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RESEARCH **P**APER

Growth and productivity of beet root (*Beta vulgaris* L.) with monetary returns as affected by different spacings

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To find out optimum spacing on growth and productivity of beet root and to standardize package of practices for beet root cultivation in Vidarbha region with monetary return a field experiment was undertaken during the winter seasons of three consecutive years. The experiment was conducted in a Randomized Block Design at the farm of Agricultural Research Station (Dr. PDKV), Yavatmal. On the basis of spacing, plants were transplanted at two row spacing *viz.*, 30 cm and 45 cm and in row three plant to plant spacing *viz.*, 10 cm, 20 cm and 30 cm with one separate 45 cm x 45 cm wider spacing plot with three replications. The result indicated that closer plant spacing had significantly increased plant height however, wider plant spacings significantly increased plant spread, number of leaves and weight of beet root. Further the closer plant spacing found significantly higher marketable quality beet root yield with highest net monetary returns.

Key words : Plant spacing, Yield, *Beta vulgaris*, Growth, Productivity, NMR

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INTRODUCTION

Beet root or garden beet (*Beta vulgaris* L.) is an important root vegetable crop belonging to the family Chenopodiaceae. It is indigenous to Southern Europe (Campbell, 1979). Beet root is a vegetable crop grown mainly for its fleshy enlarged roots in almost all the states in India but not as common as reddish and carrot. Beets are one of the few vegetables whose roots and tops are both consumed as food. Beets are a good source of folate, manganese, sodium and potassium. They also provide vitamin C, magnesium, iron, copper and phosphorus. The recent interest of people in beet root cultivation increases has been primarily driven by the discovery that sources of dietary nitrate may have important implications for managing cardiovascular health (Lundberg *et al.*, 2008). It has provided compelling evidence that beet root ingestion offers beneficial physiological effects that may translate to improved clinical outcomes for several pathologies, such as; hypertension, atherosclerosis, type 2 diabetes and dementia (Vanhatalo *et al*., 2010 and Ninfali and Angelino, 2013). Now-a-day, it is becoming popular as salad crop in Indian daily diet. As a cool weather crop, it grows well in winter with bit warm climate in the plains of India. Besides that it is a short duration seasonal crop having yield potential, so used widely in food industry with the minimum cost of cultivation and good storability ensures viability of fresh product year around.

Even though cultivation of beet root remains neglected by the farming community of the leading vegetable producing country of the world like India which present cultivation of beet root occupies an area of 5000 hectares with an annual production of 90000 tonnes

(Anonymous, 2001). It happens due to one or more reasons and the major one is lack of awareness about scientific production as well as cultivation technology for beet root production under varying climatic condition is still not recommended. So the crop having very minimum cost of cultivation which gives bumper production with higher market value *i.e.* beet root remains neglected. Hence, to standardize package of practices for beet root cultivation in Vidarbha region an experiment to find out optimum spacing for higher yield of marketable beet root was undertaken.

RESEARCH METHODOLOGY

A field experiment was conducted for three consecutive winter seasons of December, 2009, 2010 and 2011 in the farm of Agriculture Research Station, Yavatmal (MH). The experiment was laid out in Randomised Block Design with seven treatments with three replications. The variety BJ (Bejo) beet was used for the experiment and sown at various spacing *viz.,* two row spacings 30 cm and 45 cm with plant to plant spacings 10 cm, 20 cm and 30 cm and one wider spacing 45 cm x 45 cm were tested each year. The land was well prepared and formed ridges for seed sowing. The seeds were sown manually on the shoulder of the ridges during the season.

All recommended agronomic practices *i.e.* disc ploughing, two harrowing, levelling and formation of ridges and furrows were followed for beet root sowing. A basal dose of 40 kg N, 40 kg P_2O_5 was applied in furrows through single super phosphate and urea followed by top dressing of 40 kg N 30 days after sowing. Irrigation was given to the crop as per requirement at 7 to 10 days interval. Manual hand weeding was done four weeks after sowing during the three seasons.

Observations were recorded when plants showed signs of maturity, which is indicated by leaf yellowing and partial drying of lower leaves by randomly uprooting five plants per inner two ridges of plot to determine fresh weight of shoot and beet root. Simultaneously observations on beet root diameter, marketable yield per plot and yield per hector were undertaken. Cost of cultivation were calculated and determined the net monetary returns and Benefit : Cost ratio for yield obtained from varying plant spacing treatments. Statistical analysis was applied appropriate for the Randomized Block Design, Gomez and Gomez (1984). For the analysis the grades were followed to categorize the marketable yield of beet root as proposed by Kikkert *et al.* (2010). As per this study only size 2 roots were considered marketable. Size o and size 1 are undersize however, size 3 was considered oversized. The proposed scale is as follows :

Size 0 : <3/4 inches in diameter
Size 1: 1.87 cm – 4.05 cm or ¾ to 1 5/8 inch in diameter
Size 2 : 4.05 to 6.25 cm or 1 5/8 – 2 ½ inch in diameter
Size 3 : >6.25 cm or 2 ½ inches in diameter.

