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INHERITANCE OF ROOT CHARACTERS IN TURNIP (*BRASSICA RAPA* L.)

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ABSTRACT

Inheritance of root colour in turnip (*Brassica rapa* L.) was studied in nine crosses involving five parents. Purple root colour was dominant over pink, partially purple and white root colour, and was under the control of two genes P and C. These two genes in double dominant state produce purple roots. The genotype of purple parent was thus tentatively designated as PPCC. The pink and partially purple root colours were dominant over white and they were under the control of single dominant gene P and C, respectively. Genotype PPcc produces pink root and ppCC partially purple roots. White roots are produced in double recessive homozygotes: ppcc. Root shape was studied in two crosses involving round and flat round rooted parents. The F_1 generation showed dominance of round shape over flat round as a monogenic trait. The gene symbol R is proposed for this character.

Key words: Turnip, *Brassica rapa*, inheritance, root colour, root shape.

In Kashmir, a lot of variability exists in turnip for yield and other quality traits from many local cultivars under cultivation. These local cultivars mostly have unacceptable market traits and are poor in root yield. Root shape and colour being the most important characters determining acceptibility by the consumer in the market need to be improved. Further, the information on the genetic behaviour of important qualitative characters is almost nil except by Brar et al. [1] who by involving partially purple, red and white parents reported a strong evidence of genic interactions in the inheritance of skin colour with incomplete dominance for root shape. Though it is a very important crop in the Valley, no effort has so far been made to improve the existing local types. With a view to transfer good characteristics of the commercial varieties into the local cultivars, an improvement programme at this centre was taken up to study the genetics of root colour and shape from intervarietal crosses of turnip.

MATERIALS AND METHODS

The F_1, F_2, BC_1 (F_1 x P_1) and BC_2 (F_1 x P_2) generations of crosses involving five parents, viz. Purple Top White Globe (PTWG), Pusa Snow Ball (PSB) and local selections T-8, T-2 and T-1 were grown to study the genetics of root colour and shape. Characteristics of the parents involved in different crosses are presented in Table 1. Progenies of the crosses PTWG x T-1, PTWG x PSB, PTWG x T- 8, PTWG x T-2, T-8 x T-2, T-8 x T-1, T-8 x PSB, PSB x T-2 and T-2 x T-1 were analyzed to study inheritance of root colour, while the crosses PSB x T-2 and T-8 x T-1 were made to study inheritance of root shape. Seeds of different generations were sown in randomized block design with three replications at 30 cm row spacing. Harvesting of roots was done at edible stage. Roots harvested from three replications in each population were pooled and observations recorded on root colour with the help of colour chart in F_1 and each subsequent generation. Total number of roots falling in different colour classes (white, pink, partially purple, purple) were counted. The method suggested by Brar et al. [1] was followed to record root shape as ratio of horizontal to vertical diameter. The root was recorded as round when the ratio was between 0.9–1.24, flat round with the ratio 1.25–1.74 and flat with 1.75–2.00.

The χ^2 test was used to determine goodness of fit to the expected genetic ratios as suggested by Panse and Sukhatme [2].

RESULTS AND DISCUSSION

The results of nine crosses involving five parents are presented in Table 2. Parent PTWG (partially purple) was crossed with PSB (white), T-1 (white), T-2 (pink) and T-8 (purple). All F_1 plants in the crosses PTWG x T-1 and PTWG x PSB produced partially purple roots, indicating complete dominance of partially purple over white roots. Their F_2 population segregated into 3 partially purple : 1 white (Table 2). In backcross progeny (F_1 x PTWG), all the roots were partially purple, which fitted the expected genetic ratio 1 : 0. In BC_2 (F_1 x T-1, F_1 x PSB) the roots segregated for colour in the ratio of 1 partially purple : 1 white, further confirming the expected test-cross ratio 1:1. The segregation pattern in F_2 and the two backcross generations suggested that the partially purple and white roots differ by a single gene where partially purple was dominant over white colour.

