HALF DIALLEL ANALYSIS FOR YIELD COMPONENTS AND TOP TRAITS IN SELF FERTILIZED O-TYPES OF SUGARBEET.

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ABSTRACT

In this study, genetic model of sugar yield components; namely, root weight, sugar content, harmful non-sugar content (K, Na and amino-N), and tops; namely, top weight, leaf number and plant height were analyzed in the F1 generation of half diallel crosses by using self-fertilized O-types as parent. Results were as follows; for root weight, top weight, plant height and amino-N, heterosis effects were clearly shown in the F1 generation, since the dominance variances (H1) were higher than the additive variances (D), and the average degree of dominances ($\sqrt{H1/D}$) of them was over 1.0. On the other hand, for sugar content, Na, K and leaf number, the additive variances were higher than the dominance variances, and narrow sense heritability values of sugar content and K were 92.1% and 90.4%, respectively. In conclusion, sugar content, K and leaf number could be improved by the individual selection based on the phenotypes in parent. However, for other traits in which heterosis effects were shown prominently, the line selection based on the combining ability test in F1 may help to fulfill the goal.

INTRODUCTION

In the three way top cross, various hybrids of sugarbeet (*Beta vulgaris* L.) were developed with the pollinators crossed to the seed parents. These seed parents were also F1's crossed by one CMS with another O-type (maintainer), because higher heterosis effects were obtained with regard to the root weight and the seed amount for F1 seed parents than for seed parents by only CMS lines (Ogata, N. *et al.*, 1999). But it is difficult to analyze the genetic effects originated from each line on the three way top cross hybrids. For this reason knowledge of the inheritance in the seed parents should be important before analyzing in the three way top cross hybrid. However, a few clear genetic information of seed parent breeding with regard to yield components and especially top traits have so far been known in sugarbeets. This information would be useful for developing superior seed parents through the O-type and CMS breeding.

Since 1970, self-fertility (SF) lines have widely been used for developing the F_1 seed parents of sugarbeets in Japan (Hachinohe, M. *et al.*, 1984). The diallel analysis is the popular method by using the quantitative traits in self-fertility plants. However results of using diallel crosses on sugar yield and top traits in sugarbeets have been reported by a few (Watson, J. F. & Gabelman, W. H., 1984), except for studying on the seed production traits (Battle, J. P. & Whittington, W. J., 1971; Sadeghian, S. Y. & Khodai, H., 1998). In this study, genetic model of sugar yielding traits and tops were analysed in F1 hybrids of half diallel crosses by using self-fertilized O-type as seed parents.

MATERIALS AND METHODS

As the parents of diallel cross, 5 popular self fertilized O-types (NK-183mm-O, NK-185BRmm-O, NK-195mm-O, NK-219mm-O and NK-229BRmm-O) developed from different origins were used, and for 10 diallel cross F1 hybrids of them were harvested effectively by using CMS as seed parents side. Materials total 15 lines were tested in direct planting condition at the test field by random block design with 4 replications of 8.1m^2 plot. Sowing date and harvesting date were 24 April and 16 October in 2000, respectively. The traits investigated were sugar yielding traits, namely root weight, root length, root circumference, sugar content and harmful non-sugar content (K, Na and amino-N), and tops, namely top weight, leaf number and plant height. Here the leaf number and plant height were investigated an individual plant base in 2 times at 19 June and 19 September. Other traits were investigated by plot base at the harvest date. Diallel analysis was calculated for each trait of plot mean by the computer soft "DIALL" developed by Prof. Ukai (Ukai, Y., 1989). Epistasis effects were estimated from the analysis of variance on Wr (co variance of parent and F1) – Vr (variance of observed value) (Kamizima, O. & Kitazawa, S., 1978).

RESULTS

First of all, the characteristics of parent lines were shown in Tab.1. For the all traits, there were line differences; the characteristics of each line were as follows. NK-183mm-O showed almost middle values in many traits. NK185BRmm-O had the most number of leaves and the highest sugar content with high quality. NK-195mm-O had the heaviest root weight. NK219mm-O showed the lowest value in root weight and sugar content. NK-229BRmm-O was the highest plant height and heavy root weight.

Array differences were estimated from the differences Wr and Vr. No array differences were found in any traits, although block differences were shown in some traits (Tab. 2).

From the study of the diallel analysis, heterosis effects were clearly shown in F1 crosses for plant height, top weight, root weight and root length. This is because the dominance variances (H) were higher than the additive variances (D), and the average degree of dominances ($\sqrt{H/D}$) of them were over 1.0 (Tab. 3). Narrow sense heritability values of root weight and top weight were 42.0% and 15.4%, respectively. On the other hand, for sugar content, Na, K and leaf number, the additive variances were higher than the dominance variances, especially values of narrow sense heritability of sugar content and K were

92.1% and 90.4%, respectively which were clearly higher values than the case of root weight and top weight (Tab. 3).

Correlation coefficients were calculated with regard to top weight, root weight and sugar content to other traits in parents and F_1 hybrids, respectively (Tab. 4). Top weight showed positive correlations to leaf number and sugar content. Root weight showed a negative correlation to leaf number, and the correlation coefficient of root weight and root circumference was positive and higher than the case of root weight and root length. Sugar content showed a positive correlation to leaf number, and negative ones to K and Na.

