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Effect of Date of Planting and Spacing on Growth and Yield of Sprouting Broccoli (*B. oleraceae* (L.) var. *italica* Plenck) cv. Green Magic

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ABSTRACT

The field experiment was conducted during autumn-winter (October to December) seasons of 2017–18 and 2018–19 at Horticultural Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India. Treatments comprised of four planting dates viz., D_1: 21st October, D_2: 28th October, D_3: 7th November, D_4: 14th November and four spacing viz., S_1: 30×45 cm^2, S_2: 45×45 cm^2, S_3: 60×45 cm^2 and S_4: 60×60 cm^2 were assessed in factorial randomized block design with three replications. The broccoli transplanted on 21st October (D_1) reported significantly maximum head weight (464.95 g) and projected yield (11.46 t ha^{-1}) which was statistically at par with 2nd date of planting D_2 i.e 28th October (423.91 g and 11.03 t ha^{-1} respectively) over the other dates of planting, while the wider spacing S_4 i.e. 60×60 cm^2 showed significantly maximum head weight (400.74 g) over other spacing's and closer spacing S_1 i.e 30×45 cm^2 had recorded significantly highest yield (13.48 kg plot^{-1} and 14.98 t ha^{-1}). Interaction between date of planting and spacing was significant in respect of head yield per hectare. Maximum projected head yield (17.19 t ha^{-1}) was obtained in D_1S_1: 21st October and 30×45 cm^2 combination. After adopting the planting dates from October 21st (D_1) to October 28th (D_2) and closer spacing of 30×45 cm^2 (S_1) was found more gainful in terms of yield and other growth parameters also.

KEYWORDS: Broccoli, planting date, spacing, head yield

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1. INTRODUCTION

Among the various Cole crops, Broccoli (*Brassica oleraceae* (L.) var. *italica* Plenck) which belongs to the family Brassicaceae and native to Mediterranean region is generally a high-priced green vegetable compared to other vegetables locally available (Uddin et al., 2022) and itis a fast-growing annual plant that attains heights of 60 to 90 cm (Kamboj, 2023). This crop is chiefly cultivated in the hilly areas of Himachal Pradesh, Uttar Pradesh, Jammu and Kashmir, Nilgiri hills and Northern plains of India with an annual production of 88,40,000 tonnes and productivity of 19.30 t ha^{-1} (Anonymous, 2020). Compared with other vegetable broccoli is rich in higher amount of nutrients and it has well developed root system, which gives both nutritional securities to consumers and crop security to farmers (Shan et al., 2022). Broccoli is easily distinguished from cauliflower by having highly branched green colour flower bud rather than white meristematic inflorescence. Due to its high amount of vitamins and minerals content broccoli is referred to as the "crown of jewel nutrition". It contains potassium, iron, and fiber as well as Vitamins A, B1, and B2. (Singh et al., 2017) The majority portions of the plant around 30% are consumed as food, which is called florets. (Kamboj et al., 2023). The presence of vitamins (A, C, and K), isothiocyanates, folates, dietary phenolic compounds, fibers, and essential mineral nutrients makes this crop nutritious in nature (Tarafder et al., 2023). For the inhibition of carcinogenic, obesity, and cardiovascular ailments the bioactive compounds and nutritional values are beneficial (Martins et al., 2022). There are numbers of glucosinolates present in broccoli such as glucoiberin, glucoraphanin, glucoalyssin, glucoerucin, glucoibervirin, gluconapin, and 4-methoxyglucobrassicin, however their composition varies with cultivar types. They are metabolized to the biologically active isothiocyanate (ITC) sulforaphane, which is well-known to lower the risk of cancers such as lung cancer, esophageal cancer, and gastrointestinal cancer (Latte et al., 2011). It is eaten cooked or raw as salad and can also be served as mixed vegetable and in soups. Cool moist climate having day temperature between 25°C to 26°C and night temperature between 15–16°C is highly preferred for quality head production (Suthar et al., 2017). Goldberg et al., 2000 was reported along with various soil factor the temperature and planting time also effect the boron availability in soil, which drastically reduce the growth of cauliflower and other cole crops.

