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Appraisal of lesser yam (*Dioscorea esculenta* L.) tuber yield partitioning and economics under different crop geometry south Konkan coastal region

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Abstract
Different species of yam are grown around the world especially in tropical region of Africa and Asia. Lesser yam (*Dioscorea esculenta* L.) is one of the important yam species cultivated in Konkan region of Maharashtra. Field experiments were conducted at Central Experiment Station, Wakawali, Dapoli (M.S.) for three years from 2011-12 to 2013-14 to investigate the effect of different crop geometry on productivity and profitability of lesser yam. The treatment consisted of 6 crop geometry *viz.*, S_1 - 90 x 90 cm, S_2 - 90 x 60 cm, S_3 - 90 x 30 cm, S_4 - 60 x 60 cm, S_5 - 60 x 45 cm and S_6 - 60 x 30 cm. The release variety "*Konkan Kanchan*" was used in this experiment. An uniform tuber size 100-150 g was planted on ridges and furrow method on ridges at per different spacing treatment. The recommended NPK @ 80: 60: 80 Kg. ha^{-1} was uniformly applied to all the spacing treatments. The pooled mean of three year indicated that the highest total tuber yield 31.29 t ha^{-1} was recorded by the spacing 60 x 30 cm, which was substantially and significantly superior over rest of the spacing. As regards the partitioning of tuber yield, the spacing of 90 x 30 cm produced significantly the highest bold size (> 200 g) tuber yield (8.43 t ha^{-1}). However, 60 x 30 cm spacing treatment recorded significantly highest the medium (100-200 g), small (50-100 g) and very small (< 50g) category of tubers. The wider spacing 90 x 90 cm reported maximum tuber yield per plant (1.106kg) and average tuber weight (121.71 g). The economics of different spacing treatment was revealed that the spacing 90 x 30 cm realized the highest net returns of Rs. 3,66,619/- ha^{-1} and C:B ratio of 1: 2.21 in lesser yam.

Keywords: Lesser yam, crop geometry, tuber yield, partitioning, economics

Introduction
Tropical tuber crops, including cassava, sweet potato, yams (greater yam, white yam and lesser yam), and aroids (elephant foot yam, taro and tannia) form the most important staple for over one billion people in the developing world. Tuber crops are the third most important food crops of man after cereals and grain legumes. It is estimated that tuber crops provide about 6% of the world's dietary energy, apart from being good sources of β − carotene, anti-oxidants, dietary fibre and minerals (Suja and Nesunchezhiyan, 2018). Yam plants are members of genus *Dioscorea*. The world distribution of *Dioscorea* is about 850 species, out of which about 50 species are found in India (Anon., 1952) [1] but only greater yam, lesser yam, aerial yam and white yam are important cultivated species (George and Sunitha, 2018). Lesser yam (*Dioscorea esculenta* L.) is the most important commercially cultivated species cultivated throughout the tropics but its production is mainly in South Eastern Asia. The tuber is the main economically utilized part of the lesser yam. The tubers are small and characteristically born in clusters by each plant, unlike most other yams. Each plant produces 5 to 20 tubers. Each tuber is almost cylindrical, with rounded ends (Onwueme, 1978) [10]. It is an important tuber crop cultivated in *Konkan* region of Maharashtra during *Kharif* season in well drained soil or on sloppy land. This yam is known as Kangar or Kate kanke in vulnerable language in Konkan region. It is rich in carbohydrates and other nutritional compounds (Mhaskar *et al.*, 2015) [9]. There are various factors that influence the tuber yield and its size in lesser yam. Among them adoption of suitable crop geometry have been played an important role. Since, this crop is considered as a minor tuber crops in Konkan region, there is scarcity of information on the agro-techniques for lesser yam production. The productivity influenced by different agro techniques. Among agronomic practices crop geometry influences the growth and yield of crop. The level of plant population should be such that maximum solar radiation is intercepted. Farmers in this region cultivated this crop in backyards or on marginal land without any standard spacing.

