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Effect of head manipulation techniques and planting distance on seed yield and yield contributing parameters of cabbage (*Brassica oleracea* var. *capitata*)

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Abstract

The present investigation was conducted during *Kharif* of 2014 and *Rabi* of 2015 at the experimental farm of Department of Vegetable Science, V.C.S.G. Uttarakhand University of Horticulture and Forestry, Ranichauri Campus, Tehri-Garhwal with cabbage cultivar Golden Acre. The experiment was laid out in two factor Randomized Block Design (RBD) with three replications includes three head manipulation techniques *viz.,* Stump method (T_1), Stump with central core intact method (T_2) and Head intact method (T_3) and four different planting distance *viz.,* 60x60 cm (S_1), 60x45 cm (S_2), 45x40 cm (S_3) and 40x30 cm (S_4). The results of the study revealed significant differences among the treatments, stump method (T_1) exhibited earliest flowering (92.75 DAT), seed maturity (140.56 DAT), maximum number of primary branches per plant (47.12), siliqua per primary branch (65.81), seed yield per plant and per hectare (20.21 g and 9.01q) respectively. Whereas planting distance of 40x30 cm was found promising for days to 50 per cent flowering (102.0 DAT), seed maturity (154.0 DAT) and seed yield per hectare (9.99q). The stump method accompanied with 60x60 cm spacing gave highest seed yield per plant (23.03 g) However, maximum seed yield was realized in stump method along with 40x30 cm planting distance (10.50q/ha).

Key words: Cabbage, head manipulation techniques, planting distance, seed yield.

Introduction

Seed is a carrier of new technologies basic tool for securing food supply for a huge human population by virtue of good crop. Seed carry the genetic identity of the crop plant, determining the upper limit of yield and other characters. As we know that vegetable seeds mostly have very high cost. It is because the production cost is high, and moreover sufficient seed is not produced resulting in higher demand throughout. Further, seed production technology for production of vegetable seeds is different than that for commercial crop production and requires much care and attention in order to get maximum yield. Cabbage (*Brassica oleracea* var. *capitata* L.), a member of cole crop, is economically an important vegetable crop being grown and consumed widely around globe; and is good source of phyto-chemicals including vitamins, pigments, enzymes, phenols, minerals (Singh et al. 2009). It is one of the most important leafy vegetable grown extensively throughout the world. In Uttarakhand cabbage is produced in an area of 5.6 thousand hectare with 70.5 thousand metric tonnes production during 2010-11. The major cabbage producing areas are Nainital, US Nagar, Tehri Garhwal, Pauri, Uttarkashi, Haridwar and Dehradun (Anon 2011). It is considered as a popular winter season vegetable crop both in plains and hills and can be grown throughout the year in the hilly areas. Methods of seed production involving head manipulation techniques and planting distance are two important factors which affect the quality and quantity of seed produced in cole crops. In cabbage three methods of seed production are followed *viz*. stump method, stump with central core intact method and head intact method (Verma and Sharma 2000) same as in cauliflower, bolting is facilitated by different curd cutting methods like scooping, half curd cutting and curd pruning. These practices have impact on branching, seed yield and quality (Kumar et al. 2000). However, plant spacing has significant influence on growth and yield of cabbage. The inter plant and intra plant competition mainly correlate with yield. Competition associated with different spacing alters plant morphology in various ways. The optimum plant spacing depends on several factors including the growing environment,

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dose of fertilizer, source of nutrients, cultivars used, moisture availability and fertility status of the land. Early planting and wide spacing significantly enhanced the growth of cabbage (Singh et al. 2010, Ullah et al. 2013). Thus, planting density also play an important role in quantity and quality of seed produced and affect the economics of seed production (Lal 2013). Considering the above-mentioned facts, the present study was undertaken to find out the suitable head manipulation technique and plant spacing which can be used to increase seed yield of cabbage, to offer new opportunities to seed grower's and to strengthen seed production enterprises in Uttarakhand hills.

Materials and Methods

The present investigation was carried out during late *Kharif* to late *Rabi* seasons of 2014 and 2015 at the experimental farm of Department of Vegetable Science College of Forestry, Ranichauri, Tehri Garhwal, Uttarakhand. The field trial on cabbage variety 'Golden Acre' was conducted in the research block of Department of Vegetable Science.

