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Effect of plant density on growth and yield of sweet potato [*Ipomoea batatas* (L.) Lam.] Cv. Bhu Kanti

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Abstract
The experiment was conducted at AICRP on Tuber Crops, Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat during *Rabi*, 2019-20. The set of treatments consists of six different vine densities *viz.* S_1: 1,11,111 vines ha^{-1} (spacing: 60 cm × 15 cm), S_2: 83,333 vines ha^{-1} (spacing: 60 cm × 20 cm), S_3: 55,555 vines ha^{-1} (spacing: 60 cm × 30 cm), S_4: 1,48,148 vines ha^{-1} (spacing: 45 cm × 15 cm), S_5: 1,11,111 vines ha^{-1} (spacing: 45 cm × 20 cm) and S_6: 74,074 vines ha^{-1} (spacing: 45 cm × 30 cm). The experiment was laid out in Randomized Block Design (RBD) and the whole set of treatments was replicated four times. The results revealed that effect of vine density was found significant and maximum vine length (59.65 cm) at 30 days after transplanting (DATP) was recorded from the density of 83,333 vines ha^{-1} (S_2) whereas, at harvest it was found maximum (138.70 cm) in density of 55,555 vines ha^{-1} (S_3). Same density (S_3) recorded maximum no. of leaves at 30 DATP (72.95) and at harvest (104.20). Maximum tuber girth (14.11 cm), tuber length (17.35 cm), average tuber weight (149.25 g), fresh weight of tubers (562 g vine^{-1}) and marketable tuber yield (18.04 t ha^{-1}) were obtained from the lowest density of 55,555 vine ha^{-1} (S_3). Maximum no. of tubers (4.45 vine^{-1}) and total tuber yield (23.82 t ha^{-1}) were obtained from the density of 1,11,111 vines ha^{-1} (S_1). The highest benefit: cost ratio (1.37) was recorded with the lowest density (S_3).

Keywords: Sweet potato, Bhu Kanti, density, spacing

Introduction

Sweet potato [*Ipomoea batatas* (L.) Lam.] belongs to family convolvulaceae. It is popularly known as "*Sakar Kand*" in India. It is originated in South America and spread to other parts of the world. It is widely cultivated as an annual in the tropics and the sub-tropics. This crop is cultivated in large area worldwide as an alternative crop to supply food due to its high productivity and nutritive value. Both the root and the leaves can be used as food for human being as well as cattle.

Asia is the largest producer of sweet potato having 92% of production and 80% of the world area. China and India are the leading sweet potato growing countries in the world. In India, the area under sweet potato cultivation was 1,15,000 ha with production of 11,75,000 MT tubers indicating productivity of 10.11 t ha^{-1} (Anon., 2019) [2]. Uttar Pradesh, Bihar, Tamil Nadu, Odisha, Kerala, Karnataka, West Bengal, Madhya Pradesh, Assam, Maharashtra and Gujarat are the leading states for sweet potato cultivation. In Gujarat it is commercially cultivated in the districts of Mehsana, Ahmedabad, Kheda, Anand, Surat, Tapi, The Dangs, Valsad and Navsari.

In cultivation of sweet potato, vine population is one of the most important factors affecting its growth, development and yield (Sarkar, 1985) [10]. In sweet potato, number of research findings revealed that increasing planting space increased marketable tuber yield or decreasing planting space increased undersized tubers, which tends to create a market problem and ultimately decrease the profitability of the farmers. Increasing the density may increases the yield in three ways. First, the green leaves will cover the soil earlier and will absorb more sunlight and lead to more assimilation in addition to less weed population / growth. Second, few lateral shoots will grow and the third is that the growth of tubers will start earlier. Wider spacing not only leads to excessive vegetative growth but also accelerates the evaporative losses of water from the bare ground. On the other hand, the struggle for existence increases with increasing plant population because of severe competition for light, water and nutrients (Sharma, 1990) [11].

