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ANALYSIS OF HARVEST INDEX IN THREE CULTIVATED SPECIES OF BRASSICA

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ABSTRACT

Low genotypic coefficient of variation for harvest index (HI) but high for grain yield and biological yield was observed in F_1 population of *toria*. Low GCV was observed for this attribute in the elite stocks of *Brassica campestris* and *Brassica juncea* but it was high in *Brassica rugosa*. It was positively associated with grain yield. Seed yield was the major contributor to variation for harvest index in three *Brassica* species. Additive gene action was preponderant for HI but nonadditive for seed and biological yield. The parents PT 76-3, PT76-5 and PT 76-1 were good general combiners. The highest BP heterosis (67.23%) for harvest index was observed in the hybrid PT 76-2 x PT 76-6.

Key words: Heterosis, harvest index, *Brassica* spp.

Harvest index (HI) is the ratio of economic yield and total biological biomass [1]. In cereal crops, HI has been reported to be positively associated with grain yield [2]. Though, it is an important physiological index, not much is known about its genetic architecture in the oil seed crops, rapeseed and mustard. In the present investigation, an attempt was made to obtain some basic information which can be meaningfully utilized in the genetic improvement for seed yield in these crops.

MATERIALS AND METHODS

Three experiments were conducted, in which the first experiment comprised F_1 populations of 6 x 6 complete diallel of the parents selected on the basis of HI and plant type from a segregating generation of rapeseed (*Brassica campestris* L. spp. *oleifera* var. *toria*). This experiment with 38 entries (30 hybrids + 6 parents + 2 checks) was conducted in R.B.D. with three replications. Each plot consisted of single row 3 m long. The second experiment

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included 15 elite stocks of three *Brassica* species, viz., *Brassica campestris* L., *Brassica juncea* (L.) Czern & Coss. and *Brassica rugosa* Roxb. This experiment was conducted in R.B.D. with 4 replications in which the plots consisted of five 5 m long rows. The third experiment had 42 strains of various plant types, viz., normal tall, normal dwarf and bunchy dwarf of *Brassica campestris* var. *toria*. These strains were raised in compact family block design with three replications in 2–row plots of 3 m length. In all experiments, the spacing between rows and plants was maintained at 30 cm and 10 cm, respectively. Standard agronomic practices were followed to raise a good crop.

Observations were recorded on grain yield and biological yield/plant on 10 competitive plants selected randomly from each plot. The HI was determined as per [1], coefficients of variability [3], coefficients of correlation [4], direct and indirect effects through path-coefficient analysis [5] in all the three experiments. In F_1 populations of *toria*, the varietal effects (vj) and variation due to heterosis (hij) were estimated using the method of diallel analysis [6], heterosis as in [7], broad sense heritability as per [8], and expected genetic advance as in [9].

RESULTS AND DISCUSSION

In F_1 population of *toria* the genotypic coefficient of variation (GCV) was low (12.7%) for HI but higher for grain yield (22.8%) and biological yield (17.1%) (Table 1). The comparison of GCV and PCV revealed that environment played an important influence in the expression of these important economic attributes. Exploitable amount of genetic variability was observed for grain and total biological yield in all three *Brassica* species, except for grain yield in *Brassica rugosa* (Table 2). For harvest index sufficient GCV was observed only in *B. rugosa* (18.9%), but it was low in *B. campestris* (9.0%) as well as *B. juncea* (8.4%).

Table 1. Range, mean, GCV and PCV in F_1 population of *toria*

Character	Range	Mean	GCV (%)	PCV (%)
Grain yield/plant (g)	6.4–24.3	15.3 ± 3.4	22.8	45.2
Biological yield/plant (g)	24.5–82.6	51.5 ± 11.0	17.1	40.9
Harvest index (%)	17.6–37.3	29.6 ± 3.0	12.7	21.5

No significant difference was observed in the three plant types for HI (Table 3). But grain and total biological yields were significantly higher in the normal tall family as compared to normal dwarf and bunchy dwarf families. However, the progeny having highest economic yield (12.6 g/plant) in normal tall family was not significantly superior to the best progenies in bunchy dwarf (11.7 g/plant) and normal dwarf (11.1 g/plant) families. This indicate a good scope for developing dwarf varieties of *toria* with equally high economic yield as well as harvest index, as more plant population per unit area can be raised.

Table 2. Range, mean, GCV and PCV in *Brassica* ssp.

