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Effect of spacing and curd management on quality seed production and profitability of broccoli var. BARI broccoli 1

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Abstract*— A two factorial experiment with nine treatment combinations was conducted at Agricultural Research Station (ARS), Pahartali, Khulshi, Chattogram during Rabi season 2019-2020 to find out the best seed production technology for broccoli. These two factors were spacing and curd management. In case of siliqua/ plant, the highest number of siliqua (2453) was acquired from treatment H_2S_2 (de-heading with 60 cm × 60 cm spacing) followed by treatment H_1S_2 (scooping with 60 cm × 60 cm spacing) which was documented as 2054. On the other hand, treatment H_3S_3 (no de-heading with 50cm × 40 cm spacing) produced lowest number of siliqua/ plant which is documented as 677. Treatment H_2S_2 (de-heading with 60 cm × 60 cm spacing) also provided the maximum seeds/ siliqua (9.40), 1000 seed weight (4.37 g) and seed yield (680 kg/ha) .The highest length of siliqua (5 cm) was obtained from treatment H_3S_2 (control with 60 cm × 60 cm spacing) and the lowest length of siliqua (4.55cm) was obtained from treatment H_2S_3 (de-heading with 50cm × 40 cm spacing). Treatment H_3S_3 (control with 50cm × 40 cm spacing) provided lowest seeds/ siliqua (6.50). Treatment H_1S_3 (scooping with 50 cm × 40 cm spacing) produced the lowest 1000 seed weight (3.17g). The BCR of broccoli was very high due to the high price of broccoli seed. From the result of BCR, it is clear that de-heading of curd is more profitable than scooping and control for the seed production of broccoli. Among de-heading technique, H_2S_2 is more profitable as suggested by its higher BCR (41).

***Keywords*— Broccoli; Seed yield; Scooping, De-heading and BCR**

I. INTRODUCTION

Broccoli (*Brassica oleracea* L.) is thought as the non-traditional and comparatively firsthand cole crops in Bangladesh, from the Brassicaceae family. It is cultivated during the winter season in Bangladesh as a cash crop [1]. There is only one released broccoli variety in Bangladesh namely BARI Broccoli-1whcih has capability to produce seed. Broccoli is an eatable green crop whose large flowering head and stalk is consumed as a vegetable. It has a very high nutritional value due to its high content of protein, carbohydrates, fibers, calcium, iron, β-carotene, thiamine, riboflavin and ascorbic acid. It also helps in digestion and assimilation of food in human body [2]. Broccoli has good nutritional value where it is considered one of the foods with low free fat, sodium, and calories, and it is a good source for many vitamins such as vitamin A, C, D, riboflavin, niacin, carotenoids and folic acid [3][4]. Broccoli is a rich source of glucosinoldes, which has been proven to be anti-cancer [5], it was found that eating more than one meal during the week reduces the risk of cancer with the percentage of 45% as well as it helps prevent infecting with retinal diseases [6]. The green leaves of broccoli after harvesting the head is considered as the nutritive green silage during severe dearth in winter season [7]. New days, broccoli attracted more attention due its diverse use and great nutritional value [8][9].

Some investigators dealt with broccoli varieties under the different environmental conditions [10][11][12][13][14]. There is lot of techniques to produce quality seed of broccoli viz. de-heading and scooping. Plant spacing is considered as an essential element that can manipulate plant population in a unit of plant that influences the growth and development of plant. The main impact of plant density on production is due to difference in distribution of solar energy and increasing light which leads increasing yield [15]. Broccoli is a vegetable crop that responds to plant density, where the planting distance directly affects the quantity of the crop and the size, diameter and weight of the main curds and it affects the number of sub-curds formed by the plants and the formation date of the curds and completing their growth, where the density affects the prolong the flowering period. The planting distances between plants and between the cultivation lines have a great influence on the vegetative growth for plants and the quantitative and qualitative yield for the produced curds [16].

Irwin and Aarssen [17] stated that seed and biomass production was increased due to the pinching of axillary buds. Mutilation to the shoot tip commonly helps to release of horizontal meristems due to the apical dominance in plants. The removal of shoot apex also helps to inhibit reproduction [18]. Plants having main stem apex demonstrate apical dominance through obstructs the development of lateral branches. This obstruction is normally supposed to be facilitated by hormonal mechanism, but modifications in environmental circumstances can also modify the development of lateral twigs [19]. There is no specific head management and optimum spacing for quality seed production of broccoli. It is estimated that good quality

seeds of improved varieties can contribute about 25-40% increase in yield [20].Therefore, this experiment was undertaken to find out the best production technology in term of spacing and head management for quality seed of broccoli.