Most of the tribal and marginal farmers adopted their own packages in this region. So they are gaining low yield. Study on crop geometry has to be standardized to get higher production and productivity. In this context, the present experiment was conducted to work out the crop geometry of lesser yam for higher production and productivity under *Konkan* region of Maharashtra.

Materials and methods

To standardize crop geometry in lesser yam, a field experiment was conducted at Central Experiment Station, Wakawali, Dapoli, Maharashtra for three consecutive years during 2011-12 to 2013-14. The site of experimental site was lateritic in nature having acidic soil reaction (5.5). The soil of the experimental field was sandy clay loam in texture and rated as low for available N (188.16 Kg ha^{-1}), available P (9.52 Kg ha^{-1}) and available K (297.54 kg ha^{-1}). The climate of the region is characterized by warm and humid with mean annual rainfall of 3500 mm. The experiment was laid out in randomized block design (RBD) with four replications. The plot size was 3.6 m x 1.8 m. The experiment consisted of 6 crop geometry treatments consisting S_1 - 90 x 90 cm (12345 plants ha^{-1}), S_2 - 90 x 60 cm (18518 plants ha^{-1}), S_3 - 90 x 30 cm (37037 plants ha^{-1}), S_4 - 60 x 60 cm (27777 plants ha^{-1}), S_5 - 60 x 45 cm (37037 plants ha^{-1}) and S_6 - 60 x 30 cm (55555 plants ha^{-1}). Variety "*Konkan Kanchan*" released by AICRP on Tuber Crops, Dapoli Centre (M.S.) was used in this experiment (George *et al.*, 2012) [6].

The tuber size 100-150 g was planted in pits reformed into ridges and furrow method on ridges at per different spacing treatment. Well decomposed FYM @ 10 t ha^{-1} was applied. The recommended NPK @ 80: 60: 80 Kg. ha^{-1} was uniformly applied to all the spacing treatments. Full dose of Phosphorus and half dose of nitrogen and potassium was applied as basal at the time of planting. The remaining half dose of nitrogen and potassium were applied at 60 days after planting. Fertilizer type, rate, its application, seed tuber size, seed rate, variety were similar in each spacing treatment in all the years under study. The other recommended package of practices was duly followed same to all the treatments.

The yield attributes and yield were recorded at the time of harvest. The tubers was partitioning according to their weight into four categories *viz.,* very small (< 50 g), small (50 - 100 g), medium (100 – 200 g) and bold (> 200 g). Out of this, marketable and unmarketable tubers are divided by means of the tuber weight of > 50 g are marketable size and < 50 g are unmarketable size. The economics was computed on the basis of prevailing market rates of produce and agro inputs. The data collected were subjected to analysis of variance appropriatly to the design. Comparison of treatment means for significance at 5% was done using the critical difference (C.D.) as suggested by Gomez and Gomez (1984) [7].

Result and Discussion

Yield attributes and Tuber yield

It is clear from the table 1 that the yield attributes *viz.,* tuber yield per plant, average tuber weight and dry weight of vine were statistically significant. However, the length and girth of tuber did not differ significantly due to different spacing treatment. These results are on par with the findings of Onwueme (1978) [10]. The wider spacing 90 x 90 cm reported maximum tuber yield per plant (1.106 kg) and average tuber weight (121.71 g) which was significantly superior over rest of the treatment. The same yield attributes was reported lowest by close spacing 60 x 30 cm. The full yield potential of individual plant is achieved when sown at wider spacing. When sown densely, competition among plants is more for growth factors resulting in reduction in size and yield of the plant. Yield per plant is decreased gradually as plant population per unit area is increased (Reddy and Reddy, 2003) [13]. George (2000) [5] reported that closer spacing reduces the average weight of tubers in yam. As regards the dry vine yield per ha, the highest plant density of 60 x 30 cm produced significantly the highest dry vine yield of 2.48 t ha^{-1}. Reddy and Reddy, (2003) [13] pointed out that dry matter production per unit land area increased with increase in plant population. The average length of tuber ranges from 13.16 cm to 14.13 cm while average girth was 12.35 cm to 13.04 cm.