Character	Species	Range	Mean	GCV (%)	PCV (%)
Grain yield/plant (g)	*B. campestris*	6.2–11.4	8.7 ± 0.2	26.8	27.3
	B. juncea	8.7–13.3	10.2 ± 0.3	16.9	17.6
	B. rugosa	2.6–3.2	2.8 ± 0.1	9.9	11.6
Biological yield/plant (g)	*B. campestris*	23.7–38.3	30.0 ± 1.3	22.8	24.4
	B. juncea	26.1–43.7	34.1 ± 1.4	18.7	20.3
	B. rugosa	17.3–33.3	26.0 ± 1.3	21.0	23.4
Harvest index (%)	*B. campestris*	26.1–32.5	29.0 ± 0.8	9.0	10.4
	B. juncea	27.5–33.5	30.4 ± 0.7	8.4	9.4
	B. rugosa	9.1–14.9	11.2 ± 0.6	18.9	22.0

Correlation studies revealed that HI was significantly and positively associated with grain yield ($r = 0.47$, 0.88 and 0.39 in F_1 population of *toria*, elite lines of three *Brassica* species and three plant types of *toria*, respectively). Thus, HI may be used as a selection criterion in the development of high yielding genotypes. Economic yield was also positively associated with total biological yield, ($r=0.98$, 0.71 and 0.89 in all three materials under investigation, respectively). The path-analysis revealed that grain yield had high positive direct effect on HI in elite lines of three *Brassica* species (2.86) as well as three plant types of *toria* (3.94).

Table 3. Performance of three plant types of *toria*

Family	Grain yield (g)		Biological yield (g)		HI (%)	
	mean	range	mean	range	mean	range
Normal tall	10.9	9.2–12.6	33.0	26.4–37.2	33.4	31.7–34.2
Normal dwarf	9.6	8.6–11.1	28.3	24.8–30.2	33.9	31.9–36.0
Bunchy dwarf	9.1	7.2–11.7	27.5	23.5–31.7	33.2	29.8–37.0
CD (5%)	1.1	3.2	2.4	9.1	2.4	5.7

However, grain yield had negative direct effect (–1.18) in F_1 population of *toria* and indirect effects via siliquae/plant (3.44), siliquae/main shoot (2.02), and days to 75% flowering (1.35) play an important role to give the observed positive association between grain yield and HI. It has also been reported that it is possible to develop early maturing dwarf strains with high harvest index as well as high economic yield in *Brassica* ssp. [10].

The results of diallel analysis (Table 4) indicated that for HI both additive as well as nonadditive type of gene action were important, however, additive type of gene action was preponderant over nonadditive. It appears that additive genetic variance has not been fully exhausted in the parental populations involved in this investigation. But for grain and biological yield nonadditive type of gene action was preponderant over additive gene action. It is desirable to follow recurrent selection for genetic improvement of such populations.

Table 4. Analysis of variance (M.S.S.) for yield and HI in F_1 populations and varieties of *toria*

Source of variation	df	Grain yield/ plant	Biological yield/ plant	Harvest index
Varieties (vj)	5	N.S. (N.S.)	N.S. (N.S.)	** (**)
Heterosis (hij)	15	* (*)	N.S. (*)	** (*)
Average ($\bar{h}$)	1	N.S.	N.S	**
Varietal (hij)	5	(N.S.) (N.S.)	(N.S.) (N.S.)	N.S. (N.S.)
Specific (sij)	9	N.S. (**)	N.S. (**)	N.S. (N.S.)

Values in parentheses belong to reciprocals; N.S. nonsignificant;
* Significant at 5% and ** significant at 1% level.

The rating of parents on the basis of varietal effects (Table 5) indicated that parent PT 76-3 (high HI, normal dwarf) was the best general combiner for HI as well as grain and biological yield. The PT 76-1 (high HI, normal tall) and PT 76-5 (high HI, bunchy dwarf) were the other good general combiners for both HI and grain yield while the parents with low HI, i.e. PT 76-2 (low HI, normal tall), PT 76-4 (low HI, normal dwarf) and PT 76-5 (low HI, bunchy dwarf), in general, were poor general combiners. Thus, it is concluded that it is desirable to include parents with high HI in the crossing programme of *toria*. The parent PT 76-3 had higher grain yield/plant, and PT 76-5, had the highest HI. There was a close correspondence in the best parents on the basis of their mean performance and varietal effects, indicating thereby that parents could be selected on the basis of per se performance

