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Studies on Transplanting Dates and Method of Seed Production in Broccoli (*Brassica oleracea var. italica*) under Jammu Sub-Tropics

Zahida Parveen, Manoj Kumar, Satesh Kumar, Sandeep Chopra, R K Samnotra, Divyanshu Sharma*and Ursheen Dhar

Division of Vegetable Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha, Jammu and Kashmir 180009, India.

ABSTRACT

The present investigation was conducted for two consecutive years (2018-19 and 2019-20) to find out the optimum method and suitable dates of transplanting for seed production in broccoli under Jammu sub-tropics. The treatment combinations comprised three dates of transplanting viz., 30th September 15th October and 30th October and two methods viz., in-situ and ex-situ conducted in a Factorial Randomized Block Design (FRBD) with four replications. The analysis revealed that in-situ method of seed production significantly influenced all morphological and yield traits and was statistically superior to ex-situ method. Among dates, the 30th September date of transplanting proved significantly superior to all the characters except days to 50% bolting, days to 50% flowering, number of siliqua per plant, and days to seed maturity. The interaction effects revealed that treatment combinations in-situ and 30th September (M_1D_1) were significantly influenced and better performance for maximum traits than other treatment combinations. Thus, it can be concluded that in-situ method and transplanting of seedlings on the first week of October performed better concerning most characters and are the most suitable period for broccoli seed production. These findings recommend that the adoption of promising variety can increase the profitability and production efficiency of broccoli and livelihood security to the farmers of mid hills of Jammu and Kashmir.

Keywords: *Broccoli, ex-situ method, in-situ method, Interaction effect, seed production, transplanting dates*

INTRODUCTION

Broccoli (*Brassica oleracea* var*. italica*) is an exotic cole crop grown all over the world, belonging to the family Brassicaceae. In India, it was introduced many years after cabbage and cauliflower and is morphologically closely related to cauliflower. It is one of the most nutritious cole crops due to its high content of carbohydrates, protein, calcium, phosphorous, iron, fibers, b-carotene, thiamine, riboflavin, ascorbic acid, and organoleptic properties [1, 2]. It has good medicinal values due to high levels of cancer-fighting agents "sulphoraphanes" which activate the human body to combat cancer naturally and increase its resistance. It protects the eyes from macular degeneration caused by UV light and also prevents high blood pressure, heart disease, and stroke. Proper sowing method and transplanting date play a key role in guaranteeing the desired crop performance and high economic returns to the farmers. The transplanting dates directly affect yield and quality parameters in broccoli [3]. Broccoli yield decreases with a delay in planting. Early planted crops resulted in longer duration and produced taller plants with more numbers of leaves, higher plant spread, and more leaf size index [4]. The ideal temperature required for broccoli production ranged from 16° to 18°C. At high temperature i.e., above 20°C, the bud cluster grows loose and vice-versa. The process of flowering in sprouting broccoli starts at low temperature but pollination and seed setting does not occur until the average daily temperature goes above 15°C [5]. *In-situ* (seed-to-seed method) and *ex-situ* (head-to-seed method) are two important methods for seed production. The *in-situ* method is followed for commercial seed production whereas for nucleus or breeder seed production, *ex-situ* method of seed production is followed [6].

In India, it is mostly cultivated in the hilly areas of Himachal Pradesh, Uttrakhand, Uttar Pradesh, Jammu and Kashmir, Nilgiri hills (Tamil Nadu) and Northern plains. The Union Territory of Jammu and Kashmir provides ample opportunity for the successful cultivation of broccoli due to the mild climatic conditions. The agro-climate of the Jammu region is quite suitable for formation of compact heads and also favors floral stock emergence, development of bold, viable seed and provides ample opportunity for the successful cultivation of broccoli. Over the last few years, there has been an increased demand of in this nutra- ceutical vegetable among the city dwellers of the UT of Jammu and Kashmir. A few enterprising farmers have already started cultivating broccoli and fetching premium prices in local markets. Many experiments revealed that yield of cole crops is markedly influenced by sowing date and spacing [7, 8]. However, no study was conducted with regard to broccoli seed production under the sub-tropical region of Jammu. Keeping in view, the present investigation was carried out to study the suitable method of seed production and optimum date of transplanting for quality seed production in broccoli under Jammu sub-tropics.

