

Original Research Article

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Effect of IBA, types of Cutting and Rooting Media on Sprouting, Survival Percentage and Growth of Cuttings of Kartoli* (*Momordica dioica* Roxb.)

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ABSTRACT

Spine gourd is a perennial, dioecious climbing creeper belongs to family Cucurbitaceae and commonly known as Kartoli. The present study aimed to investigate the effect of different concentrations of IBA, types of cutting and rooting media on days required for sprouting, survival percentage growth of cuttings of kartoli. The cuttings taken from the tip, middle and basal portion of the vine were dipped into 250, 500, 750 and 1000 ppm of IBA (Indole-3-butyric acid) solution and planted in different rooting media such as Soil + Sand + FYM, Soil + Sand + Vermicompost and Soil + Sand + Cocopeat in 1:1:1 proportion. The experiment was laid out in Factorial Completely Randomized Block Design with two replications. The observations on days required for sprouting, survival percentage, length and number shoots and roots per cutting were recorded at 30 and 90 DAP. The data revealed that, the days required for sprouting, survival percentage and growth of cuttings of kartoli were found to be significantly influenced by the different concentrations of IBA, types of cutting and rooting media. Interactions between IBA concentrations (G), types of cutting (C) and rooting media (M), the treatment combination of G₄C₁M₁ recorded significantly minimum number of days (10.15) required for sprouting, the highest survival percentage (80.00) as compared with the remaining treatment combinations. The maximum length of main shoot and root were recorded in the treatment combination of G₄C₁M₁ (153.15 cm and 27.80cm), respectively and the highest numbers of shoots (6.10) and roots (132.80) per cutting were noticed in the same treatment combination as compared with the other treatments under study at 90 DAP.

Keywords

IBA concentrations,
Types of cutting, Rooting
media, Sprouting and
survival, Growth of
cuttings

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Introduction

Spine gourd (*Momordica dioica* Roxb.) is a perennial; dioecious climbing creeper belongs to family Cucurbitaceae and originated in Indo-Malayan. It is grown in India, Bangladesh, China, Malaysia, Nepal, Pakistan and Sri Lanka and also grown as a summer vegetable in tropical and subtropical countries. Kartoli is known by different vernacular name such as Kartoli or Katla in Marathi; Sarpadmini in Sanskrit; Kaksra or Golkandra in Hindi; Bhatkerala in Asami; Karlikal in Kanadi; Agakarai in Telgu; Kirara or Dhar Kerala in Punjab. The tubers sprout at the onset of monsoon and complete their life cycle by the end of monsoon. Its aerial part dies during the winter season (Mishra and Sahu, 1983).

Nutritional value of kartoli fruit per 100 g of edible portion is 84.1% moisture, 3.1% protein, 0.97% ether extract, 7.7% carbohydrate, 2.97% fiber and 1.1% ash. It also contains 4.6 mg iron, 33 mg calcium, 42 mg phosphorus, 2,700 IU vitamin A, 45.2 mg thiamine, 176.1 µg riboflavin, and 0.50 mg niacin (Chakravarty, 1959). The fruits also possess properties like antidiabetic (Reddy *et al.*, 2006), anticancer, (Luo *et al.*, 1998), analgesic, postcoital, anti-fertility (Shreedhar *et al.*, 2001), nematocidal, antiallergic, antibacterial (Nabi *et al.*, 2002), antimaterial (Misra *et al.*, 1991), anti-feedent and antimicrobial (Sadyojatha and Vaidya, 1995), anti-oxidant and hepato-protective (Jain *et al.*, 2008). Because of nutritional and medicinal importance of kartoli, its demand in metropolitan cities like Mumbai and Pune is increasing, where it is being sold at very higher prices.

Kartoli crop has a number of problems, including poor natural pollination of female flowers and low fruit yield. Fruits become inedible at maturity owing to the presence of

large number of hard seeds. Production of tuberous roots per plant is low. Tuberous roots have got dormancy and they sprout only at onset of monsoon. The multiplication rate of tubers is very low (Mondal *et al.*, 2006). About 2-4 tuberous roots are produced per plant per year, unavailability of planting material, lack of improved varieties, dioecious nature and lack of knowledge about the package of practices of kartoli. Due to lack of technical know-how, the success of rooting of cuttings is very low and possesses problem in germination of seed due to hard and impermeable seed coat (Rashid, 1976).