Sub Himalayan foothills of West Bengal is characterized by high annual rainfall (2100–3000 mm), high relative humidity, moderate temperature (max: 24–33°C min: 7–8°C), prolonged winter and high residual soil moisture which may favours cultivation of diverse group of vegetable crops round the year. If unfavourable weather conditions prevail then it may affect the transition of vegetative stage to reproductive stage and thus growth and development of head may be hampered. Different genetic makeup among the varieties could be the factor determines the number of days required for harvesting. Particular growing season with preferred soil and climate has tremendous impact on vegetative growth and then to reproductive phase. Thus, the proper date of planting is one of the basic requirements for obtaining maximum yield and high return of broccoli (Shivran et al., 2021). Narrow spacing hinders the proper growth and development of plants by increasing plant competition for nutrients, air, and light, whereas broader spacing results in larger plants with more robust growth and greater quality output (Kumar et al., 2021). If the plants didn't get proper nutrition via soil, air, and water, then the quantity and quantity of curds reduced and this condition also hampers the curd formation date and growth completion of the curds, where density affects the flowering duration. (Hussainy and Manea, 2019). Keeping the above views of this crop, present investigation was conducted to standardize the planting time and spacing of broccoli cv. Green Magic under sub-Himalayan foothills of West Bengal, India.

2. MATERIALS AND METHODS

The field experiment was conducted at Horticultural Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, CoochBehar, West Bengal, India situated at 26°40' N latitude and 89°38' E longitudes with an average altitude of 43 m above the mean sea level (MSL) and soil pH 5.9 during autumn-winter seasons of 2017–18 and 2018–19. Treatment combinations of total 16 were comprises of four planting dates *viz.,* D_1: 21st October, D_2: 28th October, D_3: 7th November, D_4: 14th November and four spacing *viz.,* S_1: 30×45 cm^2, S_2: 45×45 cm^2, S_3: 60×45 cm^2 and S_4: 60×60 cm^2 were assessed in factorial randomized block design with three replications. Recommended dose of N, P_2O_5 and K_2O (120 kg, 60 kg and 60 kg ha^{-1}, respectively) were supplied through Urea, Single Superphosphate and Muriate of potash, respectively on main field. Appropriate management practices were adopted to raise the crop. Seeds were sown in nursery on the four planting dates and seedlings were hardened before uprooting and transplanted after about 30 days when they were ready. Each plot had an area of 3×2.5 m^2 (7.5 m^2) accommodating 55, 37, 27 and 20 plants. Ten randomly plants were selected from each plot and observations were recorded various growth and yield parameters such as number of leaves per plant, Leaf length (cm), Leaf width (cm), Stalk length (cm), days to 50% head initiation, days to 50% head maturity, head length (cm), head width (cm), head weight (g), plot yield (kg) and total projected yield (t ha^{-1}). The Collected data of

two subsequent years were polled and statistically analysed by using OP-STAT.

3. RESULTS AND DISCUSSION

Data on Number of leaves per plant, Leaf length (cm), Leaf width (cm), Stalk length (cm), days to 50% head initiation, days to 50% head maturity, head length (cm), head width (cm), head weight (g), plot yield (kg) and total projected yield (t ha^{-1}) were statistically analysed and the pooled means of two consecutive years were presented in Table 1 and 2 along with interaction of date of planting and spacing.

