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Characters association studies in broccoli [*Brassica oleracea* (L.) var. *italica*] under mid hill of Uttarakhand

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ABSTRACT : Characters association studies may help in the selection of the traits associated with the highest expression in terms of quality and quantity (yield). The correlation study revealed that the seed yield of broccoli exhibit highly significant and positive correlation with days to maturity, plant height, number of secondary branches per plant, number of siliqua per plant, length of siliqua and number of seeds per siliqua. Seed yield also positively correlated with number of primary branches per plant and diameter of siliqua. The highly significant and positive correlation of vigour index-I was obtained with 1000-seed weight, standard germination, seedling length and seedling moisture content, while the vigour index-II showed significant and negative correlation with seedling moisture content.

KEY WORDS : Broccoli, Protein, Fat, Carbohydrate, Iron

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Broccoli (*Brassica oleracea* L. var *italica*) is a member of the Brassicaceae (Cruciferae) family, originated from west Europe has considered as cool-season crops, now been distributed in both tropical and the sub tropical areas. Other members of the family include cauliflower, cabbage and kale (Guo *et al*., 2001). Its optimum growing temperature is in the range between 16 and 20^{0}C and is a biannual, herbaceous vegetable crop **(**Karistsapol *et al*., 2013). Compared to cabbage and cauliflower, broccoli is nutritionally very rich in protein (3.6%), fat (0.3%), carbohydrate (5.9%), vitamin A (9000 I.U.), calcium (2-16%) and iron (684 ppm). This nutritious vegetable also contains a chemical known as indole-3-carbinol, which is supposed to possess anticancerous properties (Choudhury, 2005).

United States of America is a leading producer of broccoli. In India broccoli has become a commercial crop very recently and is grown in small area. The climatic conditions of North Western Himalayan hills are quite conductive for growth and development of the crop (Kalring, 1998). The cultivation of sprouting broccoli is now gaining popularity among Indian growers for the last couple of years obviously due to increasing awareness of its high nutritive values and tourist influx.

In Uttarakhand, Broccoli is less popular among vegetable growers. However, researchers/farmers experience revealed that this nutritious exotic vegetable could be grown in the state without much difficulty. Considering off-season nature of the crop, congenial climate of the region and high demand of produce in metropolitan cities, further give an opportunity to the vegetable growers of Uttarakhand to raise the crop on a large scale.

The vegetable seed production is very important and profitable enterprises but to obtain the good quality seeds,

the knowledge of raising the crop is essential (Jana *et al*., 2003). To make effective selection for higher seed yield and quality, a thorough understanding of these characters, interrelationship among themselves is necessary. Selection for one component can bring about a simultaneous change in other. The seed yield and quality of broccoli is complex characters, which is associated with several other characters having positive or negative effects on these traits. It is important to examine the contribution of each of the trait in order to give more attention to those having the greatest influence on seed yield and seed quality. Therefore, information on the association of traits with seed yield and seed quality is of great importance to define selection criteria in terms of yield. Generally, correlation co-efficients show relationships among independent characteristics and the degree of linear relation between these characteristics. The varying transplanting dates have a direct response on the growth, development, seed yield and quality of broccoli. Available information on this aspect is meager. Hence, correlations among different characters of broccoli under varying dates of transplanting were computed to understand the nature and extent of character association.

RESEARCH METHODS

An experiment was carried out at the Research Block and Seed Testing Laboratory, Department of Seed Science and Technology, G.B. Pant University of Agriculture and Technology, College of Forestry and Hill Agriculture, Hill Campus, Ranichauri, Tehri Garhwal (Uttarakhand), during winter season of 2008-09. The seed of broccoli cultivar (Punjab Broccoli-1) was used in this study, obtained from Department of Seed Science and Technology. The experiment was laid out in Randomized Block Design with five replications. Thirty days old seedlings were transplanted in the entire experimental plot at 50 cm x 50 cm spacing between plant to plant and row to row. All experimental plot received fertilizers at the rate of 100 kg nitrogen, 80 kg phosphate and 60 kg potash per hectare. Full dose of phosphate, potash and one third of nitrogen were applied at the time of transplanting of seedling and rest nitrogen was given in two equal split doses at curd initiation and flowering stage. All cultural operations like weeding, earthing up, irrigation, spraying of pesticides, etc. were done equally in all the plots as required.

For seed production seed to seed method was followed. All the observations that is directly or indirectly related to seed yield (days to maturity, plant height, number of branches per plant, number of siliqua per plant, seeds per siliqua, length of siliqua and seed yield per hectare etc.) were taken. The seed yield was recorded on net plot basis, while seed yield contributing characters were recorded by randomly selected five plants from each plot.

The four replications of each treatment (100 seeds in each replication) were taken for germination test. The germination test was done on the basis of the top of the paper method as per ISTA rules. The seedlings length (cm) and seedlings weight (g) were recorded by ten randomly selected seedlings from each replication. Vigour index-É was calculated by multiplying standard germination per cent with seedling length and Vigour index-ÉÉ was calculated by multiplying germination per cent with seedling dry weight. The correlation co-efficients were worked out between seed yield and yield contributing characters and among the seed quality characters.