Experimental details and primary transplanting: Three head manipulation techniques *viz.,* Stump method (T_1), Stump with central core intact method (T_2) and Head intact method (T_3) and four planting distance *viz.,* 60x60 cm (S_1), 60x45 cm (S_2), 45x40 cm (S_3) and 40x30 cm (S_4) were used as treatment variables. The experiment was conducted in the Two Factor Randomized Block Design with four replications. The unit plot size was 2.5m x 2 m. Seeds of variety "Golden Acre" were treated with Thiram at the recommended dose of 2.5 g/kg of seed and sown in nursery inside polyhouse under controlled condition on 10th of August 2014. After germination, when the seedlings attained at a height of 12-15 cm were transplanted in a larger area at 45x45 cm spacing on 10th September 2014 allowing the crop to bear heads. The crop raised for heads are managed with all recommended practices of fertilization, weeding, irrigation etc. to promote development of healthy heads. In the early stage of seedlings in the nursery as well as after transplanting damping off disease was controlled by spraying Bavistin (Carbendazim 50 WP) @ 2 g liter^{-1} water.

Head manipulation and secondary transplanting: After full development of heads, the true to types were selected and head manipulation techniques *viz*., removal of entire head (stump method), half cutting of heads in such a way as not to damage central core (stump with central core intact method) and cross incision in intact heads (head intact method) were adopted on 7th January, 2015 to prepare the plants for secondary transplanting. The plants were uprooted after head manipulation and transplanted in the experimental field on 8th January, 2015 as per above defined experimental layout. Before transplanting operation, the field was prepared by two deep ploughing followed by clods breaking and planking. Phosphorus and Potassium were used as a basal fertilizer @ 60 and 45 kg/ha, respectively while nitrogen was applied as top dressing in standing crop at the rate of 75 kg/ha. During flowering stage, the plants were attacked by aphids and controlled by spraying with Imidacloprid @ 2 ml per litre of water. The flower stalks were supported with bamboo stakes to avoid lodging. Five plants were selected randomly for data collection on days to 50% flowering (DAT), number of primary branches per plant, number of siliqua per primary branch, number of seeds per siliqua, seed yield per plant (g) and per hectare (q). Harvesting was started from 27th May, 2015 when the pods were brown in colour. The collected data were analyzed statistically. The crop received 623.3 mm total rainfall during crop period of 2014-15. The mean monthly maximum air temperature was 25.1° and minimum was 2.6° during crop period of 2014-15 (Fig. 1).

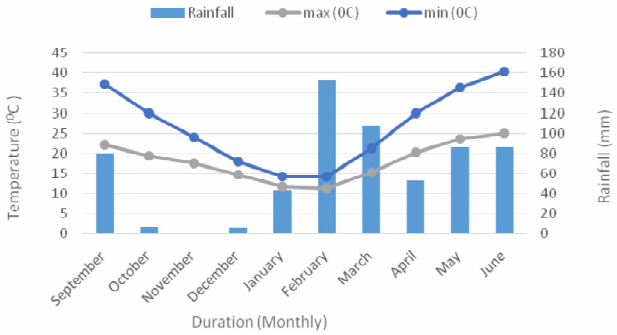

Fig. 1: Average maximum and minimum air temperature (0C) and total rainfall (mm) during the growing period (2014-2015)

Source: Meteorological Observations at College of Forestry, Ranichauri Campus, Tehri Garhwal

Results and Discussion

The statistical analysis of data recorded on plant growth, seed maturity and seed yield parameters as affected by different head manipulation techniques and planting distance revealed significant differences among the treatments and treatment combinations. The results could be discussed under following sub-heads:

Effect of head manipulation techniques on seed yield and yield contributing parameters: Among different head manipulation techniques, stump method exhibited significantly earlier 50 per cent flowering (92.75 DAT) followed by stump with central core intact method (102.94 DAT), whereas head intact method showed

maximum days to 50 per cent flowering (117.19 DAT). Days to 50% flowering is an important indicator of getting early seed yield. The probable reason for early flowering in stump method was axillary buds which were exposed to external environment and were free to sprout and grow as soon as favorable temperature was obtained, whereas, in other methods of head manipulation namely *viz*., stump with central core intact and head intact methods, the axillary buds and central bud were compressed in intact wrapper leaves and resumed growth comparatively later.