Table 1: Morphological parameter of broccoli

Characters	No. of leaves	Leaf length (cm)	Leaf width (cm)	Stalk length (cm)	Days to 50% head initiation	Days to 50% head maturity
Date of transplanting						
D_1 (21st Oct.)	17.31	27.87	18.74	36.18	30.50	55.49
D_2 (28th Oct.)	13.41	34.74	21.36	23.20	45.07	61.48
D_3 (7th Nov.)	12.76	29.98	20.31	27.63	44.59	62.11
D_4 (14th Nov.)	11.93	29.45	17.79	21.26	50.87	64.43
SEm±	0.24	0.37	0.27	0.51	0.36	0.09
CD (p=0.05)	0.82	1.29	0.95	1.77	1.24	0.30
Spacing						
S_1 (30×45 cm^2)	13.43	30.37	19.68	27.61	40.86	57.83
S_2 (45×45 cm^2)	13.83	30.91	19.11	27.60	41.87	60.00
S_3 (60×45 cm^2)	14.44	30.47	19.53	27.31	43.51	61.58
S_4 (60×60 cm^2)	13.71	30.29	19.88	25.75	44.77	64.11
SEm±	0.22	0.37	0.26	0.48	0.38	0.40
CD (p=0.05)	0.65	NS	NS	1.40	1.10	1.18
Interaction						
D_1S_1	16.18	27.87	18.43	41.65	30.27	53.48
D_1S_2	17.97	27.56	18.34	38.31	30.34	61.10
D_1S_3	18.40	28.63	19.72	34.47	30.67	64.29
D_1S_4	16.67	27.40	18.47	30.30	30.70	65.12
D_2S_1	13.26	34.62	22.50	24.46	45.41	60.37
D_2S_2	13.14	36.30	20.77	22.31	45.25	60.54
D_2S_3	13.39	34.56	20.55	23.68	43.97	66.32
D_2S_4	13.86	33.49	21.64	22.35	45.64	70.48
D_3S_1	11.73	30.14	20.05	22.93	46.44	54.21
D_3S_2	11.75	30.46	21.07	27.68	40.63	55.90
D_3S_3	12.75	29.31	19.61	30.36	39.45	55.41
D_3S_4	11.48	30.01	20.52	29.53	51.84	58.38
D_4S_1	12.53	28.86	17.75	21.34	51.51	61.34
D_4S_2	12.45	29.31	16.27	20.95	51.34	62.44
D_4S_3	13.22	29.36	18.25	21.91	49.69	62.22
D_4S_4	12.83	30.27	18.88	20.83	50.94	62.45
SEm±	0.44	0.73	0.51	0.96	0.75	0.81
CD (p=0.05)	NS	NS	1.50	2.79	2.19	2.36

Table 2: Yield parameters of broccoli

Characters	Head length (cm)	Head width (cm)	Head weight (g)	Plot yield (kg)	Projected yield (t ha^{-1})
Date of transplanting					
D_1 (21st Oct.)	14.23	14.58	464.95	10.32	11.46
D_2 (28th Oct.)	13.94	13.54	423.91	9.93	11.03
D_3 (7th Nov.)	12.30	11.13	345.83	8.35	9.27
D_4 (14th Nov.)	11.68	10.79	234.27	5.27	5.86
SEm±	0.14	0.04	11.53	0.28	0.31
CD (p=0.05)	0.50	0.14	39.89	0.96	1.07
Spacing					
S_1 (30×45 cm^2)	12.94	12.20	277.99	13.48	14.98
S_2 (45×45 cm^2)	12.84	12.46	395.20	8.78	9.76
S_3 (60×45 cm^2)	13.18	12.58	395.04	6.58	7.32
S_4 (60×60 cm^2)	13.19	12.80	400.74	5.01	5.57
SEm±	0.11	0.10	7.60	0.21	0.24
CD (p=0.05)	NS	0.30	22.18	0.62	0.69
Interaction					
D_1S_1	10.79	10.91	309.44	15.47	17.19
D_1S_2	11.29	10.55	445.17	9.89	10.99
D_1S_3	11.93	10.81	501.29	8.36	9.28
D_1S_4	14.42	15.17	603.90	7.55	8.39
D_2S_1	14.06	15.09	299.54	13.98	16.64
D_2S_2	14.18	12.26	538.86	11.98	13.30
D_2S_3	13.94	13.76	486.79	8.11	9.01
D_2S_4	13.57	14.31	370.44	4.63	5.15
D_3S_1	14.29	12.99	288.74	12.44	16.04
D_3S_2	14.13	14.69	385.11	8.56	9.51
D_3S_3	12.69	13.73	364.98	6.08	6.76
D_3S_4	14.08	12.73	344.49	4.31	4.78
D_4S_1	12.61	11.34	214.23	9.05	10.05
D_4S_2	11.75	10.79	211.66	4.70	5.23
D_4S_3	12.48	10.50	227.09	3.79	4.21
D_4S_4	12.36	10.54	284.11	3.55	3.94
SEm±	0.21	0.21	15.20	0.42	0.47
CD (p=0.05)	0.62	0.61	44.35	1.23	1.37

