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Effect of plant spacing on the growth and yield of sweet potato cultivars in medium highland condition under AEZ-9

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ABSTRACT

The experiment was conducted at Muktagacha, Mymensingh during 2015-16, to study the effect of three different plant spacing on the growth and yield of sweet potato varieties aimed at designing a production system for medium sized sweet potato tubers. Three plant spacing viz. 60 cm × 30 cm, 50 cm × 30 cm and 30 cm × 25 cm (farmers' practice) were used as treatment variables. BARI SP 11, an improved sweet potato variety was compared with a local sweet potato cultivar through this experiment. Results revealed that 50 cm × 30 cm plant spacing performed better in case of number of tuber per plant, tuber weight, tuber diameter and yielded the highest (20.53 t ha^{-1}) followed by 60 cm × 30 cm spacing (17.07 t ha^{-1}). The lowest tuber per plant, tuber weight, tuber diameter and tuber yield (15.22 t ha^{-1}) was recorded with 30 cm × 25 cm plant spacing. Between the two varieties, BARI SP 11 performed better in all the parameters (vine length, tuber weight per plant, tuber length and diameter) except numbers of tuber per plant and yielded highest (18.29 t ha^{-1}) over local cultivar (16.92 t ha^{-1}). However, there were no significant different in case of interactions between plant spacing and sweet potato varieties. Economic analysis showed that the spacing 50 cm × 30 cm along with BARI SP 11 gave the maximum gross return (Tk 2,53,560 ha^{-1}) and gross margin (Tk. 1,88,060 ha^{-1}). The lowest gross return (Tk 1,80,000 ha^{-1}) and gross margin (Tk 1,08,610 ha^{-1}) was estimated from local sweet potato with farmers' practice (30 cm × 25 cm). The highest BCR (3.87) was found from BARI SP 11 with 50 cm × 30 cm spacing and the lowest BCR (2.52) was calculated from local cultivar with 30 cm × 25 cm spacing. Therefore, 50 cm × 30 cm spacing are recommended for the cultivation of sweet potato for both the varieties in Muktagacha of Mymensingh district.

Introduction

Sweet potato (*Ipomoea batatas*) is a dicotyledonous plant that belongs to the family Convolvulaceae. It has large, starchy, sweet-tasting, tuberous roots that are used as a root vegetable. Sweet potato is the world's most important versatile and underutilized food crop grown generally for its storage roots (Tortoe, 2010). The crop can be considered very important in promoting nutritional security particularly in agriculturally backward areas with poor soils (Srinivas, 2009). In Bangladesh sweet potato is cultivated in 67 thousand acres of land and produces 263 thousand tons during 2012-13 (BBS, 2014). The yield potentiality of local variety that the farmers' cultivate in Mymensingh region is low and this is also susceptible to different pest and diseases. Thus they get very poor economic return. Bangladesh Agricultural Research Institute (BARI) has developed 13 high yielding varieties; among these farmers' prefer BARI SP 11 for its red skin color, size, shape, taste and high yielding potential. Consumer also preferred red skin color and medium sized tuber.

Plant population density or plant spacing in root crops is an important management variable that affects its production and quality (size, shape, colour and eating quality) of tubers. Increasing plant density usually results in more numbers and smaller roots. However, consumers like medium to large sized and visually appealing tubers. Farmers' of the locality follow traditional planting system. They preferred closer spacing and as a result they harvest smaller sized roots that are not economically viable. They do not know which spacing is suitable for their medium highland farms for cultivating sweet potato. The effects of in-row spacing have been studied for several sweet potato varieties, and the recommended spacing for most varieties is 23 to 40 cm (Rubatzky & Yamaguchi, 1997; Swiader et al., 1992). In New Zealand, the standard plant spacing is about 30 cm. Shaw et al. (2008) found suitable row spacing for high yielding sweet potato cultivars was 75 cm row and in-row plant spacing's were 10, 20 and 30 cm. for New Zealand conditions. Typically, as the in-row spacing for sweet potatoes increases, the yield of larger size roots increases (Schultheis et al., 1999). Evaluation and selection of different inter and intra row spacing by participating farmers based will improve production and productivity of the crop, which has great contribution for increment of the national average yield. The present field study was aimed to investigate the effects of plant spacing and variety on growth and development of sweet potato in Muktagacha, Mymensingh during the 2015-16 seasons focusing on the production of medium to large sized, economically viable sweet potato tuber.

