

The Extent of Inbreeding Depression in Seven Cultivars of Onion (*Allium cepa* L.)

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ABSTRACT

To assess the potential of breeding onion for hybrid seed production, mother bulbs of seven onion cultivars namely, Desi Red, Red Imposta, PK 10321, Rubina, Phulkara, Faisal Red and Dark Red were planted in the field. Seeds obtained from selfed and open-pollinated umbels were used to estimate the inbreeding depression at the seedling stage. There were significant differences among the cultivars for different characteristics. A considerable and varying degree of inbreeding has been found in different parameters among the onion cultivars.

Key Words: Onion; *Allium cepa*; Hybrid seed; Inbreeding; Inbreeding depression

INTRODUCTION

The availability of high quality seed of improved crop cultivars with good management practices has revolutionized the crop production. The seed industry has played a vital role in this revolution, with its expanding production capacity, efficiency in rapid seed increase of new cultivars and effective maintenance of genetic purity. Onion is predominantly a cross-pollinated crop, however, there is no self-compatibility problem and protandry does not prevent their self-pollination. Seed setting and development in onion are markedly affected by availability of pollinating insects and the genetic make up of the plant (Peter, 1998).

Onion seed production is a risky agriculture venture and the problem has been aggravated with the cultivation of hybrid crop. The production of anew hybrid seed for each crop is complementary to grow onion as a hybrid crop. Growing hybrids offer advantages over open-pollinated cultivars in productivity, uniformity in maturity and produce, quality and earliness (Currah, 1986). The hybrid seed production technology requires the development and assessment of inbred/selfed lines as a first step. The studies reported herein are first part of the research project aiming to appraise the potential for onion hybrid seed production in Pakistan.

MATERIALS AND METHODS

The part of the studies reported herein, on onion seed production, was carried out in the Department of Horticulture, University of Agriculture, Faisalabad during the year 1999-2000. The mother bulbs of seven onion cultivars namely, Desi Red, Red Imposta, PK 10321, Rubina, Phulkara, Faisal Red and Dark Red were obtained from the Ayub Agricultural Research Institute, Faisalabad. The recommended cultural practices were used to raise the plants in a field. Mother bulbs were planted in a single field on flat beds. Seed was obtained from selfed and open-pollinated umbels and this seed was used as an experimental material for laboratory studies.

After bud formation, during March-April, the individual umbels in each of the seven cultivars were selfed by covering them with the help of (15 x 10 cm) butter paper bags before anthesis. Umbels on plants of the same cultivars were also left open to produce open-pollinated seeds. In May, when umbels showed at least 50% black seeds, they were harvested. Selfed and open-pollinated seeds were collected separately avoiding any mechanical contamination. Hereafter, are given briefly the methods followed for recording observations on seedling parameters.

The selfed and open-pollinated seeds were sown under growth room conditions to study different seedling characteristics. The seeds were sown in plastic pots in the sand culture, at a temperature of $20\pm 1^{\circ}\text{C}$, by applying nutrient solution (Johnson's solution). The data on the following parameters were recorded from 12-day-old seedlings sown in three replications.

Seed germination. The germination percentage was counted under laboratory conditions at a temperature of $20\pm 1^{\circ}\text{C}$ with 16 h photoperiod. Data for the germination percentage of selfed and open-pollinated seeds for each cultivar were recorded after 12 days of sowing the seeds in the sand culture.

Seed mortality. Seed mortality was calculated as: (Total seeds sown - germinated seeds)

Number of normal seedlings. The seedlings of selfed and open-pollinated seeds were examined. The seedlings showing proper primary root, having a definite bend or knee, healthy cotyledon are considered as normal seedlings (ISTA, 1985).

Seedling length (cm). The total seedling length (shoot length + root length) was measured with the help of measuring scale by stretching the seedling. The seedlings were measured from the tip of root to the tip of shoot.

Root-shoot ratio. The root-shoot ratio was obtained as: Total root length / Total shoot length

Seedling fresh weight (g). The fresh seedling weight was taken soon after the seedlings were removed from the pots.