The sweet potato variety "Bhu Kanti" is an exotic material introduced by Regional Centre, Central Tuber Crops Research Institute, Bhubaneswar, Odisha. This exotic material was endorsed in the year 2017 by AICRP on Tuber Crops, Navsari Agricultural University, Navsari, Gujarat. The tubers of this variety are long and having off white to light yellow skin with orange colour flesh, indicating that it is rich in β-carotene and it has a high yield potential in the region.

As discussed earlier, evaluation of different densities and cultivars is pertinent to improve the production and productivity, this experiment was planned.

Materials and Methods

The experiment was conducted at Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, during *Rabi* 2019-20 with six treatments and four replications, laid out in Randomized Block Design (RBD). The set of treatments consists of six different vine densities *viz.* S_1: 1,11,111 vines ha^{-1} (spacing: 60 cm × 15 cm), S_2: 83,333 vines ha^{-1} (spacing: 60 cm × 20 cm), S_3: 55,555 vines ha^{-1} (spacing: 60 cm × 30 cm), S_4: 1,48,148 vines ha^{-1} (spacing: 45 cm × 15 cm), S_5: 1,11,111 vines ha^{-1} (spacing: 45 cm × 20 cm) and S_6: 74,074 vines ha^{-1} (spacing: 45 cm × 30cm). The site of experimental plot had good drainage as well as moderate water holding capacity and reasonably suitable for sweet potato cultivation. Approximately 15 to 20 cm long vine cuttings of cv. Bhu Kanti were used for this experiment. Vine cuttings were treated by dipping them in chlorpyrifos @ 1 ml l^{-1} for 10 minutes before planting. Vine cuttings were planted by keeping approximately 2 nodes beneath the soil surface and two nodes above the soil surface on 22nd November, 2019. Transplanting was done according to spacing of different treatments in pre irrigated wet soil. Irrigation was applied in each plot immediately after transplanting. After a week, gap filling was done accompanied with light irrigation for maintaining uniform plant stand. Well rotten farmyard manure was applied at the rate of 15 t ha^{-1} uniformly and incorporated into the soil at the time of land preparation. The chemical fertilizers were applied as per recommended dose of 75:50:75 NPK kg ha^{-1}. Half dose of nitrogen and potassium and full dose of phosphorus was applied as a basal dose at the time of transplanting. Remaining dose of nitrogen and potassium were split into two equal doses and applied at 30 and 60 DATP. Statistical analysis was done as per the methods described by Panse and Sukhatme (1985) [9].

Results and Discussion

The data presented in Table 1 illustrates that the lowest vine density S_3 (55,555 vines ha^{-1}) influenced growth parameters and produced the longest vines (138.70 cm) at the time of harvest. Same treatment produced maximum number of leaves at 30 DATP and at the time of harvest (72.95 and 104.20 leaves $vine^{-1}$, respectively) but remained at par with S_2 (83,333 vines ha^{-1}) density at 30 DATP whereas, at the time of harvest it remained at par with S_5 and S_1 densities having 1,11,111 vines ha^{-1}. This might be due to wider spacing that helped the individual vine to utilize more water, nutrient, light and air, as the competition was less. The findings of present study were agreed with the work carried out by Somda and Kays (1990) [12], Idoko *et al.* (2017) [6] and Koodi *et al.* (2017) [7]. However, maximum vine length (59.65 cm) at 30 DATP was recorded with S_2 (83,333 vines ha^{-1}) density. Minimum vine length (49.45 cm) at 30 DATP and number of leaves $vine^{-1}$ (46.35) were obtained with S_4 (1,48,148 vines ha^{-1}) density whereas, both these characters recorded minimum values (109.50 leaves $vine^{-1}$ and 80.35 cm vine length, respectively) at the time of harvest with S_2 density. In closer spacing, the plant population per unit area was higher, which led to keen competition among the vines for previously mentioned natural resources, resulting in poor growth. The results are in conformity with the findings of Lencha *et al.* (2016) [8], Ahmed *et al.* (2000) [1] and Essilfie *et al.* (2016) [4].