Similarly, the sex prediction of seed propagated plants is very difficult before flowering because of dioeciously and highly cross pollination. The major limitations of cultivation of kartoli are unavailability of planting material for large scale cultivation, seed dormancy for more than 8 months, lack of improved variety and dioecious nature of the crop (Mishra and Sahu, 1983).

Systematic approach can result into some solutions to overcome these problems. Therefore, the vegetative propagation using stem cutting is a good tool among various methods used for propagation of kartoli. Sawant (1993) and Parulekar (1994) reported the use of IBA on rooting and sprouting behavior of cuttings of kartoli. The rooting to the cuttings of kartoli can be achieved by use of growth regulators like IBA, NAA etc. Very little work with respect to vegetative propagation by use of plant growth regulators, types of cutting and rooting media for induction of rooting to the cuttings of kartoli have been carried out. Therefore, the present research work was undertaken at Horticulture Section, RCSM College of Agriculture, Kolhapur during *Kharif* 2016-17 to study the effect of IBA, types of cutting and rooting media on sprouting, rooting, survival percentage and growth of cuttings of kartoli.

Materials and Methods

Source of planting material

The healthy plants of kartoli were procured from AICRP Network Project on Potential Crops, Department of Botany, M.P.K. V, Rahuri. The experiment was carried out in green shed nethouse (50% shading intensity) at 25 - 28⁰C temperature and 70-80 per cent humidity.

Preparation of cuttings

One-month old healthy shoot of one-year-old kartoli vines collected and stem pieces of suitable size were made by keeping at least three nodes and one leaf per cutting. The cuttings were prepared by giving slanting cut about 2-3 cm at the basal end and just below the lower node. The top slanting cut was made at the distal end 2 to 2.5 cm above the upper node. The cuttings were taken from the tip (C₁), middle (C₂), basal (C₃) portion of the vines. The basal end of cuttings up to 2.5 cm was dipped in the solutions of IBA at different concentration for 30 min prior to planting.

Preparation of IBA solution

The stock solution of IBA at 1000 ppm was prepared by dissolving one-gram powder of IBA in a small quantity of ethyl alcohol and then volume made to 1 L by addition of distilled water. The subsequent dilutions of desired strength were made from the stock solution.

Preparation of rooting media mixture

The different media such as properlyde composed FYM, Soil, Sand, Vermicompost, Coco peat were obtained from Horticulture Section, RCSM College of Agriculture, Kolhapur. The media mixture of Soil + Sand + FYM (M₁), Soil + Sand + Vermicompost

(M₂), and Soil + Sand + Cocopeat (M₃) mixed together in 1:1:1 proportion along with 5 g bio-fertilizer (PSB) in each bag. The prepared rooting media were used for planting the cuttings of kartoli.

Planting of cuttings and after care

Before transplanting the cuttings were dipped for 30 min in IBA solution at different concentrations such as 250 (G₂), 500 (G₃), 70 (G₄) and 1000 ppm (G₅) were made from the stock solution along with untreated control (G₁). Then cuttings were planted in slanting position in polythene bags of 250 gauge of 6×8” size and duly punched for proper drainage. The polythene bags were previously filled with the mixture of root media as per the treatments. The media around the cutting was pressed gently after planting the cuttings and bags were watered immediately after planting and watered regularly as per the requirement. The weeding and plant protection measures were undertaken as and when required. The observations on days required for sprouting, survival percentage, length of main shoot and root, number of shoots and roots per cutting were recorded at 30 and 90 DAP.

Statistical analysis

The data generated through this investigation was analyzed for the significance and non-significance of various treatments effect was judged with the help of ‘F’ value (test) at 5 per cent levels of significance. The critical difference (CD) was calculated to assist the significant differences between treatments mean (Panse and Sukhatme, 1985).