Materials and Method

Experimental Site

The experiment was conducted at Langra Bazar village of Muktagacha under Mymensingh district during Rabi season of 2015-16 to evaluate the effect of plant spacing on the growth and yield of

sweet potato varieties. The experimental site was medium high land belongs to Old Brahmaputra Flood Plain under AEZ- 9. The soils of the experimental site were acidic in nature and sandy loam in texture. Soil sample were collected and analyzed following standard method in the laboratory of Soil Science Division of BARI. Nutrient statuses of the experimental sites are shown in Table 1.

Planting materials and plant spacing and experimental layout

BARI SP 11 and local variety were used in this experiment (Table 2). Three different plant spacing viz. 60 cm × 30 cm (BARI recommendation), 50 cm × 30 cm and 30 cm × 25 cm (farmer's practice) were used as treatment variables. The unit plot size was 6 m × 6 m. The experiment was laid out in randomized complete block design with three dispersed replications.

Table 1. Chemical properties of initial soil (0-15 cm depth) of the experimental field

Location	pH	Organic matter (%)	Total N (%)	K (meq/ 100 g soil)	P	S	Zn	B
					µg / g soil			
Langrabazar, Muktagacha	5.9 Acidic	1.58 low	0.09 Very low	0.15 low	16.20 optimum	20.50 optimum	1.15 medium	0.30 medium

Table 2. General description of sweet potato var. BARI SP 11 and local cultivar.

Characters	Variety	
	BARI SP 11	Local cultivar
Shape	Oval	Long
Size	Medium to large	Small
Skin color	Red	Light red
Flesh color	White/ cream	White
Maturity period	Medium (100-130 days)	Early (90-120 days) in the study area
Market preference	New variety for the study area. People prefer red color tuber. So, preference medium to high in that area.	Extremely demanded
Preference by farmer	Highly preferred because of easy cultural practice, high yield and medium to large sized red tuber.	Less preferred because of difficulty in management, disease incidence, low yield.

Source: BARI (2015), personal observation and Mondal *et al.* (2014).

Cultural practices

BARI SP 11 vines were collected from Tuber Crop Research Center of BARI and local cultivar vines from promising local farmers. Sweet potato vines were sown on 13 November, 2015. Manures and fertilizers were applied at the rate of 10 t ha^{-1} cowdung and 105-45-105-15-2-1Kg of NPKSZnB ha^{-1}, respectively in the form of urea, TSP, MoP, gypsum, zinc sulphate and boric acid. Fifty percent of N, K and full dose of other fertilizers were applied during final land preparation. The rest amount of N and K fertilizer were applied at 35 DAP. Intercultural operations like weeding, earthing up and other routine activities were conducted as and when necessary during the crop growing period. No plant protection measure was needed as there was no disease and pest attack.

Plant sampling and statistical analysis

The crop was harvested on 11 to 20 April, 2016. The growth (vine length), yield attributes (no. of tubers/plant, length and diameter of tuber, tuber weight/ plant) and yield of tuber were measured at harvest. For collecting data, 1 m^2 area was marked avoiding boarder effect from each plot and data on Yield and yield contributing characters were recorded plot wise and converted in to t ha^{-1}. Collected data were analyzed statistically with the help of MSTAT-C program and mean separation was done as per Least Significant Difference (LSD) test at 5% level of significance. Economic analysis of different treatments was computed on the basis of prevailing market price.

Result and Discussion

Effect of variety

The yield and yield contributing characteristics of the two sweet potato varieties are presented in Table 3. Results revealed that tubers/ plant, length of tuber, diameter, weight of tuber/ plant and yield (per hectare) were statistically significant except vine length. The highest no of tuber per plant (5.29) was found from local variety and BARI SP 11 gave the lowest number (4.52). The highest tuber weight per plant was recorded in BARI SP 11 (501.48 g) and the lowest was obtained from local cultivar (457 g). Tuber length (11.96 cm.) and diameter (3.79 cm) were higher in BARI SP 11. It yielded the highest (18.29 tha^{-1}) while the local variety gave the lowest tuber yield (16.92 tha^{-1}). Higher tuber yield in BARI SP 11 was attributed due to large size and higher tuber weight. These results are in agreement with the research report of BARI (2014-15). The finding of this report shows that among the four cultivars BARI SP 11 yielded highest (20.00 t ha^{-1}).