II. Materials and Method

Experimental site: The investigation was accompanied at ARS, BARI, Pahartali, Khulshi, Chattogram during Rabi season 2019-2020 to find out best production technology for broccoli seed production. The experimental areas lie between 22.18^0 N latitudes and 91.89^0 E longitudes at an average elevation of 20 m above the sea level. The experimental unit belongs to Agro-ecological Zone 23 known as Chittagong Coastal Plains. The physiographic unit of these areas is low hills and valleys. The soils are predominantly moderately fine textured and the pH of soil is about 6.5. The organic matter ranges from 0.7 %-1.47 % in top soil and 0.38 % – 0.76 % in sub soil [21].

Experimental design: The research was steered following Randomized Completely Block Design which has 3 replications of treatments. The size of the plot was 3 m ^{x} 3 m.

Treatments: There were two factors viz. Spacing and curd management in this experiment. The spacing were S_1 = 50 cm ^{x} 50 cm, S_2 = 60 cm ^{x} 60 cm and S_3= 50 cm ^{x} 40 cm. The curd management were H_1=Scooping, H_2 = De-heading and H_3 =Control. Hence there were 9 treatments namely H_1S_1, H_2S_1, H_3S_1, H_1S_2, H_2S_2, H_3S_2, H_1S_3, H_2S_3, H_1S_1.

Production technology: Seedlings were transplanted on 11 November, 2019. Fertilizer were applied @ 200:170:150:25 and 100 kg/ha of Urea: TSP: MP: B and Gypsum respectively. Half of the urea and all other fertilizers were applied during ultimate land preparation. The remaining part of urea was applied at two interval of growing stage. After flowering again MP fertilizer was applied at pod formation stage in the field. All intercultural tasks like weeding, irrigation, pesticide application were followed timely for the uniform growth of the plant.

Data Collection: The plant growth and yield related traits were measured from five plants which are selected randomly from each plot. Data were recorded on days to fifty percent (50%) curd initiation, days to fifty percent (50%) flowering, siliqua/plant, length of siliqua (cm), seeds/siliqua, 1000 seed wt. (g) and yield/plot. The plot yield was converted into kg/hectare.

Statistical analysis: Recorded data were analyzed statistically by R package [22].

In case of Benefit cost analysis, Total Variable Cost (TVC), Gross Margin (GM) and Benefit Cost Ratio (BCR) were calculated from the following formula-

a) Total Variable Cost (TVC) = Labour cost+ Input cost
b) Gross Margin (GM) = Gross Return (GR) - Total Variable Cost (TVC)
c) Benefit Cost Ratio (BCR) = Gross Return (GR) ÷ Total Variable Cost (TVC)

III. Results and Discussions

Effect of spacing

Significant variation was found among the studied traits due to different type of spacing (Table 1). Optimum plant density plays an important role in ensuring the yield and quality of the crop. The minimum number of days required for initial curd development from S_2 treatment. But researchers found it from 30 cm × 30 cm spacing [23]. The highest curd yield per hectare was obtained from 60 cm× 30 cm spacing [24]. Researchers found that the highest yield was attained from the closer spacing (60 cm x 40 cm) and lowest yield was obtained from wider spacing (60 cm x 60 cm) [25]. Opposite result was found from this experiment, where S_2 treatment produced the highest seed yield (685 kg/ ha) and the S_3 treatment provided the lowest seed yield (580 kg/ ha). Closer plant spacing required more days to bloom than the wider plant spacing in this experiment. It was confirmed by many scientists who described delay maturity and lower average marketable head yield were influenced by higher plant density [26]. The maximum number of siliqua (1746) and 1000 seed weight (4.17 g) were attained from S_2 treatment because wider spacing facilitated the optimum aeration and sunlight for the growth of the plant and seed. In contrary, the minimum siliqua/plant (1174) was attained from S_3 treatment. Considering yield and yield contributing characters S_2 treatment can be considered as best for quality seed production of broccoli.