Results and Discussion

Number of days required for sprouting

It is clear from the data depicted figure 1 that, the number of days required for sprouting of

cuttings of kartoli were significantly influenced by different concentrations of IBA, types of cutting, rooting media and their interactions also. The data shows that, statistically minimum number of days required for sprouting (10.15) of the cuttings when tip cuttings treated with IBA at 750 ppm and planted in the rooting media of Soil+ Sand + FYM in 1:1:1: proportion over remaining treatments while the maximum number of days required for sprouting were observed in untreated control (16.54). This might be due to exogenous application of auxins to the cuttings might have brought early breakage of bud dormancy and results in early bud sprouting. The results of present investigations are accordance with the finding of Mishra and Sahu (1983) and Taslim *et al.*, (1992) in kartoli.

Among the effect of types of cutting, the number of days required for sprouting of the cuttings of kartoli was significantly influenced by the type of cutting (Fig. 1). The tip cuttings recorded minimum number of days required for sprouting (13.08) over the middle (13.70) and basal cuttings (14.01). Hartmann *et al.*, (1990) reported that, in many vegetatively propagated species, older, lignified wood cuttings are difficult to root than newly formed stems.

The data revealed that, significant influence of rooting media on days required for sprouting of cuttings of kartoli was observed (Fig. 1). Among interactions of IBA and rooting media in which 750 ppm IBA and Soil + Sand + FYM (10.47) was significantly superior over rest the treatments. Amongst interaction of media and types of cutting, tip cutting planted in Soil + Sand + FYM which recorded minimum days required for sprouting (12.25 days) followed by tip cutting planted in Soil + Sand + Vermicompost (12.82 days). This might be due to addition of sand and FYM in equal proportion, which provided favorable

conditions for sprouting and rooting. Addition of sand facilitated proper drainage and aeration for exchange of gases. Bates and Tisdal (1957) observed that adding coarse sand in sufficient quantity greatly improve the percolation of water through soil. The minimum number of days for sprouting was noticed in cuttings grown in a mixture of black clay and FYM could be attributed to higher degree of fertility and water retaining capacity (Biswar and Mukherjee, 2009).

The treatment combination of $G_4C_1M_1$ recorded minimum number of days required for sprouting (10.15) which was significantly superior over the remaining treatment combinations under study. Similarly, Mali (1998) reported that 750 ppm IBA had taken minimum time (13 days) for sprouting followed by 500 ppm IBA (13.66). The results of present findings are in agreement with the results obtained by Sawant (1993) and Parulekar (1994) in kartoli crop and Rajarama (1997) in pomegranate and Garande *et al.*, (2002) in grape rootstocks. Chandramouli (2001) reported that the increase in the concentration of IBA significantly decreased the number of days to first sprouting of cuttings and earliness in sprouting might be due to better utilization of stored carbohydrates, nitrogen and other factors with the help of growth regulators.

Survival percentage of cuttings

Among the effect of IBA concentrations on survival percentage, the IBA at 750 ppm recorded significantly maximum survival percentage i.e. 70.56 and 61.11 followed by 500 ppm of IBA (67.52 and 57.78) whereas the minimum survival percentage i.e. 29.44 and 18.89 was recorded in untreated control at 30 and 90 DAP, respectively (Fig. 1). The data also reveals that, the tip cutting recorded significantly maximum survival percentage of 61.67 and 55.00 followed by middle cutting

(55.00 and 43.33) while the minimum survival percentage was recorded in basal cuttings (41.00 and 36.33) at 30 and 90 DAP, respectively.

Among the effect of different rooting media on survival percentage, Soil + Sand + FYM recorded significantly maximum survival percentage (59.00 and 50.67) followed by Soil + Sand + Vermicompost (53.00 and 44.33) whereas the minimum survival percentage was recorded in Soil + Sand + Coco peat (29.44 and 18.89) at 30 and 90 days, respectively. Thus, the superiority of potting mixture of Soil + FYM (1:1) and Soil + Sand + FYM (1:1:1) may be attributed to the better physical and nutritional status of the media.

The treatment combination of $G_4C_1M_1$ showed the highest survival percentage i.e. 85.00 and 80.00 at the end of 30 and 90 DAP which was significantly superior over the remaining treatment combinations under study and found to be decreased as the period increased. The differences among the different media could be attributed to the varying physical status of rooting media. Aeration is necessary for the gaseous exchange between the soil and atmosphere to remove CO_2 released by roots and micro-organisms in the soil to external atmosphere and supply of O_2 from the external atmosphere to the growing roots leading to better respiration and survival of plants (Mali, 1998). The results of present findings are in close conformity with the results reported by Govekar (1984) in pepper.