Tab. 1. The characteristics of parent lines used for F1 in half diallel cross of sugarbeet.

Traits and Dates	Unit	NK183	NK185BR	NK195	NK219	NK229BR
Plant height 29 June	cm	20.6	22.4	20.3	20.3	19.9
Plant height 29 Sep.	cm	54.5	57.9	55.8	52.6	62.6
Leaf number 29 June	leaves	12.5	12.6	11.0	11.8	11.2
Leaf number 29 Sep.	leaves	29.5	37.7	26.8	28.0	25.4
Top weight	kg/plot	14.9	17.9	14.2	10.9	13.6
Root weight	kg/plot	26.2	20.7	30.5	17.9	27.8
Root circumference	cm	29.0	26.5	32.1	24.0	30.9
Root length	cm	15.2	14.1	15.5	14.2	15.6
Sugar content	%	17.2	17.7	15.8	15.7	16.8
K	meq/100g	4.5	3.5	4.7	5.6	4.8
Na	meq/100g	0.2	0.2	0.6	0.5	0.4
A-N	meq/100g	0.7	0.9	1.1	0.9	1.1

A-N : amino nitrogen

Tab. 2. Analysis of variance of Wr - Vr in half diallel cross of sugarbeet.

	Mean squares	
Traits and Dates	Array difference	Block difference
Plant height 29 June	11.6	42.1 *
Plant height 29 Sep.	1648.2	5477.2
Leaf number 29 June	0.2	1.1 *
Leaf number 29 Sep.	12.9	107.8 **
Top weight	21.3	332.6 **
Root weight	1.6	1.9
Root circumference	2.5	2.8
Root length	0.9	2.2
Sugar content	1.0	1.9
K	0.4	2.1
Na	2.2	2.3
A-N	0.3	1.3

* and ** mean significant difference by F test at 5% and 1% level, respectively.

Tab. 3. Genetic parameters in half diallel cross of sugarbeet.

Traits and Dates	Variance		Average degree of Dominance	Heritability (%)	
	Additive	Dominance		Broad	Narrow
Plant height 29 June	0.3	20.5	8.4	89.9	15.7
Plant height 29 Sep.	12.8	108.2	2.9	94.7	29.7
Leaf number 29 June	0.4	1.1	1.6	81.6	36.1
Leaf number 29 Sep.	21.8	18.6	0.9	85.2	49.2
Top weight	4.7	37.1	2.8	87.4	15.4
Root weight	25.1	101.4	2.0	95.8	42.0
Root circumference	10.4	15.9	1.2	92.7	42.4
Root length	0.4	4.5	3.5	90.8	21.6
Sugar content	0.7	0.1	0.3	94.4	92.1
K	0.5	0.2	0.6	97.0	90.4
Na	0.0	0.0	0.4	95.6	88.6
A-N	0.0	0.0	1.8	49.9	33.6

Average degree of dominance: 0 verdom [illegible]

Tab. 4. Correlation coefficient for top weight, root weight and sugar content to other traits in sugarbeet.

Traits and Dates	Top weight		Root weight		Sugar content	
	0-types	F1	0-types	F1	0-types	F1
Plant height 29 June	0.72	0.75 *	-0.49	0.06	0.70	-0.06
Plant height 29 Sep.	0.55	0.38	0.40	0.28	0.40	-0.26
Leaf number 29 June	0.41	0.23	-0.60	-0.32	0.73	0.14
Leaf number 29 Sep.	0.69	0.64 *	-0.51	-0.55	0.71	0.47
Top weight	–	–	0.18	-0.21	0.88	0.38
Root weight	0.18	-0.21		–	-0.09	-0.85 **
Root circumference	0.27	-0.13	0.99 **	0.94 **	0.04	0.71 *
Root length	-0.01	-0.45	0.94 **	0.76 *	-0.09	-0.67 *
Sugar content	0.85	0.38	-0.09	-0.85 **	–	–
K	-0.97 **	-0.57	-0.07	0.63 *	-0.84	-0.86 **
Na	-0.71	-0.39	0.21	0.85 **	-0.96 **	-0.94 **
A-N	-0.02	-0.20	0.40	0.51	0.44	-0.57

0-types: n=5, F1; n=10
* and ** mean significant difference at 5% and 1% [illegible]

CONCLUSION

The origins of parent lines used for F1 were different from each other (Hachinohe, M. *et al.*, 1984), and in this study line differences of parent were clearly shown as quantitative traits. From the analysis of variance of the Wr – Vr, since array differences were not shown, epistasis effects do not exist in any of traits, and all traits could be fitted to the Additive-Dominance model. Sugar content, K and leaf number could be improved efficiently by individual selection based on the phenotypes from mother populations, because of the high narrow sense heritabilities. For another traits in which heterosis were shown prominently, line selection based on the combining ability test in F_1 may help fulfill the goal. However it should be noted that improving toward higher sugar content could lead to higher top weight with more leaf numbers. From this study, some new information was obtained for breeding superior F1 seed parents, but it should, in the next step, be examined whether these genetic model could be applied to three way top cross hybrids.

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