Effect of Curd management

Significant variation was found among the studied traits due to different type of curd management (Table 2). Scooping of curd provided higher seed yield/ ha than control in cauliflower reported by many researchers [27]. Similar result was found in this experiment where H_1 (scooping of curd) produced more seed (575 kg /ha) than control (515 kg/ha). But from result it was clear that de-heading of curd produced the maximum seed yield (675 kg/ha) than all other treatments. Many researchers reported that the number of siliquae/flowering stalk, seed/siliqua, 100-seed weight and seed yield/plant were highest with scooping and side cutting [28]. Central curd scooping increased 26.52% higher yield than that of no curd cutting treatment in cauliflower [29]. H_1 (Scooping) and H_2 (de-heading) performed better than the control in all aspects in this experiment. But H_2 (de-heading of curd) treatment produced the highest siliqua/ plant, length of siliqua, seeds/ siliqua, 1000 seed weight (g), seed yield (kg/ha). The performance of H_3 (control) treatment was the minimum among the treatment. Considering yield and yield contributing characters H_2 treatment can be considered as best for quality seed production of broccoli.

Table 1: Effect of spacing on yield and yield contributing characters of broccoli

Spacing	Days to 50% curd initiation	Days to 50% flowering	Siliqua/ plant	Length of siliqua (cm)	Seeds/ siliqua	1000 seed weight (g)	yield (kg/ha)
S_1	45.22 a	71.00 a	1477 b	4.80	8.13	3.86	590
S_2	44.11 b	68.11 c	1746 a	4.82	7.93	4.17	685
S_3	45.33 a	69.44 b	1174 c	4.86	7.54	4.03	580
CV (%)	2.40	1.77	7.65	5.71	9.80	20.96	18.86

Table 2: Effect of curd management on yield and yield contributing characters of broccoli

Curd management	Days to 50% curd initiation	Days to 50% flowering	Siliqua /plant	Length of siliqua (cm)	Seeds/ siliqua	1000 seed weight (g)	yield (kg/ha)
H_1	45.00	69 b	1416 b	4.84 ab	7.83 b	4.11	575a
H_2	44.56	72 a	2090 a	4.96 a	8.61 a	4.22	675a
H_3	45.11	67 c	891 c	4.68 b	7.17 b	3.72	515b
CV (%)	2.40	1.77	7.65	5.71	9.80	20.96	18.86

Table 3: Interaction effect of spacing and curd management on yield and yield contributing characters of broccoli

Treatment	Days to 50% curd initiation	Days to 50% flowering	Siliqua/ Plant	Length of siliqua (cm)	Seeds/ siliqua	1000 seed weight (g)	Yield (Kg/ha)
H_1S_1	46.00 ab	73.00 a	1218.67 d	4.73	7.87 b	4.17	583a
H_2S_1	44.33 bc	68.33 cd	1947.00 bc	4.98	7.87 b	4.23	633a
H_3S_1	44.67 bc	67.00 de	1083.33 d	4.81	7.77 bc	3.93	553b
H_1S_2	45.33 abc	73.00 a	2054.00 b	4.97	8.07 ab	4.23	630a
H_2S_2	43.67 c	71.00 ab	2453.00 a	4.91	9.40 a	4.37	680a
H_3S_2	44.67 bc	71.00 ab	1762.33 c	5.00	8.37 ab	4.07	600a
H_1S_3	44.33 bc	67.00 de	758.67 e	4.6	7.13 bc	3.17	578 a
H_2S_3	44.33 bc	65.00 e	1237.67 d	4.55	7.87 b	3.90	628a
H_3S_3	46.67 a	70.33 bc	677.00 e	4.79	6.50 c	4.10	548b
CV (%)	2.41	1.77	7.65	5.86	9.8	20.96	18.90

Interaction effect

Significant variation was found among the studied traits due to interaction effect between spacing and curd management (Table 3). In case of siliqua/ plant the highest number of siliqua (2453) was acquired from treatment H_2S_2 followed by treatment H_1S_2 (2054). On the other hand, treatment H_3S_3 produced lowest number of siliqua/ plant which is documented as 677. On contrary, highest and lowest no. of siliqua/ plant were recorded 151.7 and 62.53 from BARI Sarisha 15 which was sown on 10 November and BARI Sarisha 14 which was cultivated on 30 December respectively [30] .In mustard, the highest seed yield was found from BJ-11536(12)-3 which is 1.79 ton/ha had a higher number of branches noted as 6. While genotype BJ-11536(9)-6 lower seed yield recorded as 1.05

ton/ha [31]. Similar result was found in this experiment. Due to higher number siliqua/plant (2453), treatment H_2S_2 produced the highest seed yield (680 kg/ha). Treatment H_2S_2 also provided the maximum seeds/siliqua (9.40) and 1000 seed weight (4.37 g). The lowest seed yield (548 kg/ha) was obtained from H_3S_3 treatment. In case of mustard, the highest length of siliqua was acquired from BJ-11536(12)-3 which is 4.93 cm while the lowest length of siliqua recorded from entry BJ-11536(9)-2 which is 4.03 cm [31]. In this experiment, the highest length of siliqua (5 cm) was obtained from treatment