Effect of plant spacing

Plant spacing significantly influenced almost all the parameters under study except vine length and tuber length (Table 4). The widest spacing (60 cm × 30 cm) produced the tallest plant (172.67 cm) followed by the spacing 50 cm × 30 cm (158.33 cm) whereas the closest spacing i.e. farmer's practice (30 cm × 25 cm) gave the lowest plant height (154.47 cm). It is indicated that the wider plant

spacing resulted the longest vine. Beyene K. et al. (2015) found the similar result. They found that statistical result showed similar height in all the factors. The maximum number of tuber per plant (5.28) was found from the spacing of 50 cm × 30 cm, but the widest spacing (60 cm × 30 cm) was statistically at par with 50 cm × 30 cm spacing. The minimum number of tuber per plant (4.16) was found in closest spacing (30 cm × 25 cm). Swiader et al. (1992) reported that closer spacing appear to reduce the number of tuber production and hence increase overall yields. Root diameter was higher (3.55 cm diameter) in wider spacing at 50 cm × 30 cm. Both 50 cm × 30 cm and 60 cm × 30 cm plant spacing produced identical root diameter. The lowest size of root was obtained from closer spacing (30 cm × 25 cm).

The spacing 50 cm × 30 cm gave the maximum weight of tubers per plant (548.72 g) which was statistically identical to the 60 cm × 30 cm spacing (513.67 g) but significantly higher than the tuber weight per plant recorded in the closest plant spacing (30 cm × 25 cm) (375.38 g). Maximum tuber weight per plant might be due to the heavier individual tuber weight or tuber size (length 11.57 cm and diameter 3.55 cm). It showed that closer spacing produced roots with comparatively less weights. Abdissa et. al. (2011), found the similar results. He reported that root size was higher (125.87 g/root) in wider spacing at 75 cm × 60 cm. The lowest size of root was obtained from closer spacing (75 cm × 15cm).

The tuber yield ranged from 15.22 to 20.53 t ha^{-1} at different plant spacing. Maximum tuber yield (20.53 t ha^{-1}) was recorded in 50 cm × 30 cm spacing followed by the spacing 60 cm × 30 cm (17.07 t ha^{-1}). Closer spacing (30 cm × 15 cm), practiced by the farmers gave the minimum tuber yield (15.22 t ha^{-1}). This result is in agreement with Abdissa et. al. (2011). In the former two spacing, the tuber got enough space for better absorption of water and nutrient that helped in extending and thickening of the root system. But this makes the tuber less preferred by the market because of higher cooking time, more fiber development, more susceptible to the attack of insects like weevil and extra fuel need (Abdissa et. al., 2011).

Table 3. Effect of variety on yield and yield attributes of sweet potato at Muktagacha, Mymensingh during 2015-16

Sweet potato varieties	Vine length (cm)	Tubers $plant^{-1}$ (no.)	Length of tuber (cm)	Diameter of tuber (cm)	Tuber weight $plant^{-1}$ (g)	Yield (t ha^{-1})
BARI SP 11	168.42	4.52	11.96	3.79	501.48	18.29
Local	155.22	5.29	10.81	2.86	457.04	16.92
CV (%)	11.10	10.72	2.98	8.87	8.52	7.43

Table 4. Effect of plant spacing on yield and yield attributes of sweet potato at Muktagacha, Mymensingh during 2015-16

Plant spacing	Vine length (cm)	Tubers $plant^{-1}$ (no.)	Length of tuber (cm.)	Diameter of tuber (cm.)	Tuber weight $plant^{-1}$ (g)	Yield (t ha^{-1})
60 cm × 30 cm	172.67	5.25	11.40	3.40	513.67	17.07
50 cm × 30 cm	158.33	5.28	11.57	3.55	548.72	20.53
Farmer's practice (30 cm × 25 cm)	154.47	4.16	11.18	3.02	375.38	15.22
LSD (0.05)	NS	0.68	NS	0.38	52.54	1.68
CV (%)	32.67	10.72	2.98	8.87	8.52	7.43

Interaction effect of variety and plant spacing

Results revealed that tuber yield and other attributes were not significantly influenced by the interaction of plant spacing and variety. Similar result was found from the report of Detpiratmongkol (2011). They concluded that the increased plant spacing up to 50 cm × 30 cm gave the highest fresh and dry storage root weight yield (kg/rai) while wider spacing 100 cm × 50 cm gave the lower yield and there were no interaction between sweet potato cultivars and plant spacing. However, BARI SP 11 with 50 cm × 30 cm spacing gives the highest tuber yield (21.13 t ha^{-1}) following local cultivar with the same spacing (19.93 t ha^{-1}). BARI SP 11 along with 50 cm × 30 cm spacing increased 40.87% yield over control treatment (local cultivar with farmers spacing) (Fig. 1).