Stump method showed earliest maturity of seed crop (140.56 DAT) followed by stump with central core intact method (160.50 DAT) and head intact method (170.00 DAT). The early seed maturity in stump method is associated with early onset of reproductive phase (flowering) owing to early and fast emergence of flowering twigs as a result of flow of nutrients towards axillary buds after decapitation of heads. Maximum number of branches per plant was found in stump method (47.12) followed by stump with central core intact method (12.18) and minimum in head intact method (10.68).

Maximum value for number of siliqua per primary branch was found in stump method (65.81) followed by stump with central core intact method (34.43) and minimum in head intact method (24.56). Higher number of siliqua per primary branch was associated with vigorous early emerging flowering primary twigs inn stump method. In the stump method, the head is completely removed and therefore, nutrient flow takes place towards axillary buds which consequently grow vigorously. In contrary to it, in other two methods of head manipulation *viz*., stump with central core intact method and head intact method, partial or whole head, the storage part is retained which leads to partial and slow flow of nutrients towards axillary buds consequently, the flowering twigs emerging in these two methods remain less vigorous. The analyzed data on number of seeds per siliqua revealed that head manipulation techniques had non-significant effect on it. The analyzed data revealed that head manipulation techniques had non-significant effect on number of seeds per siliqua.

Highest mean value for seed yield per plant was obtained in stump method (20.21g) followed by stump with central core intact method (18.02g) and the lowest value was noticed in head intact method (12.99 g). Maximum seed yield per hectare was found in stump method (9.01q) followed by stump with central core intact method (8.19q). Minimum seed yield per hectare was found in head intact method (6.40 q).

From the above results it was clear that among the different head manipulation techniques, stump method exhibited earliest flowering and seed maturity (92.75 DAT and 140.56 DAT, respectively), maximum number of primary branches per plant (47.12), siliqua per primary branch (65.81), seed yield per plant and per hectare (20.21 g and 9.01 q, respectively) (Table 1). These results were in complete agreement with those reported by Rahman et al. (1988), Kumar et al. (2000), Singh et al. (2005), and Moniruzzaman et al. (2007) in cauliflower and Elyazied et al. (2007) and Mehta et al. (2015) in broccoli.

Effect of planting distances on seed yield and yield contributing parameters: Earliest flowering was noticed in 40x30 cm (102.00 DAT) followed by 45x40 cm (103.67 DAT) and 60x45 cm (105.17 DAT), whereas maximum days to 50 per cent flowering were noticed in 60x60 cm (106.33 DAT) spacing. Early flowering in closer spacing might be associated with higher competition between plants for nitrogenous compounds, an essential element for longer vegetative phase which might have led to onset of reproductive phase in the plants. The planting distance did not influence the days to maturity of seed crop, significantly. However, plants spaced at 40x30 cm and 45x40 cm showed earliest seed crop maturity (154.0 DAT and 154.9 DAT, respectively). While, the crop planted at 60x60 cm spacing took maximum days to seed maturity (160.16 DAT). In closer spacing, plant competition for nutrients might have played major role in transformation of plants from vegetative phase to reproductive phase, Morrison *et al.* (1990). However, Mehta *et al.* (2015) noted non-significant effect of planting density on days to seed maturity in broccoli.

Planting distances had significant effect on number of primary branches per plant and maximum number was found in wider spacing *i.e*. 60x60 cm (28.25) followed by 60x45 cm (23.50), 45x40 cm (21.75) and 40x30 cm (19.83). From the above observations, it was evident that number of primary branches per plant increased with increasing plant spacing. Similar findings have also been reported by Ali et al. (1996) and Ozer, (2003) in rapeseeds.

Planting distance also influenced number of siliqua per primary branch significantly and maximum value was registered in widest spacing i.e., 60x60 cm (45.25) followed by 60x45 cm (43.33), 45x40 cm (40.08) which were statistically *at par*. Lowest value for number of siliqua per primary branch was observed in the plant spacing 40x30 cm (37.75). Similarly, planting at wider spacing also reduces plant competition for nutrition and therefore, plants grow vigorously with more number

Table 1: Effect of head manipulation techniques on seed yield and yield contributing parameters