The lowest density S_3 (55,555 vine ha^{-1}) recorded maximum tuber girth (14.11 cm) but remained at par with S_6, S_5, S_2 and S_1 densities. Same density also recorded maximum tuber length (17.85 cm) but the difference between treatments found non-significant. As a result of maximum tuber girth and length, average tuber weight (149.25 g) was also found maximum with S_3 density which was remained at par with S_6 density. Thought the maximum number of tubers (4.45) $vine^{-1}$ was recorded in S_1 density, it remained at par with the number of tubers produced by S_3, S_2 and S_4 densities. The data on tuber girth, length and average weight showed cumulative effect on fresh weight of tubers $vine^{-1}$ and maximum fresh weight of tubers (562 g $vine^{-1}$) was recorded with S_3 density which was remained at par with S_6, S_2 and S_1 densities. Though the maximum total tuber yield (23.82 t ha^{-1}) was recorded by S_1 density, significantly the highest marketable tuber yield (18.04 t ha^{-1}) was obtained under S_3 density over all other densities tested.

As mentioned above, the maximum tuber yield was recorded under S_1 (1,11,111 vines ha^{-1}) density, consist more population per unit area compared to S_3 density, which might not provides enough space to develop tubers and as a result the tubers produced in this density remained thin and short and could not attained marketable size. On the other hand, S_3 density consist of minimum population per unit area which may allows efficient utilization of light to produce maximum assimilates as this density also produced maximum number of leaves. Moreover, less competition for nutrients, space and water also plays an important role for higher production. Apart from these, maximum tuber girth and average tuber weight may be the result of maximum and uninterrupted movement of assimilates to sink, which ultimately helps to increase marketable tuber yield. The finding is the same with that of Farooque *et al*. (1983) [5], Sarkar (1985) [10] and Bianco (1975) [3].

Table 2 (a, b and c) reflects the economics of different densities studied and found profound influence on gross income, net income and benefit:cost ratio. The highest gross return (₹ 3,60,800), net return (₹ 2,08,628) and BCR (1.37) were obtained with S_3 (55,555 vines ha^{-1}) density. This is mainly due to the lowest cost of planting material and the highest marketable tuber yield (18.04 t ha^{-1}) obtained in this density.

Table 1: Effect of vine density on growth and yield parameters

Densities (vines ha^{-1}) / Spacing	Vine length (cm)		Number of leaves vine^{-1}		Tuber girth (cm)	Tuber length (cm)	Number of tubers vine^{-1}	Fresh weight of tubers vine^{-1} (g)	Average tuber weight (g)	Total tuber yield (t ha^{-1})	Marketable tuber yield (t ha^{-1})	Harvest index (%)
	30 DATP	At the time of harvest	30 DATP	At the time of harvest								
S_1 - 1,11,111 (60 cm × 15 cm)	53.40	113.15	52.90	92.60	12.90	17.48	4.45	488	119.75	23.82	15.67	40.11
S_2 - 83,333 (60 cm × 20 cm)	59.65	109.50	72.60	80.35	13.10	17.21	4.05	495	122.75	20.52	14.33	35.19
S_3 - 55,555 (60 cm × 30 cm)	52.25	138.70	72.95	104.20	14.11	17.85	4.30	562	149.25	18.12	18.04	33.92
S_4 - 1,48,148 (45 cm × 15 cm)	49.45	111.95	46.35	83.00	11.45	17.10	3.95	433	105.25	21.50	12.57	39.98
S_5 - 1,11,111 (45 cm × 20 cm)	53.20	119.15	60.70	96.20	13.14	17.10	3.60	480	114.50	18.97	12.89	34.08
S_6 - 74,074 (45 cm × 30 cm)	54.65	119.05	61.60	88.50	13.24	17.75	3.80	515	129.50	18.44	12.23	33.95
S.Em. ±	1.77	5.66	3.66	4.43	0.46	0.60	0.17	24.59	8.76	1.17	0.75	1.49
C.D. at 5%	5.35	17.04	11.02	13.35	1.39	NS	0.51	74.12	26.41	3.53	2.26	4.49
C.V.%	6.60	9.54	11.95	9.76	7.12	6.84	8.39	9.93	14.19	11.59	10.48	8.22