Length of main shoot (cm)

Among the effect of IBA concentrations on length of main shoot, the IBA at 750 ppm recorded maximum length of main shoot i.e. 15.74 and 140.82 cm followed by 500 ppm of IBA (15.18 and 139.03 cm) at 30 and 90 DAP, respectively (Table 1). The minimum length of main shoot i.e. 6.40 and 57.08 cm was

recorded in untreated control at 30 and 90 DAP, respectively. Auxins activated shoot growth which might have caused hydrolysis and translocation of carbohydrates and nitrogenous substances at the base of cuttings and resulted in accelerating cell elongation and cell division (Singh *et al.*, 2003).

It also seen that, Soil + Sand + FYM recorded significantly maximum length of main shoot i.e. 13.42 and 126.55 cm followed by Soil + Sand + Vermicompost of 12.18 and 113.57 cm) whereas the minimum length of main shoot was recorded in Soil + Sand + Cocopeat (11.15 and 104.30 cm) at 30 and 90 DAP, respectively (Table 1). Mishra and Sahu (1983) reported that equal amount of sandy loam soil and compost gave better establishment of kartoli cuttings. The interaction between types of cutting and IBA concentrations, tip cutting with 750 ppm IBA showed maximum length of main shoot i.e. 16.53 and 148.62 cm followed by basal cutting treated with IBA at 500 ppm i.e. 16.05 and 143.27 cm at 30 and 90 DAP, respectively. The interaction between rooting media and types of cutting, the tip cuttings planted in Soil + Sand + FYM showed significantly maximum length of main shoot i.e. 14.37 and 132.81 cm followed by Soil + Sand + Vermicompost (13.28 and 124.49 cm) at 30 and 90 DAP, respectively.

The presented in Table 1 clearly indicated that, tip cuttings treated with 750 ppm IBA planted in Soil + Sand + FYM (1:1:1) i.e. $G_4M_1C_1$ showed maximum length of main shoot (17.95 and 153.15 cm) followed by $G_3M_1C_1$ (17.05 and 150.30 cm) at 30 and 90 DAP, respectively. This might be due to availability of coarse sand medium with adequate level of essential elements (Adriance and Brison, 1955 and Hudson, 1955). The results of present findings are in accordance with the finding of Rahman (2004) in softwood cuttings of guava.

Table.1 Effect of IBA, types of cutting and rooting media on length of shoot of kartoli at 30 and 90DAP

		Media							
		M ₁		M ₂		M ₃		Mean	
DAP		30	90	30	90	30	90	30	90
IBA Concentration	G ₁	7.77	92.80	6.43	54.52	5.00	23.92	6.40	57.08
	G ₂	13.13	120.28	11.13	114.22	10.27	110.17	11.51	114.89
	G ₃	16.12	143.27	15.28	138.97	14.13	134.87	15.18	139.03
	G ₄	16.93	145.05	15.68	140.97	14.60	136.43	15.74	140.82
	G ₅	13.17	131.37	12.35	119.02	11.75	116.12	12.42	122.17
Mean		13.42	126.55	12.18	113.57	11.15	104.30	12.25	114.80
		SE±		CD (5%)					
G		0.12	2.94	0.34	8.37				
M		0.09	2.28	0.26	6.48				
G×M		0.21	5.09	0.59	14.49				

		Types of cutting							
		C ₁		C ₂		C ₃		Mean	
DAP		30	90	30	90	30	90	30	90
Media	M ₁	14.37	132.81	13.76	129.41	12.14	117.44	13.42	126.55
	M ₂	13.28	124.49	12.50	113.65	10.75	102.47	12.18	113.54
	M ₃	12.39	119.57	11.13	102.84	9.93	90.49	11.15	104.30
Mean		13.35	125.62	12.46	115.30	10.94	103.47	12.25	114.80
		SE±		CD (5%)					
M×C		0.16	3.94	0.46	11.23				