S. No.	50 % flowering (DAT)	Days to seed maturity (DAT)	No. of primary branches/ plant	No. of siliqua per primary branch	No. of seeds per siliqua	Seed yield per plant (g)	Seed yield per ha (q)
First Factor: Head manipulation techniques (T)							
Stump method ($T_{1)}$	92.75	140.56	47.12	65.81	23.62	20.21	9.01
Stump with central core intact method (T_2)	102.94	160.50	12.18	34.43	22.62	18.02	8.19
Head intact method (T_3)	117.19	170.00	10.68	24.56	22.50	12.99	6.40
SEm	0.23	2.21	1.09	1.36	0.45	0.63	0.27
CD (5%)	0.65	6.61	3.16	3.92	1.30	1.82	0.77
Second Factor: Planting distance (S)							
60x60 cm (S_1)	106.33	16016	28.25	45.25	21.66	22.47	6.23
60x45 cm (S_2)	105.17	159.00	23.50	43.33	22.83	18.71	6.88
45x40 cm (S_3)	103.67	154.91	21.75	40.08	24.00	15.09	8.38
40x30 cm (S_4)	102.00	154.00	19.83	37.75	23.16	12.01	9.99
SEm	0.26	2.22	1.26	1.57	0.52	0.73	0.31
CD (5%)	0.75	6.70	3.65	4.53	1.50	2.11	0.89
Interaction Effect (TxS)							
T_1S_1	94.50	143.50	60.00	71.25	21.00	29.03	8.05
T_1S_2	93.50	142.50	46.25	68.50	24.00	23.04	8.53
T_1S_3	92.00	138.50	43.00	64.25	25.25	16.17	8.97
T_1S_4	91.00	137.75	39.25	59.25	24.25	12.61	10.50
T_2S_1	104.50	163.50	13.75	38.25	23.75	24.25	6.73
T_2S_2	103.50	162.50	12.75	35.75	20.75	19.92	7.37
T_2S_3	102.50	158.25	11.75	32.00	23.00	16.39	9.10
T_2S_4	101.25	157.50	10.50	31.75	23.00	11.50	9.58
T_3S_1	120.00	173.50	11.00	26.25	20.25	14.14	3.92
T_3S_2	118.50	172.00	11.50	25.75	23.75	13.15	4.73
T_3S_3	116.50	168.00	10.50	24.00	23.75	12.72	7.06
T_3S_4	113.75	166.50	9.75	22.25	22.25	11.94	9.90
SEm	0.45	4.42	2.19	2.73	0.90	1.27	0.54
CD (5%)	1.30	13.22	6.32	7.85	2.61	3.65	1.55

Head manipulation technique: Stump method (T1), Stump with intact central core (T2) Head intact method (T3)
Planting distance: 60x60 cm (S1), 60x45 cm (S2), 45x40 cm (S3) 40x30 cm (S4)

of siliqua. Higher number of siliqua per branch and/or per plant as a result of wider spacing and head decapitation has also been realized by Mihov and Antonova, (2009) and Mehta et al. (2015) in broccoli.

Maximum number of seeds per siliqua was registered in 45x40 cm spacing (24.0) followed by 40x30 cm (23.16), 60x45 cm (22.83) which were statistically *at par*. Minimum number of seeds per siliqua was noted in 60x60 cm (21.66) spacing. However, significant effect of plant density on number of seeds per siliqua was reported by Bhutia and Ram, (1980) and Rahman et al. (1988) in cauliflower and Pathak et al. (1984); Gurjar and Chauhan (1997; Jahan and Zakaria (1997) and Mamun et al. (2014) in rapeseed and Indian mustard.

Among different spacing, highest seed yield per plant was obtained in wider spacing *i.e*. 60x60 cm (22.47 g) which significantly higher than that in 60x45 cm (18.71 g), 45x40 cm (15.09 g) and 40x30 cm (12.01 g). Wider spacing exhibited higher seed yield per plant as compared to closer spacing. Corresponding results on higher seed yield per plant in wider spacing has also been reported by Mehta et al. (2015) i.e. 37.06 g at 60x60 cm in broccoli. The higher seed yield per plant in crop transplanted at wider spacing could be associated with better branching, growth and seed setting in plants due to less competition among the plants for nutrient and light.

