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INBREEDING DEPRESSION IN SUGARBEET (*BETA VULGARIS* L.)

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ABSTRACT

Inbreeding depression for root yield and sucrose content was studied in six sugarbeet cultivars. Inbreeding depression for root yield varied from variety to variety. Average inbreeding depression after selfing in S_3 & S_4 was 30.56% and 34.85%, respectively, as compared to the S_0 parent. Sucrose content was not depressed by inbreeding even up to S_4 generation. As expected, the depression in the progeny of sib-mated plants was of a lower magnitude.

Key words: Selfing, depression, homozygosity.

In cross-pollinated crops, the extent of inbreeding depression gives an idea about the productivity of hybrids, and synthetic varieties. In composite and synthetic breeding programmes, inbreeding is 'taken as an index of non-additive gene action. In majority of the cross-pollinated crops, inbreeding is generally accompanied by reduction in plant size and vigour.

Sugarbeet (*Beta vulgaris* L.) is a highly cross-pollinated crop. It however, represents an amalgam of different breeding systems depending on the presence of self-incompatibility mechanism. Some genotypes, however, can be selfed due to the presence of genes for self-fertility [1]. Information on the extent of inbreeding depression in sugarbeet germplasm available in India is rather meagre. In the present study an attempt has been made to estimate the extent of inbreeding in some diploid genotypes of sugarbeet.

MATERIALS AND METHODS

Six promising open-pollinated, multigerm, diploid (2n = 18) varieties of sugarbeet were grown at Lucknow (Table 1). Steckling of these varieties were transplanted 'at Mukteswar (Kumaon hills, U.P.) in December each year for providing photothermal induction. Some plants in each of these varieties were selfed in S_1 and S_2 generations by putting whole plant under cotton bags. Selfing as well as sibbing was resorted to in S_3 and S_4 generations. Sb_3 and Sb_4 seed was harvested from sib-mated plants of S_3 and S_4 selfed plants, respectively.

Therefore, Sb_3 and Sb_4 have not been used for studying inbreeding depression from Sb_3 and Sb_4. On first generation selfing (S_1) the seed yield per plant was 12 to 26 g, which was nearly half of the seed yield under open pollination. However, in the subsequent generations the seed yield reduced considerably and the S_4 plants yielded 0.9 to 2 g seed. Therefore, after S_4, sib-mating was resorted to maintain these lines.

Table 1. Characteristics of varieties used for selfing or sibbing

Population	Country of origin	Ploidy & other details
AJ-3	Poland	Diploid, open pollinated, multigerm, moderate yield, low sugar
AJ-4	Poland	Diploid, open pollinated, multigerm, moderate yield, moderate sugar
Dobrovicka-c	Czechoslovakia	Diploid, open pollinated, multigerm, moderate yield, medium sugar
OPH	Sweden	Diploid, open pollinated, multigerm, moderate yield. medium sugar
US 75	U.S.A.	Diploid, open pollinated, multigerm, moderate yield, medium sugar, tolerant to curly top virus
Ramonskaya 06	U.S.S.R.	Diploid, open pollinated, good yield, medium sugar, wide adaptability, good pollen producer

The root crop evaluation was done at the experimental farm at Indian Institute of Sugarcane Research, Lucknow. Selfed and sibbed seed of S_3 and S_4 generations along with open-pollinated or caged seed of parent varieties was sown on ridges, in single-row plots of 6 m length with 20 cm spacing between plants. The experiment was laid out in RBD having three replications. In all, there were six S_0, 15 S_3 selfed, 9 S_4 selfed 14 S_3 sib, and 9 S_4 sib lines. Root yield and sucrose content were recorded in 6-month-old crop on plot basis. Inbreeding depression between generations was calculated for root yield. Values of sucrose content are presented as percentage of the S_0 generation.

RESULTS AND DISCUSSION

The differences in top yield and root yield between S_3 and S_4 compared to S_0 were high. The reduction in root yield was significant in S_3 and S_4 in varieties Ramonskaya 06, OPH, and US-75 (S_4 selfed) (Table 2). The extent of reduction due to selfing

Table 2. Extent of inbreeding depression for root yield of sugarbeet

Variety	Inbreeding depression between different generations, %				
	S_0–S_3	S_0–S_4	S_3–S_4	S_0–Sb_3	S_0–Sb_4
AJ-3	13.20	23.36	11.30	1.48	10.71
AJ-4	53.33**	—	—	40.32**	—
Dobrovicka-c	11.28	25.58	16.12	10.47	31.05
OPH	25.30	38.00*	16.06	16.00	30.00
US-75	36.80	40.52*	5.88	13.26	29.37
Ramonskaya 06	43.45**	46.81**	5.94	38.99**	52.35**
Mean	30.56	34.85	11.14	20.08	30.70

*, **Significant at 5% and 1%, respectively.
S_0—open pollinated/cage seed; S_3 & S_4—third and fourth selfed generations; Sb_3—third sib-mated generation, Sb_4—fourth sib-mated generation.

was dependent on the extent of variability as a result of heterozygosity existing in the base population of the genotype. Variety Ramonskaya 06 showed more variability and, thus, recorded higher inbreeding depression. Variety AJ-4 also showed higher value of depression. However, yield potential of Ramonskaya 06 was more stable than in OPH and US-75. In accordance with the theoretical expectations, inbreeding depression for root yield in sib-mated generation was less compared to the selfed population.