Corresponding Author:* ***Divyanshu Sharma*

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MATERIALS AND METHODS

The present investigation was carried out at the experimental farm of the Division of Vegetable Science and Floriculture, Sher-e-Kashmir University of Agriculture Science and Technology, Jammu (J&K) during *rabi* season of 2018-19 and 2019-20 to study the effect of the method of seed production and date of transplanting in broccoli. The experiments comprised of two method viz *in-situ* (M_1) and *ex-situ* (M_2) method and three date of transplanting viz 30th September (D_1), 15th October (D_2) and 30th October (D_3) was laid down in Factorial Randomized Block Design with 4 replications. Seeds of the Jammu broccoli-07 variety were sown on different dates at 15-day interval (1st September, 15th September and 30th September) in raised nursery beds. Healthy seedlings of 30 days old were transplanted in the afternoon hours as per the treatments. Transplanting was done in a plot size of 3m × 3m and the plants were spaced at 60 cm row to row and 45 cm plant to plant. Besides the application of farm yard manures (FYM) @ 25t/ ha, the chemical fertilizers (120kg N, 60kg P_2O_5, 60kg K_2O) were applied as per the recommendations in Packages and Practices of Vegetable Crops, 2018. FYM was mixed at the time of transplanting along with 1/3rd dose of N and full doses of P_2O_5 and K_2O.The remaining 2/3rd of N was top dressed in two equal amounts after 30 and 45 days of transplanting. Other intercultural operations were carried out in accordance with the recommended package of practices from time to time. For seed crop, an additional dose of 50 kg N, 50 kg $P_2O_{5,}$ and 50 Kg K_2O was given to the *in-situ* crop, whereas for *ex-situ* seed production, a separate field was selected and after proper ploughing, pits of 1 feet diameter and 1feet depth were dug. Half the pit was filled with well-rotten FYM and NPK was applied in these pits. The plants were lifted with mud ball without disturbing the roots and were replanted in these pits. Data were recorded for both the crops (*in-situ* and *ex-situ*) for various parameters viz., days to 50% bolting, days to 50% flowering, plant height (cm), plant spread (cm), days to seed maturity, number of siliqua per plant, siliqua length (cm), number of seeds per siliqua, seed yield per plant (g), seed yield per ha (kg), test weight (g) and germination (%) from ten plants per treatment per replication and analyzed by using OPSTAT online software [9].

RESULTS AND DISCUSSION

In present investigation, most of the growth and seed production traits were significantly affected by method and dates of transplanting.

Methods of seed production

Analysis of the data revealed that mean values for seed production traits depicted significant differences (Table 1). The *in-situ* method of seed production (M_1) took a significantly lesser number of days to 50% bolting (107.17), 50% flowering (130.92), and days to seed maturity (193.11) than *ex-situ* method. The results are by the earlier findings of [10, 11, 12]. Maximum plant height (85.39 cm) was recorded in *in-situ* method of seed production which was significantly higher than the plant height (63.83 cm) observed in *ex-situ* method. More plant spread (51.79 cm) and number of primary branches (25.58) observed in *in-situ* method are similar to the findings of [12]. The replanted crop required some time to recover from the transplanting shock due to their displacement and *in-situ* technique exhibited a significant improvement for plant spread. Maximum number of siliqua per plant (712.32), siliqua length (6.13cm), more number of seeds per siliqua (12.71), maximum seed yield per plant (27.59 g), seed yield per hectare (715.33 kg), test weight (3.23) and germination percentage (94.58) was observed in *in-situ* method of seed production which was significantly superior to *ex-situ* method. The present findings are in agreement with the finding of [12] in cauliflower, [13] in Knol-khol and [14] in cabbage.