Table 2(a): Economics of different treatments (₹ ha^{-1})

Densities (vines ha^{-1}) / Spacing	Marketable tuber yield (t ha^{-1})	*Cost A (₹)	**Cost B (₹)	***Cost C (₹)	Gross profit (₹)	Net profit (₹)	BCR
S_1 - 1,11,111 (60 cm × 15 cm)	15.67	174733	43571	218304	313400	95096	0.44
S_2 - 83,333 (60 cm × 20 cm)	14.33	141615	38573	180188	286600	106412	0.59
S_3 - 55,555 (60 cm × 30 cm)	18.04	108497	43675	152172	360800	208628	1.37
S_4 - 1,48,148 (45 cm × 15 cm)	12.57	218949	40466	259415	251400	-8015	-0.03
S_5 - 1,11,111 (45 cm × 20 cm)	12.89	174733	38011	212744	257800	45056	0.21
S_6 - 74,074 (45 cm × 30 cm)	12.23	130517	33596	164113	244600	80487	0.49

***Cost A:** Total treatment cost (Fixed + Variable); ****Cost B:** 10% land revenue of yield appraisal + 7% interest on capital; *****Cost C:** Cost A + cost B

Table 2(b): Treatment wise variable cost, fixed cost and total cost

Treatments	No. and cost (₹) of cuttings	Planting Cost (₹)	Harvesting Cost (₹)	Total of variable cost (₹) (2 + 3 + 4)	Fixed cost (₹)	Cost A (₹) (5 + 6)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
S_1	111111	7120	14240	132471	42262	174733
S_2	83333	5340	10680	99353	42262	141615
S_3	55555	3560	7120	66235	42262	108497
S_4	148148	9493	19046	176687	42262	218949
S_5	111111	7120	14240	132471	42262	174733
S_6	74074	4747	9434	88255	42262	130517

Table 2(c): Particulars of economics

Particulars	Details/Cost	Particulars	Details/Cost
Ploughing	₹ 400 hr^{-1}	Pendimethalin	₹ 350 l^{-1}
Harrowing	₹ 300 hr^{-1}	Chlorpyrifos	₹ 330 l^{-1}
FYM	₹ 450 ton^{-1}	Cutting cost	₹1.00 cutting^{-1}
Urea	₹ 267 45 kg^{-1}	Labour wages	₹178 day^{-1} (8 hrs.)
SSP	₹ 395 50 kg^{-1}	Planting cost of control treatment (S_2)	₹ 5340 ha^{-1} (30 labours)
MOP	₹ 950 50 kg^{-1}	Harvesting cost of control treatment (S_2)	₹ 10,680 ha^{-1} (60 labours)
Irrigation	₹ 30 hr^{-1}	Selling price of tubers	₹ 20.00 kg^{-1}

Conclusions

The results of the study inferred that effect of different densities had significant influenced on growth and yield parameters. The S_3 density (55,555 vines ha^{-1}) obtained maximum vine length (138.70 cm) at harvest, no. of leaves at both growth stages *i. e.* 30 DATP (72.95) and at harvest (104.20). Tuber girth (14.11 cm), average tuber weight (149.25 g), fresh weight of tubers (562 gvine^{-1}), marketable tuber yield (18.04 t ha^{-1}) and the highest benefit: Cost ratio (1.37) were also recorded maximum in same density. From the above enumeration and on the basis of economics, inference can be drawn that population of 55,555 vines ha^{-1} largely improves yield and economics of sweet potato cv. Bhu Kanti.

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