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Effects of spacing and planting time on growth and fruit yield of *Solanum aethiopicum*

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Abstract
Solanum aethiopicum, an important vegetable of African origin has find special place in the diet of local community of Sikkim Himalayas. Though there is no written record of introduction, this crop is cultivated in almost every household of Sikkim state and abundantly grown in North Eastern part of India. The cultivation of *S. aethiopicum* in Sikkim hills has gain more importance after the declaration of Sikkim as Organic state owing to its wide adaptability to biotic and abiotic factors. Despite being an important crop there has been no study for standardization of cultivation practices. The present investigation was carried out to study the effect of planting time and spacing on the growth and fruit yield of the *'Bihi'* (*S. aethiopicum*) and its market potential. The result of the present experiment showed significant effect of spacing on growth and fruit weight. Plants spaced at 60x60 cm recorded maximum for all the parameters under observations except for plant height. The maximum plant height was recorded in plants with 45x45 cm. On the other hand, June planting recorded maximum plant height, maximum number of branches per plant and maximum number of fruits per plant. While maximum plant spread was achieved by May planting. A late planting (July) yielded the bigger sized fruits with highest fruit weight, however, no significant effect was observed due to variation in planting times on fruit size. Despite the satisfactory growth parameters in June planted crop with the spacing of 60x60cm, May planting is recommended with 60x60 cm keeping in view the high marketable yield and wider availability period. More parameters on nutrient, irrigation, canopy management and adaptation to climate change can be the future thrust for research.

Keywords: Growth, planting, *Solanum aethiopicum*, spacing, yield

Introduction
Solanum aethiopicum, known as scarlet eggplant, African eggplant and garden eggplant, belongs to family Solanaceae (Kouassi *et al*., 2014) [3]. The crop locally known as "*Bihi"* is an indigenous underutilized vegetable and it is found growing by majority of farmer in their homestead garden in low and mid hills of Sikkim (a small Himalayan state in North-East India), where entire cultivable land is organically certified. Though native to African countries, growing in the tropical climate, this crop has attained considerable place in the diet of population of North East India. However, there is no written evidence of introduction of the crop in Sikkim Himalayas. The fruit is cooked as vegetable and believe to have high medicinal properties like ailments including asthma, allergic rhinitis, nasal catarrh, skin infections, rheumatic disease and swollen joint pains, gastro-esophageal reflux disease, constipation and dyspepsia (Bello *et al.,* 2005) [1]. It is desired vegetable for diabetic patients and is a favorite constituent of daily food of people. Being a popular vegetable, it also has high market demand and fetch fairly remunerative price. Underutilized crops, providing food and nutritional, adapted to biotic and abiotic stress conditions covering about 10% of inhabiting in remote, tribal and backward areas (Thakur *et al*., 2017) [5]. Any specific crop for their better growth and yield performance need to be sown at right time and spacing. The optimum sowing time and planting distance usually brings about proper growth and development of plant resulting in good yield of the crop and economic use of land influencing the growth parameters like number of days to germinate, germination percentage, height of the plant, plant spread, leaf area, number of branches, number of fruits per plant and yield, etc. Optimum spacing contributes the crop performance by suppressing the weeds growth and also reduces the nutrient competition. Despite the commercial and nutraceutical values, its popularity, *Solanum aethiopicum* cultivation practices is not yet standardized. In Sikkim, the optimum spacing and planting time in the crop *'Bihi'* is yet not practiced. If planting time and spacing is standardized, the crop production of *'Bihi'* can be increased and also fulfils the growing

demand of vegetable in the market. Keeping in view the above facts, the experiment was undertaken to access the effects of planting time and spacing on growth and yield parameters of *S. aethiopicum* and to survey the availability period of *'Bihi'* and its price in the local market.

Material and Methods

The present study was carried out in the farmers' field at Martam Rurntek, Chenzey Village, East Sikkim, and India. The location of the study was situated at 27° 17.736' North and 088° 34.792' East at an elevation of 3662 ft. from MSL. Seeds of *S. aethiopicum* were collected from the local farmers and seedlings were raised in nursery bed and one month old seedlings were transplanted in the main field. The crop *(S. aethiopicum)* was identified by Department of Botany, Sikkim University, 6th Mile Gangtok, Sikkim, and India. The two factorial treatments of planting time (April (P1), May (P2), June (P3) and July (P4)) and spacing (30x 40 cm (S1), 45x45 cm (S2), 45x60cm (S3) and 60x60 cm (S4)) was laid out in a Factorial Randomized Block Design with three replications. Recommended organic package of practices of brinjal was followed for its cultivation as Sikkim is fully organic certified state. The parameters viz. plant height (cm), plant spread (cm), number of branches, number of fruits per plant, fruit diameter (mm) and fruit weight (g) were recorded in the study. Market potential of *Bihi (S. aethiopicum)* at local market (Tadong, Lal Bazar and Ranipool) of Sikkim was conducted. The survey period was lasted for eight months from April to December 2015 which is based on the interview with the vendors of local lands races to know the price of the crop and its availability in the market. The perception of consumer towards purchasing the fruit was done on the base of free listing methods with 20 consumers selected using a sample random sampling technique. Studied data was analyzed using STPR software.