RESEARCH FINDINGS AND ANALYSIS

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Growth factors :

Plant height :

Effect of plant spacings on plant height of beet root is illustrated in Table 1. Plant height was recorded significantly higher in the treatment where plant sown on closer spacing *i.e.* 30 cm x 10 cm and 30 cm x 20 cm (41.17 cm and 39.99 cm, respectively), however, no similar references observed. Similarly plant spread was also found significantly increased with wider spacing treatments. Higher the plant density decreased the plant spread.

Plant spread and number of leaves :

Wider plant spacing significantly increased the plant spread and number of leaves *i.e.* 38.66 cm and 22.12 leaves in 45 cm x 45 cm spacing followed by 36.48 cm and 20.09 leaves in 45 cm x 30 cm spacing, revealed from Table 1. The closer spacing 30 cm x 10 cm recorded minimum *i.e.* 22.69 cm plant spread and 15.29 leaves. These observations are supported with the findings of Kogali *et al.,* 2012. The highest number of leaves were recorded in the treatment where plants spaced at 45 x 45 cm. Number of leaves found gradually decreasing with the decrease in plant spacings.

Harvesting of beet root:

Varying plant spacing treatments affect significantly on the harvesting time of beet root revealed in Table 2. Plants from treatment T_7 *i.e.* 45 cm x 45 cm spacings, came to harvest early. It may be due to in wider spacings,

distant the plant spacing accumulates less plants per unit area, facilitate more space and feasible nutrient with more light exposure to plants results in early maturity and comes to harvest early as compared to closer spacings where higher plant density gets less space and nutrients with less light exposure delays the crop maturity.

Diameter of the beet root :

Data from Table 2 indicated that, plant spacings have a significant effect on the diameter of beet root. Higher

Table 1 : Effect of spacing on growth parameters of beet root

Sr. No.	Treatments	Height of plant (cm)			Pooled mean	Plant spread (cm)			Pooled mean	No. of leaves			Pooled mean
		2009-10	2010-11	2011-12		2009-10	2010-11	2011-12		2009-10	2010-11	2011-12	
1.	30 x 10 cm	40.56	42.76	40.20	41.17	30.63	19.20	18.24	22.69	13.27	16.80	15.80	15.29
2.	30 x 20 cm	39.85	40.56	39.55	39.99	33.50	25.00	22.20	26.90	14.61	20.60	17.40	17.54
3.	30 x 30 cm	32.70	36.64	35.39	34.91	35.00	22.20	25.68	27.63	17.19	17.80	16.60	17.20
4.	45 x 10 cm	35.57	38.82	37.38	37.26	40.64	22.50	22.56	28.57	15.17	19.40	17.00	17.19
5.	45 x 20 cm	34.32	38.10	36.00	36.14	43.22	26.50	26.10	31.94	16.59	21.40	21.20	19.73
6.	45 x 30 cm	38.60	35.57	33.75	35.97	45.08	32.60	31.75	36.48	15.07	23.20	22.00	20.09
7.	45 x 45 cm	38.82	33.75	32.70	35.09	46.33	35.00	34.64	38.66	17.97	25.00	23.40	22.12
	F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
	S.E. (M)	1.66	1.69	2.24	1.28	2.36	1.43	1.63	0.86	0.89	1.28	1.25	0.77
	C.D. ±	5.11	5.21	6.91	3.94	7.29	4.41	5.03	2.65	2.75	3.95	3.85	2.36
	C.V.	7.71	7.70	10.66	10.30	10.49	9.48	10.92	8.50	9.86	10.08	11.35	12.47

Table 2 : Effect of spacing on maturity, root diameter and marketable yield of beet root (g)