Seedling dry weight (g). The seedlings after being weighed were put in the petri dishes and placed in an oven at 80°C

for 17±1 h. The seedlings were then reweighed and average was calculated and analyzed. Petersen (1994) was followed for statistical analysis, and inbreed depression was estimated as: $\{(Open\ pollinated - Self\ pollinated / Open\ pollinated)100\}$.

RESULTS AND DISCUSSION

Development of inbred lines, a requisite for hybrid seed production, needs inbreeding, and cross-pollinated crops are mostly intolerant to inbreeding and leads to inbreeding depression because of the expression of recessive alleles, which become homozygous on selfing (Gabelman, 1974). This research project was conducted to assess the performance of selfed and open-pollinated progenies of the seven onion cultivars at the seedling stage under laboratory conditions. The data collected on different parameters were statistically analyzed and the results obtained are presented in seriatim.

Seed germination. Mean squares for between cultivars were significant at 0.01 probability level in both selfed and open-pollinated seeds (Table I), suggesting differences among the onion varieties for germination percentage of their seed, whether obtained after open pollination or controlled self pollination.

The extent of inbreeding depression in each cultivar is shown in Table II. A perusal to the table indicated varying level of inbreeding depression. The Red Imposta experienced maximum depression due to selfing. However, PK 10321, Rubina and Dark Red did not show any reduction in germination percentage on selfing. It seems that the genes controlling the character were already fixed in these genotypes and the character is predominantly

conditioned by the genes acting additively.

Seed mortality. The analysis of variance showed highly significant differences among the cultivars for the mortality percentage in both selfed and open-pollinated seeds (Table I). The results indicated that the tested cultivars differ considerably for seed mortality and this variability may be exploited to develop onion cultivars through selection and breeding with minimum seed mortality.

Inbreeding depression in the seven cultivars presented in Table II exhibited that except PK 10321 and Rubina none of the cultivars showed any inbreeding depression. It appears from the results that mortality of the seed is probably controlled by additive genes to a greater extent.

Number of normal seedlings. The analysis of variance revealed that the differences among the cultivars for number of normal seedlings were non-significant in both selfed and open-pollinated seedlings (Table I).

Inbreeding depression in the seven cultivars is shown in Table II. The cultivar Dark Red showed the maximum positive value of inbreeding depression, which was 46.70%. The minimum value was obtained for Red Imposta, which was 8.87%, while Rubina was a cultivar, which showed no depression for this particular character. The extent of inbreeding depression in these cultivars suggested that higher proportion of non-additive genes effect the expression of seedling length in onions.

Seedling length (cm). Differences between the cultivars for seedling length in both selfed and open-pollinated seeds were highly significant (Table I). It is evident from the significance of mean squares that variability for seedling length does exist among the tested onion cultivars. It is further evident that most of the cultivars showed inbreeding

Table I. Mean squares for self and open-pollinated progenies of onion cultivars at the seedling stage

	SOV	Seed germination	Seed mortality	No of normal seedlings	Seedling length	Root-shoot ratio	Seedling fresh weight	Seedling dry weight
Self pollinated	Between Cultivars	5.492**	5.492**	9.746**	3.855**	0.027**	0.003*	0.004*
	Within Cultivars	0.571	0.571	1.095	0.384	0.001	0.001	0.001
Open pollinated	Between Cultivars	9.937**	9.317**	4.317**	18.429**	0.015**	0.036**	0.032**
	Within Cultivars	0.810	0.810	0.667	0.287	0.001	0.0001	0.001

*, **, Significant at 5% and 1% probability level, respectively

Table II. The extent of inbreeding depression in onion cultivars for seedling parameters