Results and Discussion

Effect of spacing on growth and fruit weight

The significant effect of spacing on growth and fruit weight was observed. Plants spaced at 60x60 cm recorded maximum and plants of 30x40 cm spacing recorded minimum values for all the parameters under observation, except for plant height. The maximum and minimum plant height was recorded in plants with larger spacing (60x60 cm) and 45x45 cm respectively. Decreased number of plants with wider spacing had less competition among the plants that led increase in plant spread, number of branches per plant, number of fruit per plant, fruit size and fruit weight. The results are agreement with Islam *et al*. (2011) [2] where he had found highest number of fruit set, maximum plant spread and maximum fruit weight of sweet pepper under wider spacing. Mishriky and Alphonse (1994) [4] also recorded decreased in number of fruits per plant and yield per plant decreased with closer plant spacing.

Table 1: Effect of spacing on growth and fruit weight

Treatments	Plant height (cm)	Plant spread (cm)	No. of branches/plant	No. of fruit/plants	Fruit size (mm)	Fruit weight (g)
S1	48.49	57.07	41.70	48.40	21.90	8.60
S2	52.42	67.35	51.40	70.10	24.40	10.85
S3	46.30	73.35	61.95	93.60	26.40	13.67
S4	41.80	83.90	67.15	102.30	30.50	17.34
CD (5%)	1.26	2.74	2.88	6.43	1.07	0.39

Effect of planting time on growth and fruit weight

It was found no significant difference for plant height due to planting time among the plants of May, June and July, having maximum plant height in the June plants, while early planting produced minimum plant height. Analyzing the data (Table 2), May and July plants measured for maximum and minimum plants spread respectively. When the plants were compared, the June plants produced maximum number of branches and fruits per plant. On the other hand, early and late planting recorded to be responsible for less branching and fruiting respectively. Plants of both June and July had biggest fruit size compared to April and June plants. A trend of July plants being superior for fruit size was followed in case for fruit yield also and the lowest fruit weight was yielded by early planting.

Table 2: Effect of planting time on growth and fruit weight of *S. aethiopicum*

Treatments	Plant height (cm)	Plant spread(cm)	No. of branches/plant	No. of fruit/plants	Fruit size (mm)	Fruit weight (g)
P1	43.60	73.55	39.56	72.30	25.30	11.53
P2	47.70	78.60	47.45	86.10	25.10	12.65
P3	49.10	71.20	77.00	121.90	26.00	12.71
P4	48.60	58.30	58.20	34.10	26.80	13.57
CD (5%)	1.26	2.74	2.88	6.43	1.07	0.39

Effect of interaction (spacing x planting time) on growth and fruit weight of *S. aethiopicum*

Plant Height

The highest plant height was obtained in the June plants spaced at 45x45 cm and the minimum was found with plants spaced at 45x60 cm in April. There was no significant effect due to planting time for plants spaced at 45x45 and 60x60 cm.

Plant Spread

It was observed that maximum plant spread was found with maximum plant spacing (60x60 cm) plants of May which was significantly at par with April planted with same spacing. Likewise, closed spaced plants (30x40 cm) of July month had a minimum plant spread among the observed plants which were at par with April plants with same spacing.

Number of branches per plant

June plants having spacing of 45x60 cm had profuse branching which was superior compared to other plants, while early planting with minimum spacing had minimum number of branches per plant. Both the maximum and minimum branching plants were significantly different among all the plants.

Number fruits per plant

The interaction between June plants and 60x60 cm spacing produced a maximum number of fruits per plant and it was found to be at par with the plants spaced at 45x60 cm in the same month. Large spacing plants in the month of July produced minimum number of fruits per plants. There was a highly significant difference between maximum and minimum number of fruiting plants.

Fruit size

An increasing trend was found in the fruit size as spacing increased. Plants with spacing of 30x40 cm and 45x60 cm did not show variation due to different planting time, however the significant effect between planting time and spacing was observed in the spacing of 45x45 cm and 60x60 cm. Plants spaced at 60x60 cm of July, June and April produced biggest sized fruits while plants at spacing of 30x40 cm in all four months produced smallest sized fruits.