Table 1. Characters of parents involved in different crosses of turnip

Parent variety	Root colour	Root shape
Purple Top White Globe (PTWG)	About top 1/3 root purple, rest white (partially purple)	Round
Pusa Snow Ball (PSB)	Pure white	Round
T-1	Pure white	Flat round
T-2	Pink	Flat round
T-8	Purple	Round

Table 2. Segregation for root colour in turnip

Cross and generation	No. of roots observed					Expected genetic ratio	χ^2	P
	total	purple	pink	partially purple	white			
PTWG x PSB:								
F_2	704	—	—	535	169	3:1	0.37	0.5–0.7
BC_1	318	—	—	318	—	1:0	0.00	1.00
BC_2	366	—	—	194	172	1:1	1.32	0.2–0.3
PTWG x T-1:								
F_2	741	—	—	547	194	3:1	0.55	0.3–0.5
BC_1	330	—	—	330	—	1:0	0.00	1.00
BC_2	352	—	—	162	190	1:1	2.22	0.1–0.2
PTWG x T-3:								
F_2	638	483	—	155	—	3:1	0.17	0.5–0.7
BC_1	260	136	—	124	—	1:1	0.55	0.3–0.5
BC_2	293	293	—	—	—	1:0	0.00	1.00
PTWG x T-2:								
F_1	602	352	98	114	37	9:3:3:1	2.51	0.3–0.5
BC_1	207	108	—	99	—	1:1	0.39	0.5–0.7
BC_2	236	115	121	—	—	1:1	0.15	0.5–0.7
T-8 x T-2:								
F_2	698	518	180	—	—	3:1	0.23	0.5–0.7
BC_1	307	307	—	—	—	1:0	0.00	1.00
BC_2	264	144	120	—	—	1:1	2.18	0.1–0.2
T-8 x T-1:								
F_2	689	363	135	147	44	9:3:3:1	4.29	0.2–0.3
BC_1	234	234	—	—	—	1:0	0.00	1.00
BC_2	345	80	91	76	98	1:1:1:1	3.34	0.3–0.5
T-8 x PSB:								
F_2	660	385	116	128	31	9:3:3:1	3.84	0.2–0.3
BC_1	299	299	—	—	—	1:0	0.00	1.00
BC_2	314	68	89	74	83	1:1:1:1	3.32	0.3–0.5
PSB x T-2:								
F_2	721	—	548	—	173	3:1	0.93	0.5–0.7
BC_1	306	—	162	—	144	1:1	1.06	0.3–0.5
BC_2	381	—	381	—	—	1:0	0.00	1.00
T-2 x T-1:								
F_2	639	—	492	—	147	3:1	1.36	0.2–0.3
BC_1	396	—	396	—	—	1:0	0.00	1.00
BC_2	330	—	158	—	172	1:1	0.59	0.3–0.5

All the 75 F_1 roots of the cross PTWG (partially purple) x T-8 (Purple) were purple indicating dominance of purple roots over partially purple. The 638 roots analysed in F_2 generations segregated into 483 purple and 155 partially purple which fitted well to the expected genetic ratio of 3:1. In BC_1 (F_1 x PTWG), 260 roots segregated into 136 purple and 124 partially purple, which was very close to the expected 1:1 ratio, while in BC_2 all the roots were purple. In this cross again, it was observed that the parents PTWG and T-8 differ by a single gene where purple colour was dominant over partially purple. The above crosses thus indicated that the white and purple rooted plants differ in two different genes where purple is a double dominant and white double recessive situation. This situation became further clear from the cross PTWG (partially purple) x T-2 (pink), where F_1 was purple. This phenotype did not resemble either of the two parents involved in the cross, and this was a result of interaction between genes causing partially purple and pink colour of roots. Presence of genic interactions in the inheritance of root skin colour has also been reported [1].