3.1. Growth response

The effects of planting dates, spacing and interaction of both on growth of broccoli were presented in table 1. Number of leaves $plant^{-1}$, leaf length, leaf width, stalk length, days to 50% head initiation and days to 50% head maturity of broccoli was significantly affected by a different planting date. Maximum number of leaves $plant^{-1}$ (17.31), stalk length (36.18 cm), days to 50% head initiation (30.50) and days to 50% head maturity (55.49) were recorded from 21st October of planting date, while highest leaf length (34.74 cm) and leaf width (21.36 cm) were acquired from D_2 (28th Oct.). This could be due to the fact that at the early planting date have favourable environmental conditions which was suitable for growth and development of broccoli. The

present findings corroborated with the findings of Rahman et al. (2020), Shapla et al. (2014) and Getachew et al. (2016). It was also observed that all the growth parameters were significantly varied with the different spacing employed except Leaf length and leaf width. Highest number of leaves was obtained by employing 60×45 cm^2 (14.44), However closer spacing of 30×45 cm^2 had produced highest stalk length (27.61 cm), days to 50% head initiation (40.86) and days to 50% head maturity (57.83). Closer spacing of 30×45 cm^2 accommodated highest plant density which conferred the inter-competition among the plants for soil nutrient and moisture along with for light which tends the plant for elongation of stalk. Interaction effect of date of planting and spacing significantly varied for Leaf width, stalk length, days to 50% head initiation and days to 50% head maturity except number of leaves and leaf length which showed non-significant differences among the growth response. 21st October planting and 30×45 cm^2 spacing recorded maximum stalk length (41.65 cm), minimum days to 50% head initiation (30.27 days) and minimum days to 50% head maturity (53.48 days). A minimum day for head initiation and head maturity recorded by 21st October planting and 30×45 cm^2 spacing implies earliness which would be feasible for the farmers from economic point of view.