Cultivars	Seed germination			Seed mortality			No of normal seedlings			Seedling length			Root-shoot ratio			Seedling fresh weight			Seedling dry weight		
	Self	Open	I. Dep	Self	Open	I. Dep	Self	Open	I. Dep	Self	Open	I. Dep	Self	Open	I. Dep	Self	Open	I. Dep	Self	Open	I. Dep
Desi Red	15.60	17.60	11.36	4.33	2.33	-85.84	8.33	11.30	26.28	7.09	10.73	33.92	0.39	0.52	25.00	0.26	0.49	46.94	0.10	0.36	72.22
Red Imposta	12.30	16.00	23.13	7.66	4.00	-91.50	9.66	10.60	8.87	9.05	8.14	-11.18	0.34	0.53	35.85	0.19	0.27	29.63	0.06	0.12	50.00
PK 10321	15.60	14.30	-9.09	4.33	5.66	23.50	11.00	8.66	-27.02	8.89	7.79	-14.12	0.36	0.44	18.18	0.20	0.23	13.04	0.05	0.08	37.50
Rubina	14.60	12.30	-18.70	5.33	7.66	30.42	8.00	8.00	0.00	7.82	4.71	-66.03	0.40	0.42	4.76	0.26	0.21	-23.81	0.06	0.08	25.00
Phulkara	12.60	14.30	11.89	7.33	5.66	-29.51	9.66	9.33	-3.54	7.38	10.68	30.90	0.40	0.45	11.11	0.18	0.23	21.74	0.05	0.13	61.54
Faisal Red	15.00	16.60	9.64	5.00	3.33	-50.15	9.33	10.60	11.98	6.71	12.19	44.95	0.58	0.49	-18.37	0.25	0.40	37.50	0.15	0.24	37.50
Dark Red	14.60	14.00	-4.29	5.33	5.00	-6.60	5.33	10.00	46.70	5.92	9.66	38.72	0.55	0.62	11.29	0.25	0.22	-13.64	0.10	0.11	9.09

I. Dep: Inbreeding Depression percentage

depression for the character, which suggested a considerable degree of heterozygosity for the genes controlling seedling height under open pollinated situation. The cultivars, Faisal Red, Dark Red, Desi Red and Phulkara showed inbreeding depression of 44.95, 38.72, 33.92 and 30.90%, respectively (Table II). The extent of inbreeding depression in these cultivars suggested the higher proportion of non-additive gene effects controlling the expression of seedling length in onions.

Root/shoot ratio. Mean squares from the analysis of variance were highly significant, suggesting differences among the cultivars in both selfed and open-pollinated seeds. The results indicated the differences in the growth rate of the cultivars at the seedling stage. Table II exhibited that except Faisal Red all the cultivars showed a considerable degree of inbreeding depression for the root/shoot ratio. The cultivar, Faisal Red showed the negative value for root/shoot ratio, which shows that selfing did not affect the character adversely in this cultivar.

Seedling fresh weight (g). The analysis of variance showed significant differences among the cultivars in self-pollinated seedlings while in open-pollinated seedlings, the difference between cultivars were highly significant (Table I). Whilst the cultivars appeared to have considerable differences for seedlings fresh weights, the magnitude of the difference seemed to vary between the seed obtained through open pollination and self pollination. This suggests differences in the extent of inbreeding depression in the cultivars for the character expression.

The cultivar Desi Red showed the maximum positive depression, which was 46.94%. While PK 10321 showed the minimum inbreeding depression which was 13.04%. The cultivar Dark Red showed the maximum negative value of inbreeding depression for seedling fresh weight, which showed that selfing did not cause any depression in the character manifestation.

Seedling dry weight (g). The analysis of variance showed that the differences among the cultivars were significant in self-pollinated seedlings while these results were highly significant in case of open-pollinated seedlings. The dissimilarity in the significance level of the variability between the seedlings grown from open pollinated and selfed seed seems to depict differences in the degree of inbreeding depression.

The cultivar Desi Red showed the maximum depression percentage (72.22) on inbreeding and the minimum value of depression was 9.09%, which was observed in Dark Red. The extent of inbreeding depression in Phulkara, Red Imposta, PK 10321 and Faisal Red with 61.54, 50, 46.87, 37.50 and 37.50%, respectively suggested the higher proportion of non-additive gene effects controlling seedling dry weight in onions.

It may be concluded from the present studies that the cultivars exhibited a considerable degree for variation for seedling traits. The extent of inbreeding depression also varied among the cultivars for character expression and suggested the possibility of developing potential inbred lines for hybrid seed production in onion.

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