The pooled mean of three consecutive years (2011-12 to 2013-14) indicated that the highest tuber yield 31.29 t ha^{-1} was recorded by the close spacing treatment 60 x 30 cm, which was substantially and significantly superior over rest of the spacing (Table 1). This might be due to highest plant density per unit area. The lowest tuber yield of 13.66 t ha^{-1} was recorded by 90 x 90 cm. CTCRI (1992) reported similar results in African yam and observed that closer spacing recording the highest yield while wider spacing gave significantly lower yield. The results are in conformity to those given by George (1991) [4]. The increase in tuber yield over 60 x 60 cm spacing by 60 x 30 cm, 60 x 45 cm, 90 x 30 cm, 90 x 60 cm and 90 x 90 cm spacing treatments to the tune of 43.98%, 17.19%, 27.60%, -6.43% and -35.51%, respectively.

Partitioning tuber yield

Yield of the crop is the result of plant population. Spacing influenced the plant population per unit area. As the plant population differs, it resulted on size of the tuber. The average of three years pooled tuber data was partitioning in to four category and results was depicted in Table 2. The spacing treatment of 90 x 30 cm produced significantly the highest bold size (> 200 g) tuber yield (8.43 t ha^{-1}) over rest of the spacing except 60 x 45 cm spacing. Both the former treatments were on par. With regards the medium (100-200 g), small (50-100 g) and very small (< 50 g) category of tubers, the spacing treatment 60 x 30 cm recorded significantly highest tuber yield. The total tuber yield was also significantly influenced by different plant density and the same close spacing (60 x 30 cm) resulted significantly the highest tuber yield of 31.29 t ha^{-1} over remaining plant densities followed by 90 x 30 cm (27.17 t ha^{-1}).

Marketable and unmarketable tuber yield

The data pertaining to the marketable and unmarketable tuber yield of lesser yam and their percentage as influenced by spacing treatment are presented in Table 3. Data showed that the marketable and unmarketable tuber yield was statistically significant. The spacing 60 x 30 cm produced the maximum marketable and unmarketable tuber yield of 28.22 t ha^{-1} and 3.07 t ha^{-1}, respectively over pooled data. However, the per cent marketable tube yield numerically highest in spacing 90 x 60 cm followed by 90 x 90 cm and 90 x 30 cm. In general, the marketable tuber yield percentage was in the range of 90.08% to 93.78%. In respect of unmarketable tuber yield percentage, the spacing 60 x 30 cm reported numerically highest value of 9.92%. However, the lowest unmarketable tuber yield percentage was in 90 x 60 cm spacing. The range of unmarketable tuber yield percentage was 6.22% to 9.92%. Similar results were reported by Ravindran and George (1989) [12] and Palaniswami and Shirly (2006) [11].

Economics

It is seen from the data presented in Table 4 that, the highest pooled marketable tuber yield was recorded by closer spacing of 60 x 30 cm (28.22 t ha^{-1}) followed by 90 x 30 cm (25.01 t ha^{-1}). The economics of different spacing treatment was evaluated at cost C level and revealed that the spacing 90 x 30 cm realized the highest net returns of Rs. 3,66,619/- ha^{-1} followed by the spacing of 60 x 30 (Rs. 3,38,590/-). However, the C:B ratio of 1: 2.21 was highest in spacing of 90 x 60 cm in lesser yam.