Maximum seed yield per hectare was harvested in 40x30 cm (9.99 q) which was significantly higher than that in other spacing. There was a decreasing trend in seed yield per hectare with increasing spacing *i.e.* from 8.38q/ ha in 45x40 cm to 6.23q/ha in 60x60 cm. (Table 2). The trend realized in seed yield per hectare was contrasting to that in seed yield per plant in relation to planting density because of accommodation of more number of plants per unit area in closer spacing. From the comparative results on seed yield per plant and per hectare, it was evident that the number of plants per unit area was more important for increasing seed yield as compared to vigorous plants in wider spacing. Higher seed yield at increased planting density have also been reported by Cuocola and Duranti, (1988) as high as 8.0 q/ha at 1.5 plants/m^2 and Hossain et al. (2015) as high as 3.15 q/ha at 60x50 cm in cauliflower, by Gurjar and Chauhan (1997) as high as 16.76q/ha at row spacing of 30 cm, Ozer (2003) as high as 11.95q/ha at 30 cm row

spacing and Bagheri et al. (2011) as high as 11.95 q/ha at row spacing of 15 cm in *Brassica rapa* by Sharma, (2001) as high as 10.34 q/ha at 30x45 cm spacing in Chinese cabbage, and by Mehta et al. (2015) as high as 11.45 q/ha at 45x40 cm spacing in sprouting broccoli.

Interaction effect of head manipulation techniques and planting distances on seed yield and contributing parameters: Interaction of stump method and 40x30 cm spacing was found to be best for days to 50% flowering (91.0 DAT), days to seed maturity (137.75 DAT) and seed yield per hectare (10.50 q) whereas combination of stump method and 60x60 cm spacing was promising for number of primary branches per plant (60.0), number of siliqua per primary branch (71.25), number of siliqua per plant (4238.75) and seed yield per plant (29.03 g) (Table 3). Similar results were reported by Rahman et al. (1988) and Moniruzzaman *et al.* (2007) in cauliflower, Mihov and Antonova (2009) and Mehta et al. (2015) in broccoli. The present study reveals that seed yield of cabbage cv. Goden Acre is significantly higher in stump method of head manipulation techniques and planting distance of 40x30 cm in hills of Uttarakhand.

सारांश

वर्तमान प्रयोग खरीफ 2014 एवं रबी 2015 सब्जी विज्ञान विभाग के शोध प्रक्षेत्र में वीर चन्द्र सिंह गढ़वाली औद्यानिक एवं वानिकी विश्वविद्यालय रानीचौरी परिसर, टिहरी, गढ़वाल (उत्तराखण्ड) में पत्तागोभी की प्रभेद 'गोल्डेन एकड़' पर किया गया। प्रयोग हेतु प्रक्षेत्र परीक्षण चार अनुकरणों में फैक्टोरियल रेण्डोमाइज्ड ब्लॉक डिजायन में तीन बार प्रतिकृति कर किया गया। कारणों में तीन शीर्ष कृन्तन तकनीकों ठिूंठ विधि (टी–1) अभिन्न केन्द्र युक्त ठूँठ विधि (टी–2) एवं शीर्षयुक्त विधि (टी–3) एवं चार रोपण दूरियों (60 x 60 सेमी. (एस. –1) 60 x 45 सेमी. (एस.–2), 45 x 40 सेमी. (एस.–3) एवं 40 x 30 सेमी. (एस.–4) का यथासम्भव संयोजन किया गया। अध्ययन से स्पष्ट रूप से सार्थक विविधता शोधनों के बीच ठूँठ विधि (टी–1) में सबसे पहले पुष्पन (92.75 दिन पौध रोपण उपरान्त, बीज पकाव (140.56 दिनों, पौध रोपण उपरान्त), प्रति पौध शाखाओं की संख्या (47.12), फली प्रति प्राथमिक शाखा (65.81), प्रति पौध व प्रति हेक्टेयर बीज उपज (20.21 ग्राम व 9.01 कु.) क्रमशः पाया गया। अपनीय गयी रोपण दूरियों में में 40 x 30 सेमी. रोपण दूरी में 50 प्रतिशत फूल खिलने में न्यूनतम दिन (रोपणोपरान्त 102 दिन), बीज परिपक्वता में न्यूनतम दिन (रोपणोपरान्त 154 दिन) एवं अधिकतम प्रति हेक्टेयर बीज उत्पादन (9.99 कुन्तल) प्राप्त किया गया। जब ठूँठ विधि का संयोजन दूरस्थ रोपण दूरी 60 x 60 सेमी. के साथ किया गया तो उनके संयोजन के प्रभाव से सर्वाधिक प्रति पौध बीज उत्पादन (23.03 ग्रा.) प्राप्त किया गया जबकि अधिकतम प्रति हेक्टेयर बीज उत्पादन (10.50 कुन्तल) ठूँठ विधि एवं नजदीक रोपण दूरी 40 x 30 सेमी. से प्राप्त हुआ।

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