Transplanting dates

The effect of transplanting dates on seed quality traits in broccoli are shown in Table 1.Data revealed that transplanting on 30th October recorded minimum days to 50% bolting (104.62), days to 50% flowering (130.38) and days to seed maturity (187.74) followed by 15th October and then 30th September. These results are in accordance with the findings of [10] in Knol khol, [11] in cauliflower and [15] in broccoli. The reason might be that late sown crop was exposed to low temperature immediately irrespective of its vegetative growth. Plant height was maximum (82.23cm) when transplanted on 30th September followed by 15th October planting (73.41cm), while 30th October planting produced the plants with 68.19 cm height which was significantly lower. Similarly, maximum plant spread (55.97cm) and number of primary branches (27.07) were observed in 30th September (D_1) transplanting in comparison to other planting. Similar results were reported by [16], [17] in broccoli, [18] and [19] in cauliflower. This increase in plant height in the earliest sown crop may be because of better environmental conditions resulting in better vegetative growth. Plant height is directly related with the vegetative growth of the plant [20]. However, late-sown crop attained lesser vegetative growth and head diameter, which lead to less number of primary branches. Number of siliqua per plant (754.47) was highest in 15th October planting, which was statistically at par with 30th September planting (648.45cm) and the lowest from 30th October planting (494.54). A similar finding on broccoli was also reported by [17]. [19] obtained highest number of pods per plant from 1st October sowing, which was significantly influenced by the prevailing growing conditions of a crop. Similarly, [15] reported maximum number of siliqua per plant in 10th October planting dates due to fact that temperature during late transplanting may caused reduced growth and development of seed yield contributing characters of broccoli plants. A maximum number of seeds per siliqua (13.49) and siliqua length (6.18cm) was recorded in 30th September transplanting which again decreased with delay in planting. Similar results were obtained by earlier workers [21, 15, 22, 23]. This may be attributed to the fact that earlier plantings get increased juvenile period. Significantly highest seed yield per plant (28.51 g) and seed yield per hectare (739.12 kg) were obtained from 30th September transplanting. The lowest yield of seed was noticed when plants were planted on 30th October. These results are in accordance with the earlier work of [15, 22]. Seed yield decreased with delay in planting from 15th October onwards. The highest seed yield was obtained from 30th September transplanting possibly due to the higher number of branches as well as the maximum number of seeds per siliqua and siliqua length. Moreover, by transplanting the crop on 30th September the phonological phase of the plant influenced to thermal regimes conceded with optimum temperature lead to improved growth and yield attributes favorably. Similar results were reported by [19, 15]. There was a significant difference among the transplanting dates with respect to test weight and germination percentage. Maximum test weight (3.29 g) and germination percentage (97.02) was obtained on 30th September of planting.

However, the values were decreases with the advancement of date from 15th October planting. These results corroborate the findings of [13, 12].

Method × Dates of transplanting

The results of the interaction effect of the method of seed production and dates of transplanting are presented in Table 2. Analysis revealed that the treatment combination *in-situ* and 30th October (M_1D_3) took minimum days to 50% bolting, 50 % flowering and seed maturity which was statistically at par with the treatment combination *in-situ* and 15th October (M_1D_2). Highest plant height (95.63 cm) at the maturity stage, larger plant spread (63.38cm) and maximum number of primary branches per plant (29.35) was obtained *in-situ* and 30th September (M_1D_1) which were statistically superior to all other treatment combinations (Table 2). The lowest values were recorded with a treatment combination of *ex-situ* and 30th October (M_2D_3) and found statistically at par with *ex-situ* and 15th October (M_2D_2). *In-situ* and 15th October (M_1D_2) recorded the highest number of siliqua per plant (851.60) followed by *in-situ* and 30th September (M_1D_1) treatment combination. Lowest number of siliqua per plant (455.12) was observed with treatment combination *ex-situ* and 30th October (M_2D_3). Interaction effect also showed significant differences for number of seeds per siliqua, Seed yield per plant, Seed yield per hectare and germination percentage. *In-situ* and 30th September (M_1D_1) treatment recorded statistically superior to all other interactions. Lowest seed yield and germination percentage was observed with treatment combination *ex-situ* and 30th October (M_2D_3). There is no significant difference statistically among methods of seed production and transplanting date of test weight. However, highest values were recorded for *in-situ* and 30th September (M_1D_1). These findings are in accordance with earlier work of [15, 10, 12].