Table 1: Effect of spacing on yield attributes and tuber yield of lesser yam (pooled Mean)

Tr. No.	Spacing (cm)	Yield attributes					Tuber yield (t ha^{-1})	
		Tuber yield per plant kg)	Average tuber weight (g)	Length of tuber (cm)	Girth of tuber (cm)	Dry weight of vine (t ha^{-1})	Pooled mean	% increase over 60 x 60 cm spacing
T_1	90 x 90	1.106	121.71	13.75	13.04	0.88	13.66	- 35.51%
T_2	90 x 60	1.056	113.02	13.89	12.86	1.01	19.55	- 6.43%
T_3	90 x 30	0.734	98.19	14.13	12.76	1.20	27.17	27.60%
T_4	60 x 60	0.772	99.68	13.16	12.88	1.36	21.43	--
T_5	60 x 45	0.672	93.12	13.78	12.54	1.32	24.87	17.19%
T_6	60 x 30	0.563	80.16	13.83	12.35	2.48	31.29	43.98%
	S.E. m +	0.014	1.71	0.11	0.08	0.03	0.43	
	C.D.@ 5%	0.043	5.31	NS	NS	0.11	1.35	

Table 2: Effect of spacing on partitioning tuber yield of lesser yam (pooled Mean)

Tr. No	Spacing (cm)	Tuber yield (t ha^{-1})				
		Bold (> 200gm)	Medium (100 – 200 gm)	Small (50 - 100gm)	Very Small (< 50gm)	Total
T_1	90 x 90	5.33	4.47	2.83	1.02	13.66
T_2	90 x 60	7.55	7.31	3.49	1.21	19.55
T_3	90 x 30	8.43	10.43	6.15	2.16	27.17
T_4	60 x 60	5.93	8.37	5.30	1.83	21.43
T_5	60 x 45	7.66	8.90	6.41	1.90	24.87
T_6	60 x 30	6.91	12.61	8.70	3.07	31.29
	S.E. m +	0.25	0.31	0.16	0.09	0.43
	C.D.@ 5%	0.77	0.95	0.51	0.29	1.35

Table 3: Effect of spacing on Marketable and unmarketable tuber yield of lesser yam and their percentage (pooled Mean)

Tr. No	Spacing (cm)	Tuber yield t ha^{-1} and percentage				
		Pooled Yield	Marketable Yield	Per cent Marketable Yield	Unmarketable Yield	Per cent Unmarketable Yield
T_1	90 x 90	13.66	12.64	92.66	1.02	7.34
T_2	90 x 60	19.55	18.34	93.78	1.21	6.22
T_3	90 x 30	27.17	25.01	92.13	2.16	7.87
T_4	60 x 60	21.43	19.60	91.26	1.83	8.74
T_5	60 x 45	24.87	22.97	92.06	1.90	7.94
T_6	60 x 30	31.29	28.22	90.08	3.07	9.92
	S.E. m +	0.43	0.47	0.52	0.09	0.52
	C.D.@ 5%	1.35	1.46	NS	0.29	NS

Table 4: Effect of spacing on economics of lesser yam

Tr. No.	Spacing	Marketable Yield (t ha^{-1})	Gross Income (Rs ha^{-1})	Cost of Cultivation (Rs ha^{-1})	Net Return (Rs ha^{-1})	C: B ratio
T_1	90 x 90	12.64	379061/-	186331/-	1,92,731/-	2.03
T_2	90 x 60	18.34	550343/-	248526/-	3,01,817/-	2.21
T_3	90 x 30	25.01	750326/-	383707/-	3,66,619/-	1.96
T_4	60 x 60	19.60	588107/-	302578/-	2,85,528/-	1.94
T_5	60 x 45	22.97	689210/-	373521/-	3,15,689/-	1.85
T_6	60 x 30	28.22	846499/-	507909/-	3,38,590/-	1.67

Conclusion

It is concluded from the three years pooled tuber yield data that the total tuber yield (31.29 t ha^{-1}) as well as marketable tuber yield (28.22 t ha^{-1}) in lesser yam was significantly the highest by adopting closer crop geometry of 60 x 30 cm followed by 90 x 30 cm. The economics of different spacing treatment was revealed that the crop geometry of 90 x 30 cm realized the highest net returns of Rs. 3,66,619/- ha^{-1}. However, the C:B ratio of 1: 2.21 was highest in plant density of 90 x 60 cm. Planting of lesser yam at spacing of 90 x 30 cm for gaining higher net returns ha^{-1} is recommended.

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