Fruit weight

A highest fruit weight was obtained by the plants of July month spaced at 60x60 cm which was significantly different among all. It was followed by plants of June and May of same spacing. However, April planted plants spaced at 30x40 cm had minimum fruit weight.

Table 3: Effect of interaction (spacing x planting time) on growth and fruit weight of *S. aethiopicum*

Treatments	Plant height (cm)	Plant spread (cm)	No. of branches/plant	No. of fruit/plants	Fruit size (mm)	Fruit weight (g)
S1P1	42.32	*54.00*	*33.00*	44.80	*21.70*	*7.66*
S1P2	47.26	64.18	38.80	60.80	*22.20*	*8.10*
S1P3	52.52	60.00	50.80	70.20	*21.80*	8.68
S1P4	51.86	*50.00*	44.20	*17.80*	*21.80*	9.94
S2P1	*51.60*	71.00	38.60	56.80	*23.00*	10.10
S2P2	*52.56*	76.60	46.20	72.40	*23.00*	*11.34*
S2P3	*53.08*	66.40	62.20	116.00	24.60	*10.94*
S2P4	*52.42*	*55.40*	58.60	35.20	26.90	*11.02*
S3P1	38.32	77.80	43.40	82.60	26.10	12.88
S3P2	49.58	80.40	50.20	104.20	26.20	14.44
S3P3	48.84	74.20	91.00	148.80	26.40	13.42
S3P4	48.44	61.00	63.20	38.80	27.10	14.24
S4P1	41.96	91.40	43.20	105.00	30.30	15.48
S4P2	41.42	93.20	54.60	106.80	28.90	17.02
S4P3	42.12	84.20	104.00	152.80	31.20	17.80
S4P4	41.56	66.80	66.80	44.40	31.60	19.06
CD (5%)	2.51	5.48	5.74	12.85	2.14	0.79

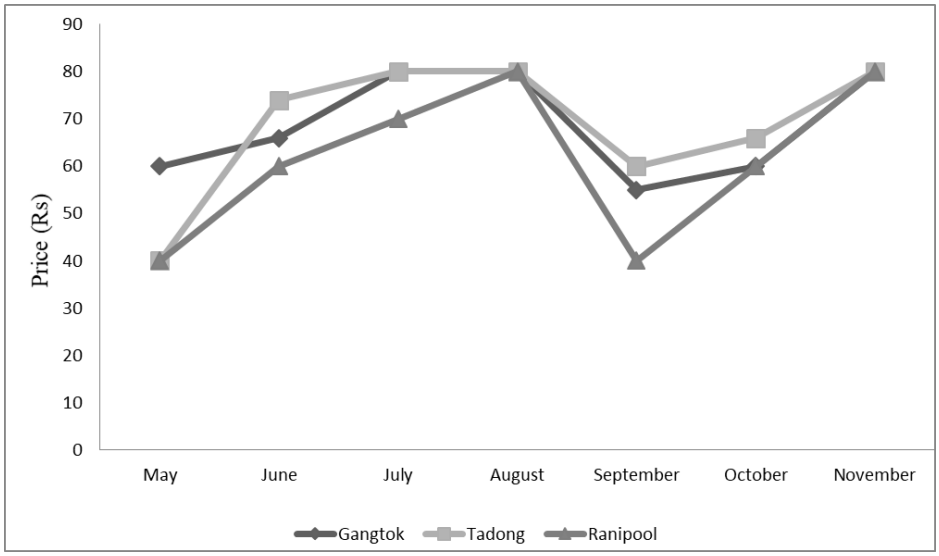

Fig 1: Market price of *S. aethiopicum* at Gangtok and its adjoining areas in different months. Price is in Rupees (Rs.)

The Fig.1. Depicts the price varies depending on the season of the crop and its availability. The availability of the crop was almost through the year except in the months of January, February, March, April and December. It was observed that highest price per kg of fruit was reported in the month of August and November in all three markets. However, the least price was recorded in the month of May from Tadong and Ranipool market. While observing the market data the average price of S. Aethiopicum of all three markets throughout the seasons was found to be 40-60 rupees per kg.

Conclusion

It was found that the wider spacing (60x60 cm) produced the highest number of fruits per plants and highest weight of marketable fruits per plant. Close spacing of 45x45 cm has better height growth during the field experiment. Planting time during the month of July recorded the highest number of the fruit and fruit weight but due to the extended harvesting period, crop planted on May showed the highest marketable fruit weight per plant. The results indicated that the optimum planting time and spacing have remarkable effects on the growth and yield of the' *Bihi' (Solanum aethiopicum)*

Recommendation

Wider spacing and optimum planting time is recommended for the production of *Solanum aethiopicum.* More parameters on nutrient, irrigation, canopy management and adaptation to climate change can be the future thrust for research.

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