Table 5. Rating of *toria* parents based on varietal effects

Character	PT 76-1	PT 76-2	PT76-3	PT 76-4	PT 76-5	PT 76-6
Grain yield/plant	G	P	G	A	G	P
Biological yield/plant	P	P	G	G	P	P
Harvest index	G	P	G	P	G	P

G—good combiner; A—average combiner and P—poor combiner.

for a hybridization programme. A comparison of the hybrids on the basis of mean performance and highest specific heterosis showed that the hybrids were same for grain and biological yield but not in HI (Table 6). It was also observed that hybrids showing very high heterosis over better parent may not have high mean yield. Similarly, it was observed that estimates of specific heterotic effects may not always lead to the correct choice of cross combination. It was also interesting to note that hybrids involving one parent with high and the other with low value of grain or biological yield exhibit the best performance for grain or biological yield. But it was not so for HI. However, for all these three traits, the best hybrid based on mean performance, specific heterosis and BP heterosis, involved one tall and other dwarf parent. It is, therefore, desirable to include the dwarf *toria* in hybridization to exploit the high heterotic potential. Arunachalam and Katiyar [11] also reported similar findings in other crops.

The estimates of heterosis are presented in Table 7. Significant heterosis over better parent was observed in two hybrids for harvest index. Nine hybrids showed significant

Table 6. Best parent and best F_1 based on various parameters

Character	Best parent based on			Best F_1 based on		
	mean performance	varietal effect	varietal heterosis	mean performance	specific heterosis	BP heterosis
Grain yield/plant (g)	PT 76-3 (19.0)	PT 76-3	PT 76-6	PT 76-5 x PT 76-2 (24.3)	PT 76-5 x PT 76-2	PT 76-2 x PT 76-6
Biological yield/plant (g)	PT 76-4 (69.2)	PT 76-4	PT 76-2	PT 76-3 x PT 76-2 (82.6)	PT 76-3 x PT 76-2	PT 76-5 x PT 76-2
Harvest index (%)	PT 76-5 (30.5)	PT 76-5	PT 76-2	PT 76-1 x PT 76-5 (37.3)	PT 76-1 x PT 76-4	PT 76-2 x PT 76-6

positive relative heterosis. However, none of the hybrids showed significant positive standard heterosis for HI and grain yield. Only one hybrid, PT 76-2 x PT 76-6, showed significant positive heterosis over better parent (106.7%). However, significant positive heterosis over midparent was observed in four hybrids for grain yield. None of the hybrids showed yield poorer than mid parent value. The hybrids had significant positive standard heterosis for biological yield. When heterosis was related with per se performance of the hybrids, it was observed that the hybrids showing maximum heterosis for HI did not have highest mean performance similar is the case with grain and biological yield. Therefore, selection based on mean performance would be more effective than heterosis in the hybrids alone. The most important traits contributing towards high heterosis for HI were siliquae/main shoot and plant height, as these atttributes showed significant heterosis in 5 out of 9 hybrids showing heterosis for HI. Such expression of heterosis due to favourable combination of yield components and HI in the hybrids could be viewed as a case of combinational heterosis [12].

Table 7. Range of various types of heterosis and best hybrids for different quantitative characters in *toria*

Heterosis	Grain yield/ plant (g)	Biological yield/ plant (g)	Harvest index (%)
Relative heterosis (%):			
range	–56.7–141.7*	–63.0–49.9	–2.3–79.4*
best hybrid	PT 76-2 x PT 76-6	PT 76-5 x PT 76-6	PT 76-2 x PT 76-6
BP heterosis (%):			
range	–62.8–106.7*	–64.6–44.6	–12.6–67.2*
best hybrid	PT76-2 x PT 76-6	PT 76-5 x PT 76-2	PT 76-2 x PT 76-5
Standard heterosis (%):			
range	–60.5–65.6	–46.7–84.9*	–43.9–12.2
best hybrid	PT 76-5 x PT 76-2	PT 76-3 x PT 76-2	PT 76-1 x PT 76-5

*Significant at 5% level.

The low broad sense heritability (34.8%) as well as low genetic advance (4.6% of mean) for HI in F_1 population of *toria* revealed considerable environmental influence in the expression of this attribute.

Therefore, simple selection for higher HI in this material is unlikely to bring about a conspicuous improvement in yield. However, considerable improvement could be expected in HI by turning the promising hybrids into composites, followed by recurrent selection for developing stable improved populations.

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