RESEARCH FINDINGS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarised under following heads:

Correlation between seed yield and seed yield contributing characters:

Correlation is a powerful tool to study the character association, so it is very useful to facilitate selection for improvement of important characters without sacrificing the gain of other characters. The character associations among different morphological characters were computed to know the dependency of one character to another. The character association between seed yield and seed yield contributing parameters has shown in Table 1. When there is a positive association of major yield contributing characters, component breeding would be very effective but when these characters are negatively associated, it would be difficult to exercise simultaneous selection for them in developing variety. The seed yield showed highly significant and positive correlation with days to maturity (0.935**), plant height (0.775**), number of secondary branches per plant (0.751**), number of siliqua per plant (0.879**), length of siliqua (0.712**) and number of seeds per siliqua (0.598**). The number of primary branches per plant (0.417*), diameter of siliqua (0.425*) and size of seed (0.422) also showed significant and positive correlation with seed yield. Similar results were also reported by Mishra (1989), Mishra (2010) and Abideen *et al*. (2013). These finding shows that if seed yield contributing characters like days to maturity, plant height, number of branches per plant, number of siliqua per plant, length of siliqua, diameter of siliqua and seeds per siliqua etc. increases the seed yield of broccoli will also increases.

It was observed that the diameter of siliqua had non-significant correlation with all the seed yield contributing characters except number of siliqua par plant and length of siliqua. Similarly, the size of seed of different transplanting dates showed non-significance correlation with all seed yield contributing characters like plant height, number of primary branches per plant, number of secondary branches per plant, number of siliqua par plant etc. except diameter of siliqua.

Table 1 : Character association between seed yield and seed yield contributing characters

Characters	Days to maturity	Plant height (cm)	No. of primary branches/ plant	No. of secondary branches/ plant	No. of siliqua/ plant	Length of siliqua (cm)	Diameter of siliqua (mm)	No. of seeds/ siliqua	Size of seed (mm)	Seed yield/ plant (g)	Seed yield/ ha (kg)
Days to maturity		0.750**	0.497*	0.731**	0.814**	0.667**	0.354	0.432*	0.254	0.935**	0.935**
Plant height (cm)			0.736**	0.755**	0.811**	0.570**	0.271	0.591**	0.231	0.775**	0.775**
No. of primary branches/plant				0.751**	0.698**	0.634**	0.352	0.621**	0.241	0.417*	0.417*
No. of secondary branches/plant					0.896**	0.789**	0.310	0.667**	0.251	0.751**	0.751**
No. of siliqua /plart						0.802**	0453*	0.780**	0.232	0.879**	0.879**
Length of siliqua (cm)							0419*	0.885**	0.215	0.712**	0.712**
Diameter of siliqua (mm)								0.305	0.468*	0.425*	0.425*
No. of seeds/ siliqua									0.249	0.598**	0.593**
Size of seed (mm)										0.422*	0.422*
Seed yield/ plant (g)											1.000**
Seed yield/ ha (kg)											

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 2 : Character association among seed quality characters

Characters	Germination first count (%)	Standard germination (%)	Seedling length (cm)	Seedling fresh weight (g)	Seedling dry weight (g)	Seedling moisture content (g)	Vigour index-I	Vigour index- II	1000-seed weight (g)
Germination first count (%)		0.681**	0.582**	0.345	0.375	0.337	0.358	0.456*	0.468*
Standard germination (%)			0.835**	0.703**	0.645**	0.608**	0.852**	0.725**	0.822**
Seedling length (cm)				0.789**	0.805**	0.821**	0.874**	0.436*	0.886**
Seedling fresh weight (g)					0.726**	0.782**	0.415*	0.448*	0.785**
Seeding dry weigh: (g)						0.218	0.361	0.619**	0.602**
Seedling moisture content (g)							0.403*	-0.468*	0.798**
Vigour index-I								0.483*	0.921**
Vigour index-II									0.461*
1000-seed weight (g)									

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Correlation among seed quality parameters:

Correlation values among seed quality parameters of broccoli shown in Table 2. It was interesting to note that most of the characters showed highly significant positive correlations with each other. This is an indication that these characters influence the total quality and performance of broccoli seeds. The standard germination showed highly significant and positive correlation with seedling length (0.835**), seedling fresh weight (0.703**), seedling dry weight (0.645**), seedling moisture content (0.608**), 1000-seed weight (0.822**), vigour index-É (0.852**) and vigour index-II (0.725**). This result was in agreement with finding of Maloo *et al*. (1990).

The seed lots having lower test weight (1000-seed weight) may perform poorly when compared with lots having higher test weight. The information of 1000-seed weight is also needed to determine the number of pure lived seed (PLS) per unit of weight. The character association study revealed the highly significant and positive correlation of 1000-seed weight with most of the seed quality parameters like standard germination per cent, seedling length, seedling fresh weight, seedling dry weight, seedling moisture content and Vigour index-I.

The first quality component to show signs of deteriorations is that of seed vigour, followed by a loss of germination or normal seedling production and finally the death of the seed (Ramamoorth, 2006). Hence it is important to know that the association between seed vigour and other seed quality attributes. Highly significant and positive correlation was observed between vigoue index-É and standard germination (0.852**), seedling length (0.874**) and 1000-seed weight (0.921**). The vigour index-I also positively and significantly correlated with seedling fresh weight, moisture content and vigour index-II. The non significant association of vigour index-I with germination first count and seedling dry weight had also found. The standard germination per cent and seedling dry weight had strong positive correlation with vigour index-II. The vigour index-II showed negative and significant association with seedling moisture content. Significant and positive correlation also showed by vigour index-II with germination first count, seedling length, seedling fresh weight and vigour index-I. These observations were supported by the finding of Mahla *et al*. (2003).

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