Inbreeding depression in the selfed generation gives an idea of the state of heterozygosity in the base population. One generation of self-fertilization in diploid plants should have resulted in about 50% homozygosity of all loci in S_1 and each subsequent selfed generation. Therefore, the inbreeding depression for root yield in the present case is due to breakdown of heterozygosity and gradual increase of homozygosity. This was reflected by the morphological uniformity within the plants of individual inbred lines and distinct differences between the lines (after selfed generations). In the sib-mating generation, lesser inbreeding depression was observed, which is in agreement with theoretical expectations [1]. Doloi and Rai [2] reported similar results for seed yield in rapeseed. Aycock and Wilsie [3] suggested from their work on alfalfa that sib-mating should be resorted to maintain requisite heterozygosity so as to avoid drastic reduction in yield and vigour. In sugarbeet also, sib-mating can be successfully used to maintain inbred populations.

Table 3. Sucrose contents in different inbreeding generations of sugarbeet

Variety	S_0	Selfed generation		Sib-generation	
		S_3	S_4	Sb_3	Sb_4
AJ-3	13.2	14.0 (106)*	14.6 (111)	13.9 (105)	13.5 (102)
AJ-4	14.0	14.8 (106)	—	14.7 (105)	—
Dobrovicka-c	15.5	14.2 (92)	14.6 (94)	14.0 (90)	12.6 (81)
OPH	15.5	14.0 (92)	15.0 (97)	14.0 (90)	14.2 (92)
US-75	14.1	15.5 (110)	14.3 (101)	15.0 (106)	14.5 (103)
Ramonskaya 06	14.0	13.0 (93)	13.0 (93)	14.2 (101)	15.0 (107)
Mean	14.4	14.2 (99.5)	14.3 (99.2)	14.3 (99.5)	14.0 (97.0)

*Figures in parentheses are percent of S_0 values.
SE ±0.68; CD 5% 1.41.

Sucrose content of roots was not consistently affected by inbreeding (Table 3). Some varieties showed slightly improved sucrose content while others showed a little reduction. Similar observation after inbreeding in diploid strains has been reported earlier [4]. Varieties AJ-3 and US 75 in the present study showed better sucrose content in the selfed and sib-mated populations compared to S_0 generation. Varieties AJ-4, Dobrovicka-c, OPH and Ramonskaya 06 showed marginal reduction in sucrose content after inbreeding. The average of all the genotypes showed less than 1% reduction in sucrose in S_3 and S_4 compared to S_0 generation.

In cross-pollinated species, the yield, vigour and productivity could be attributed to heterozygosity per se. Root yield in sugarbeet has been reported to be generally governed by nonadditive gene action [5, 6]. Therefore, reduction in root yield after inbreeding in the present material clearly indicates that it is governed by nonadditive gene action, which breaks down on selfing and increasing homozygosity. Sucrose content, on the other hand, showed very little depression even in S_3 and S_4. It was noticed that the varieties were highly selected for sucrose content and mostly nonsignificant genetic variability was recorded. Moreover, additive variation has been reported [5] to be important for this trait. Varieties US 75 and R-06 showed slight improvement after sib-mating, which clearly indicates that this character is predominantly governed by additive gene action.

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REFERENCES

1. F. V. Owen. 1938. Genetics of self-sterility in sugarbeets. Proc. Am. Sco. Sug. Beet. Technol., **1**: 72–73.
2. P. C. Doloi and B. Rai. 1981. Inbreeding depression in rapeseed. Indian J. Genet. **41**: 368–373.
3. M. K. Aycock and C. P. Wilsie. 1967. Inbreeding *Medicago sativa* L. by sib-mating. I. Cross-, sib- and self-fertility. Crop Sci., **7**: 281–284.
4. R. J. Hecker. 1972. Inbreeding depression in diploid and autotetraploid sugarbeet, *Beta vulgaris* L. Euphytica, **21**: 106–111.
5. G. A. Smith, R. J. Hecker, G. W. Maag and D. M. Rasmuson. 1973. Combining ability and gene action estimate in an eight-parent diallel cross of sugarbeet. Crop. Sci., **13**: 312–316.
6. H. M. Srivastava, R. Kapur and B. L. Srivastava. 1986. Heterosis, combining ability and gene action in a seven-parent diallel of sugarbeet. Indian J. Genet., **46**(3): 484–489.