3.2. Yield response

The effects of planting dates, spacing and interaction of both on yield and yield parameters of broccoli were presented in table 2. The date of planting had significant effect on head length and head width. The head length (14.23 cm) and head width (14.58 cm) was higher with October 21st (D_1) compared to rest of the planting dates. Head length of 14.23 cm was statistically at par with October 28th (D_2) planting (13.94 cm). Lowest head length (11.68 cm) and head width (10.79 cm) was recorded with November 14th planting (D_4). The spacing also had varied significantly among themselves independently for head width but not for head length which showed non-significant differences. The wider spacing of 60×60 cm^2 (S_4) had recorded maximum head width (1280 cm) which was statistically at par with S_3 (60×45 cm^2) level of spacing (12.58 cm) and the least head width (12.20 cm) was recorded in S_1 (30×45 cm^2) spacing level. The interactions also differed significantly with each other in respect to head length and head width. The higher head length (14.42 cm) and head width (15.17 cm) were recorded with 21st October planting with a wider spacing of 60×60 cm^2 (D_1S_4). The reason for better head quality in terms of head length and breadth in last week of October planting dates might be due to exposure of favourable low temperature during head initiation and development stage compared to later planting on November. Later planting during November month where high temperature might had coincided with the head development stage which affects adversely. Adverse effects of high temperature exposure for at least one week during head development stage could reduce the quality of head in broccoli (Lin et al., 2019). Similar findings of influence of temperature on the quality of head were also reported by Pradhan et al. (2023), Giri et al. (2020), Mehra and Singh (2013) and Singh et al. (2017) in cauliflower and El-Magd (2013), Hossain et al. (2011) in broccoli. Interaction effects of date of transplanting and spacing on head length and head width revealed that the crop transplanted on 21st October with a spacing of 60×45 cm^2 (D_1S_4) produced highest head length (14.42 cm) and head width (15.17 cm) compared to all other combinations. Favourable growing environment for growth and development of heads in wider spacing which accommodates less density of plant facilitates better establishment of plants which ultimately improves the quality of head in terms of head length and breadth. Results were in lines with the findings of Hossain et al. (2011) in broccoli. Head weight varied significantly among the dates of planting, spacing and interactions of both. Head weight was maximum (464.95 g) during D_1 planting date i.e. 21st of October but it decreases gradually on later planting dates. It had been observed that there was around 49.61% decreased head weight during D_4 (14th Nov.) level of date of planting. Good vegetative growth and congenial temperature of 20–25°C during head development stage of 21st October (D_1) and 28th October (D_2) plantings resulted in heavy heads. Gradual increase in temperatures beyond 25°C during head development stage at later planting dates reduces head weight. Such influence of climatic factors on head weight was also reported by Sermenli et al. (2011) and Hossain et al. (2011) in broccoli. Spacing also brought significant variation in head weight. Maximum head weight (400.74 g) was observed in wider spacing of 60×60 cm^2 (S_4) whereas minimum head weight (277.99 g) was recorded in closer spacing of 30×45 cm^2 (S_1). Heavy head in wider spacing might be due to more accumulation of photosynthates due to more vegetative growth (number of leaves) in wider spacing and also less competition for nutrients, space and light between the plants. Results were corroborated with the findings of Abhijithnaik et al. (2023), Azam et al. (2020) and Khatun et al. (2011) in broccoli. Regarding the interaction of dates of planting and spacing, the maximum head weight was recorded from 21st October with a spacing of 60×60 cm^2 (D_1S_4).

Plot yield and Projected yield (t ha^{-1}) also varied significantly among different planting dates, spacing and interaction of both. Maximum plot yield (10.32 kg) and projected yield (11.46 t ha^{-1}) was recorded in D_1: 21st October level of planting date which were statistically at par with D_2: 28th October level of planting (9.93 kg, 11.03 t ha^{-1} respectively). It had also been observed that plot yield and projected yield gradually decreased after D_2 level of planting. Closer spacing

of 30×45 cm^2 (S_1) had recorded maximum plot yield (13.48 kg) and projected yield (14.98 t ha^{-1}) as compare to the wider spacing (60×60 cm^2) whereas, treatment combination of 21st October planting (D_1) with the spacing of 30×45 cm^2 (S_1) had recorded maximum plot yield (15.47 kg) and projected yield (17.19 t ha^{-1}) as compare to the other treatment combinations. Maximum head yield in terms of plot and projected yield during October planting might be due to congenial climatic factors for profuse growth and development of plant and consequently production of more photosynthates due to photosynthesis which ultimately led to more yield. Similar results were quoted by Rahman et al. (2020) in broccoli and Singh et al. (2017) in cauliflower. Here, closer spacing had recorded less head weight in spite of that it had recorded maximum plot and projected yield because it had accommodated more number of plants per plot. Azam et al. (2020) was also recorded that the closer spacing effect the yield of broccoli crop through different characters namely minimum days taken to curd initiation, weight of primary curd, number of secondary curds, weight of secondary curds and total weight of plant, which characters was recorded maximum effect towards yield under their experiment.

4. CONCLUSION

Planting of broccoli from October 21st (D_1) to October 28th (D_2) and adopting closer spacing of 30×45 cm^2 (S_1) was found to be ideal to get higher yields. The time frame and spacing was revelled from the above investigation will be more profitable for the farmers of terai agro-ecological region and adjoining areas.

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