Sr. No.	Treatments	Days required for harvesting			Pooled mean	Diameter of beet root (g)			Pooled mean	Yield per ha. (t)			Pooled mean
		2009-10	2010-11	2011-12		2009-10	2010-11	2011-12		2009-10	2010-11	2011-12	
1.	30 x 10 cm	91.98	88.47	89.92	90.12	4.57	5.30	5.80	5.22	22.69	37.26	27.97	29.30
2.	30 x 20 cm	89.25	86.60	85.56	87.14	7.20	7.00	6.66	6.95	22.44	36.77	24.29	27.83
3.	30 x 30 cm	82.68	79.60	78.84	80.37	6.87	6.80	5.25	6.31	13.22	23.52	26.55	21.10
4.	45 x 10 cm	83.67	82.60	80.20	82.16	5.12	6.50	5.20	5.61	20.47	19.17	14.92	18.19
5.	45 x 20 cm	84.38	84.00	82.62	83.67	6.87	7.37	7.26	7.17	11.06	22.83	19.16	17.68
6.	45 x 30 cm	73.49	75.73	75.78	75.00	7.32	7.30	6.85	7.16	10.88	19.63	14.86	15.12
7.	45 x 45 cm	70.89	72.20	72.40	71.83	7.57	7.50	7.30	7.46	8.40	13.83	10.04	10.75
	F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
	S.E. (M)	4.38	3.33	3.32	2.92	0.67	0.41	0.43	0.37	1.25	1.94	1.45	1.95
	C.D. ±	13.49	10.27	10.23	8.99	2.07	1.28	1.33	1.31	3.84	5.99	4.47	5.99
	C.V.	9.2	7.10	7.12	10.74	17.94	10.53	9.67	7.92	11.31	11.13	10.43	13.79

Table 3 : Table showing cost of cultivation and B:C ratio of different spacing treatments on beet production

Treatments	Yield (t/ha)	Cost A (Rs.)	Cost B (Rs.)	Cost of cultivation /cost C (Rs.)	GR (Rs.) @ (Rs.10000/t)	Net profit (Rs.)	B:C ratio
30 x 10 cm	29.30	86460.28	135293.61	136973.61	293000	156026.39	2.14
30 x 20 cm	27.83	84509.88	130893.21	132573.21	278300	145726.79	2.10
30 x 30 cm	21.10	80439.48	115606.14	117286.14	211000	93713.86	1.80
45 x 10 cm	18.19	83449.88	113766.54	115446.54	181900	66453.46	1.58
45 x 20 cm	17.41	80439.48	109906.14	111586.14	176800	65213.86	1.58
45 x 30 cm	15.12	76793.08	101993.08	103673.08	151200	47526.92	1.46
45 x45 cm control	10.75	72892.28	90808.94	92488.94	510700	15011.06	1.16

*cost of beet root Rs.10000/t

beet root diameter 7.46 cm was recorded in treatment 45 cm x 45 cm plant spacing. In wider plant spacing greater beet root diameter and in closer plant spacings smaller the beet root diameter was recorded. However, beet root with optimum diameter *i.e.* marketable size diameter was obtained in the treatment 30 cm x 10 cm and 45 cm x 10 cm. Therefore, rather than row to row planting distance, plant to plant spacings have more effect on the size of beet root.

The significant increase in the diameter of beet root obtained in wider plant spacings treatments also obtained by Basha (1998) in fodder beet and sugar beet cultivars. It might be due to wider spacings gave more space to roots to grow horizontally and its roots diameter was bigger than the closer planted beet root as reported by Basal *et al.* (2002) working on fodder beet.

Yield of beet root :

Different plant spacings illustrated the effect on marketable yield of beet root shown in Table 3. Marketable yield of beet root was found significantly greater under closer plant spacings. Higher marketable yield of beet root was obtained in the treatment where plants were spaced at 30 cm x 10 cm distance followed by 30 cm x 20 cm distance. This might be due to accumulation of greater number of plants compared to wider spacing, which resulted in higher yield. Closer plant to plant spacings 10 cm followed by 20 cm gave significantly higher yield. The results are in agreement with the findings of Augustinussen (1974) and Kamel *et al.* (1990).

Monetary returns :

Significant difference in the net monetary returns obtained from the beet root yield under varying plant spacings (Table 3). Less number of plants per unit area was observed in wider plant spacings. Even though having higher beet root weigh but due to less number of plants per unit area harvest less quantum of yield and hence gains less net monetary returns and benefit cost ration (B:C ratio). The highest NMR and B:C ratio were obtained in the treatment where seeds were sown at 30 cm x 10 cm spacings with harvesting quality marketable yield.

Conclusion :

Varying plant spacings have significant influence on growth and yield attributes of beet root. Growth parameter *viz.*, plant height, plant spread, number of leaves was found to be increased in closer planting distances (30 cm x10 cm) as compared to the other spacing treatments. Closer the plant spacing delays the maturity. However, wider spaced plants came to harvest earlier as compared to close planted beet root. Under wide spacing treatments beet root diameter was increased but marketable size beet root found under plant spacing 30 cm x 10 cm and 45 cm x 10 cm plant spacing treatments. Higher marketable yield of beet root, net monetary return and benefit : cost were obtained under 30 cm x 10 cm plant spacings.

Overall, it was found that, rather than row spacings, plant to plant spacings have more significant influence on growth, quality and yield of beet root. Therefore, it is recommended that, to get market quality higher yield of beet root for higher monetary returns, beet root may sown at 30 cm x 10 cm plant spacing.

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