaya svekla, **44** (12), 7-8.

Shanin, Y. 1977. Methods of field experiment. Zemizdat, Sofia, p.231-275.

Shevtzov A. 1996. Problems of heterosis and its application for increasing sugar beet productivity. Physiology and biochemistry of cultural plant, **28** (4), 156-166.

Stosic M, Koljajic V, Dinic B, Lazarevic D, Djordjevic N. 1999. Some aspects of forage production and conservation. Biotechnologija u stocarstvu, **5-6**, 41-49.

Turk M. 2010. Effects of fertilization on root yield and quality of fodder beet (*Beta vulgaris var. crassa* Mansf.). Bulgarian Journal of Agricultural Science, **16** (2), 212-219.

Yankulov M, Daskalov S, Tomov N, Atanassov A, Vitanov M, Rozeva A, Lidanski T, Georgiev H, Achkova Z. 1993. Principles of Modern Breeding. Zemizdat, Sofia, p.150-157.

Van Bockstaele E. 1990. Influence of fodder beet pollinators on the characteristics of sugar-fodder beet hybrids, Euphytica, **54** (2),119-125.