Cost and return analysis

Cost and return analysis is important because any benefits associated with increased planting density in terms of increased revenue may be offset by increased costs associated with crop establishment. Total cost of production varied due to different plant spacing used that approached to the variation of gross margin. The lowest variable cost (Tk 63,780 ha^{-1}) was involved in the widest spacing (60 cm × 30 cm) followed by 50 cm × 30 cm spacing (Tk 65,500 ha^{-1}) whereas the highest variable cost (Tk 71,390 ha^{-1}) was needed in farmer's practice. The variation of total variable cost was due to the variation of vine number needed and labor cost associated with the planting of sweet potato. From the six treatment combinations highest gross return (Tk 2,53,560 ha^{-1}) and gross margin (Tk 1,88,060 ha^{-1}) was calculated from BARI SP 11 with 50 cm × 30 cm spacing. Moreover, the lowest gross return (Tk 1,80,000 ha^{-1}) and gross margin (Tk 1,08,610 ha^{-1}) was estimated from local cultivar with the farmers' practice (30 cm × 25 cm). Shaw et al. (2008) found 20 cm plant to plant spacing was most profitable for gourmet-sized sweet potato. Benefit cost ratio (BCR) also found highest (3.87) from BARI SP 11 with 50 cm × 30 cm spacing and lowest BCR (2.52) calculated from local cultivar with 30 cm × 25 cm spacing.

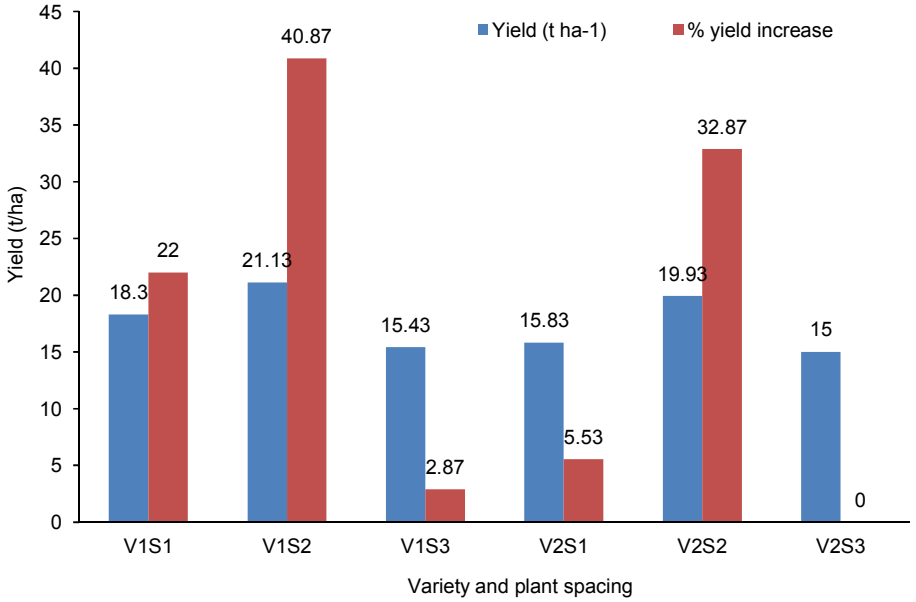

Fig 1. Interaction effect of variety and spacing on the yield of sweet potato and % yield increase over control. BARI SP 11 (V1), Local cultivar (V2), 60 cm × 30 cm (S1), 50 cm × 30 cm (S2), Farmer's practice (30 cm × 25 cm) (S3).

Table 5. Cost and return analysis of sweet potato varieties sown in different spacing

Interaction of variety and plant spacing	Gross return (Tk ha^{-1})	Total variable cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})	BCR
V_1S_1	2,19,600	63,780	1,55,820	3.44
V_1S_2	2,53,560	65,500	1,88,060	3.87
V_1S_3	1,85,160	71,390	1,13,770	2.59
V_2S_1	1,89,960	63,780	1,26,180	2.98
V_2S_2	2,39,160	65,500	1,73,660	3.65
V_2S_3	1,80,000	71,390	1,08,610	2.52

Price of input and output: Urea Tk. 20 kg^{-1}, TSP Tk. 22 kg^{-1}, MOP Tk. 15 kg^{-1}, Gypsum Tk. 10 kg^{-1}, Zinc sulphate Tk. 140 kg^{-1}, Boric acid Tk. 350 kg^{-1}; Sweet Potato: 12 Tk Kg^{-1}; BARI SP 11 (V1), Local cultivar (V2), 60 cm × 30 cm (S1), 50 cm × 30 cm (S2), Farmer's practice (30 cm × 25 cm) (S3).

Conclusion

To increase production and productivity of sweet potato, adopting different agronomic practices are important and out of which working for optimum plant density is the major. Based on the present findings 50 cm × 30 cm spacing are recommended for the cultivation of sweet potato for both the varieties in Muktagacha of Mymensingh district.

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