On the basis of results, it can be concluded that transplanting on 30th September and following *in-situ* method resulted in maximum seed yield and quality of broccoli under Jammu Sub-tropics. These findings recommend that the adoption of promising variety can increase the profitability and production efficiency of broccoli and livelihood security to the farmers of mid hills of Jammu and Kashmir.

Conflict of interest

The authors declare that there is no conflict of interest regarding this manuscript.

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Table 1 Effect of methods of seed production and dates of transplanting on various characters in broccoli

Characters	Methods of Seed Production				Dates of Transplanting				
	M_1	M_2	CD (5%)	SE (d)	D_1	D_2	D_3	CD (5%)	SE (d)
Days to 50% bolting	107.17	115.75	2.92	1.36	118.87	110.87	104.62	3.58	1.66
Days to 50% flowering	130.92	142.17	2.54	1.18	143.13	136.13	130.38	3.11	1.45
Plant height (cm)	85.39	63.83	3.09	1.44	82.23	73.41	68.19	3.78	1.76
Plant spread (cm)	51.79	35.29	0.22	0.10	55.97	43.65	31.00	0.27	0.12
Number of primary branches	25.58	21.44	0.93	0.43	27.07	23.44	20.03	1.14	0.53
Days to seed maturity	193.11	203.83	1.70	0.79	207.96	199.71	187.74	2.08	0.97
Number of siliqua per plant	712.32	552.66	26.27	12.22	648.45	754.47	494.54	32.18	14.96
Siliqua length (cm)	6.13	5.73	0.11	0.05	6.18	6.06	5.56	0.12	0.06
Number of seeds per siliqua	12.71	11.15	0.28	0.13	13.49	11.79	10.50	0.34	0.16
Seed yield per plant (g)	27.59	23.02	0.80	0.37	28.51	25.26	22.14	0.98	0.46
Seed yield per hectare (kg)	715.33	596.66	20.71	9.63	739.12	654.75	574.12	25.36	11.79
Test weight (g)	3.23	3.02	0.09	0.04	3.29	3.12	2.96	0.10	0.05
Germination (%)	94.58	93.50	0.61	0.28	97.02	93.98	91.12	0.74	0.34

Table 2: Interaction effect of methods of seed production × dates of transplanting (M × D) on various characters in broccoli

Interaction	Days to 50% bolting	Days to 50% flowering	Plant height	Plant spread	Number of primary branches	Days to seed maturity	Number of siliqua per plant	Siliqua length	Number of seeds per siliqua	Seed yield per plant	Seed yield per hectare	Test weight	Germination (%)
M_1D_1	113.00	134.50	95.63	63.38	29.35	203.20	751.40	6.27	14.54	31.83	825.00	3.44	97.95
M_1D_2	105.50	130.75	84.10	53.66	26.17	191.88	851.60	6.18	12.43	27.10	702.50	3.24	94.87
M_1D_3	103.00	127.50	76.45	38.33	21.22	184.25	533.95	5.95	11.16	23.84	618.50	3.02	90.92
M_2D_1	124.75	151.75	68.83	48.56	24.80	212.73	545.50	6.08	12.45	25.19	653.25	3.14	96.10
M_2D_2	116.25	141.50	62.73	33.65	20.70	207.55	657.35	5.94	11.15	23.42	607.00	3.01	93.10
M_2D_3	106.25	133.25	59.93	23.67	18.83	191.22	455.12	5.18	9.85	20.44	529.75	2.90	91.32
CD (5%)	5.06	4.40	5.35	0.38	1.61	2.95	45.51	0.17	0.49	1.39	35.87	N/S	1.05
SE (d)	2.35	2.05	2.49	0.17	0.75	1.37	21.16	0.08	0.23	0.65	16.67	0.07	0.49

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