H_3S_2 and the lowest length of siliqua (4.55) was obtained from treatment H_2S_3. Treatment H_3S_3 provided lowest seeds/ siliqua (6.50). Treatment H_1S_3 produced the lowest 1000 seed weight (3.17 g). Treatment H_2S_1, H_2S_2 and H_2S_3 produced extra 6250 kg, 7503 kg and 7124 kg of curd/ha as de-heading was done in these treatments. Considering the yield and yield contributing characters treatment H_2S_2 that mean 60 cm × 60 cm spacing with de-heading can be considered as best technique for quality seed production of broccoli.

Benefit cost analysis

Most of the broccoli seed is being imported from abroad. The price of seed is too high. It is estimated that per kg imported broccoli seed in Bangladesh is about Tk.50000. Now Bangladesh is able to grow BARI broccoli 1 seed under different agro-ecological zone. Hence the price of per kg seed of BARI broccoli1 was estimated at Tk.5000 which is very lower than that of imported seed price.

In benefit-cost analysis, the treatment-wise gross return was calculated as total yield of seed multiplied by per kg seed price. In case of de-heading (H_2) technique, total yield of curd multiplied by per kg of curd price also estimated. The highest gross return was obtained at Tk.4000240 from treatment H_2S_2 due to collect higher amount of seed and curd. The lowest gross return was estimated at Tk. 2737500 from H_3S_3 due to collect lower amount of seed. The variable cost includes all input cost such as seed, fertilizers, labours, irrigation and power tiller cost. The total variable cost was estimated at Tk. 96690 for al treatments except control where the total variable cost was estimated at Tk. 93690. It is due to the extra labours needed for scooping and de-heading of curd.

The highest gross margin (Tk.3903550) was obtained from treatment H_2S_2 followed by treatment H_2S_3 and H_2S_1. The highest BCR (41) was obtained from treatment H_2S_2 followed by treatment H_2S_1 and H_2S_3. The BCR of broccoli was so high due to the high price of broccoli seed. It is concluded that the treatment H_2S_2 is more profitable than other treatment. It is noted that extra curd was obtained from de-heading technique which is not found from scooping and control treatment. It is clear that de-heading of curd for the seed production of broccoli is more profitable than scooping and control. Among de-heading techniques, H_2S_2 is more profitable suggested by its higher BCR (Table 4).

Table 4: Benefit-cost analysis of broccoli seed production in respect to different treatments

Treatment	GR	TVC	GM	BCR
H_1S_1	2912500	96690	2815810	30.0
H_2S_1	3662500	96690	3565810	38.0
H_3S_1	2762500	93690	2668810	29.0
H_1S_2	3150000	96690	3053310	33.0
H_2S_2	4000240	96690	3903550	41.0
H_3S_2	3000000	93690	2906310	32.0
H_1S_3	2887500	96690	2790810	30.0
H_2S_3	3707420	96690	3610730	38.0
H_3S_3	2737500	93690	2643810	29.0

Note: labour @ 600 tk/ man day, Urea (200 kg) @16 tk/kg, TSP (170)@ 22 tk/kg, MOP (150 kg) @30 tk/ kg, Boric acid (25 kg) @25 tk/kg, Zypsum (100 kg) @ 200 tk/kg, Seed @5000 tk/kg, Curd @80 tk/kg

IV. Conclusion

Broccoli is gaining popularity day by day in Bangladesh. The price of broccoli seed is very high as hybrid seed is imported from abroad. So seed business of broccoli can be profitable for the farmer. From the result of BCR, it is clear that de-heading of curd for the seed production of broccoli is more profitable than scooping and control. Among de-heading technique, H_2S_2 is more profitable as suggested by its higher BCR (41).Considering the yield and yield contributing characters treatment H_2S_2 that mean broccoli cultivation maintaining 60 cm × 60 cm spacing with de-heading can be considered as best technique for quality seed production of broccoli.

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CONFLICT OF INTEREST

THE AUTHORS DECLARE THAT THEY HAVE NO CONFLICT OF INTEREST.

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