The F_2 population of 602 roots in this cross segregated into four colour classes of 352 purple : 98 pink : 114 partially purple : 37 white roots, fitting well to the expected digenic ratio 9:3:3:1. The backcross of F_1 with the partially purple type (BC_1) had 207 roots which segregated into 108 purple and 99 partially purple, fitting the 1:1 ratio. The backcross of F_1 with pink rooted parent with 236 roots segregated into 115 purple : 121 pink, also fitting the expected 1:1 ratio. These above observations revealed that the purple root colour is produced as a result of interaction between two independently inherited dominant genes. These genes have been tentatively designated as P and C. Both P and C, which are dispersed in two parents, PTWG and T-2, when come together interact and produce purple phenotype. The dominant gene P in absence of gene C produces only pink roots and the dominant gene C in absence of dominant gene P results in the formation of only partially purple roots where 1/4th to 1/3rd top of the root, which is fully exposed to light, develops purple colour. In PTWG, the recessive gene p could not produce purple roots even though dominant gene C for purple colour development under exposure to solar radiation is present in this variety. However, the dominant gene C, which alone cannot produce totally purple roots, in combination with dominant gene P is able to form purple roots even in the absence of light. When both the genes are in homozygous recessive state (p and c) the roots are totally colourless (white). Based on the above assumptions, the genotypes of different parents are proposed as follows:

Purple Top White Globe (partially purple)	ppCC	T-8 (purple)	PPCC
		PSB (white)	ppcc
T-2 (pink)	PPcc	T-1 (white)	ppcc

In the cross T-8 (purple) x T-2 (pink) purple root colour was dominant over pink. In F_2, BC_1 (F_1 x T-8) and BC_2 (F_1 x T-2) generations the purple : pink root colours segregated into 3 : 1, 1:0 and 1:1 ratios, respectively, indicating that purple parent T-8 differs from the pink

parent T- 2 only at one locus and the purple parent T-8 is homozygous dominant at both P and C loci.

All the roots in F_1 of the crosses T-8 (purple) x T-1 (white) and T-8 (purple) x PSB (white) were purple, suggesting dominance of purple root colour over white. The F_2 plants in both crosses segregates into 9 purple : 3 pink : 3 partially purple : 1 white roots (Table 2). In the BC_1 (F_1 x purple parent) generation of both crosses, all the roots were purple while in BC_2 (F_1 x white parent) the plants segregated into 1 purple : 1 pink : 1 partially purple : 1 white, which finally confirms digenic inheritance of root colour in turnip.

The crosses PSB (white) x T-2 (pink) and T-2 (pink) x T-1 (white) also confirmed single gene difference between pink parent and white parent where pink root colour was dominant over white (Table 2).

In the present investigation although efforts have been made to understand genetics of root colours from the available germplasm (purple, partially purple, pink and white), however there are turnip varieties with basic colours like yellow (Golden Ball), red (Local Red) etc. These varieties with basic colours must also be involved in the crosses for getting more precise and reliable information.

Inheritance of root shape was studied in the crosses PSB (Round) x T-2 (Flat Round) and T-8 (Round) x T-1 (Flat Round). In both the crosses all the F_1 roots were round, indicating

Table 3. Segregation for root shape in turnip

Cross and generation	No. of roots observed			Expected genetic ratio	χ^2	P
	total	round	flat round			
PSB x T-2:						
PSB	65	65	0	—	—	—
T-2	59	0	59	—	—	—
F_1	83	83	0	—	—	—
F_2	717	535	182	3:1	0.06	0.8–0.9
BC_1	306	306	0	1:0	0.00	1.00
BC_2	318	202	179	1:1	1.39	0.2–0.3
T-8 x T-1:						
T-8	70	70	0			
T-1	72	0	72			
F_1	90	90	0			
F_2	689	524	165	3:1	0.41	0.5–0.7
BC_1	234	234	0	1:0	0.00	1.00
BC_2	345	183	162	1:1	1.28	0.2–0.3

dominance of round shape over flat round shape (Table 3). In a cross between varieties with round and flat roots, Brar et al. [1], however, observed incomplete dominance of the allele determining round roots over flat roots. In the F_2 generation, the roots of both the crosses made by us segregated into 3 round : 1 flat round. The BC_1 (F_1 x round rooted parent) populations in both crosses, all roots were round, confirming the expected 1:0 ratio while the BC_2 (F_1 x flat round rooted parent) populations segregated into 1 round : 1 flat round, confirming further the expected 1 : 1 ratio. The 3 : 1 F_2, 1 : 0 BC_1 and 1 : 1 BC_2 ratios of both the crosses suggest that root shape is under the control of single gene where the genotype RR and rr produce round and flat round roots, respectively. However, for confirmation further studies utilizing distinct shapes may be necessary.

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