		Types of cutting							
		C ₁		C ₂		C ₃		Mean	
DAP		30	90	30	90	30	90	30	90
IBA Concentration	G ₁	8.40	82.47	5.35	43.37	5.45	45.40	6.40	57.08
	G ₂	12.40	121.50	11.65	118.62	10.48	104.55	11.51	114.89
	G ₃	15.97	146.55	16.05	143.37	13.52	127.18	15.18	139.03
	G ₄	16.53	148.62	16.55	145.12	14.13	128.72	15.74	140.82
	G ₅	13.43	128.98	12.72	126.03	11.12	111.48	12.42	122.17
Mean		13.35	125.62	12.46	115.30	10.94	103.47	12.25	114.12
		SE±		CD (5%)					
C		0.09	2.28	0.26	6.48				
G×C		0.21	5.09	0.59	14.49				

G × C × M	M ₁				M ₂				M ₃									
	C ₁		C ₂		C ₃		C ₁		C ₂		C ₃		C ₁		C ₂		C ₃	
DAP	30	90	30	90	30	90	30	90	30	90	30	90	30	90	30	90	30	90
G ₁	8.55	94.45	7.65	91.45	7.10	92.50	8.30	81.20	5.55	38.65	5.45	43.70	8.35	71.75	2.85	-	-	-
G ₂	14.20	127.25	13.25	124.25	11.85	109.35	12.05	120.40	10.10	117.80	10.25	104.45	10.95	116.85	10.50	113.80	9.35	99.85
G ₃	17.05	150.30	17.10	146.80	14.20	132.70	16.10	147.05	16.30	144.60	13.45	125.85	14.75	142.30	14.75	139.30	12.90	123.00
G ₄	17.95	153.15	17.30	148.70	15.55	133.30	16.35	148.50	16.80	145.40	13.70	129.00	15.10	144.20	15.55	141.20	13.15	123.85
G ₅	14.10	138.90	13.40	135.85	12.00	119.35	13.40	125.30	12.75	122.40	10.90	109.35	12.80	122.75	12.00	119.85	10.45	105.75
				G×C×M	SE±		CD (5%)											
					0.36	8.81	1.02	25.10										

G ₁ – Control	C ₁ - Tip cutting	M ₁ –Soil + Sand + FYM
G ₂ – 250 ppm IBA	C ₂ - Middle cutting	M ₂ - Soil + Sand + Vermicompost
G ₃ – 500 ppm	C ₃ – Basal cutting	M ₃ - Soil + Sand + Coco peat
G ₄ - 750 ppm IBA		
G ₅ – 1000 ppm IBA		

Table.2 Effect of IBA, types of cutting and rooting media on number of shoots per cutting of kartoli at 30 and 90 DAP

		Media							
		M ₁		M ₂		M ₃		Mean	
DAP		30	90	30	90	30	90	30	90
IBA Concentration	G ₁	1.17	2.70	0.98	1.80	0.35	0.78	0.83	1.76
	G ₂	1.82	5.00	1.50	4.25	1.45	4.13	1.59	4.46
	G ₃	2.57	6.55	2.13	6.30	1.92	5.28	2.21	6.14
	G ₄	2.67	6.47	2.18	6.37	2.02	6.02	2.32	6.28
	G ₅	1.90	5.28	1.73	4.77	1.62	4.47	1.75	4.84
Mean		2.02	5.20	1.73	4.70	1.47	4.20	1.74	4.70
		SE±		CD (5%)					
G		0.040	0.11	0.11	0.32				
M		0.03	0.09	0.08	0.325				
G×M		0.06	0.19	0.18	0.55				

		Types of cutting							
		C ₁		C ₂		C ₃		Mean	
DAP		30	90	30	90	30	90	30	90
Media	M ₁	2.17	5.28	2.01	5.22	1.83	5.10	2.02	5.20
	M ₂	1.89	5.04	1.77	4.60	1.52	4.45	1.73	4.70
	M ₃	1.70	4.67	1.42	4.03	1.29	3.89	1.47	4.20
Mean		1.92	5.00	1.73	4.62	1.57	4.48	1.74	4.70
		SE±		CD (5%)					
M×C		0.05	0.15	0.14	0.43				

		Types of cutting							
		C ₁		C ₂		C ₃		Mean	
DAP		30	90	30	90	30	90	30	90
IBA Concentration	G ₁	1.20	2.40	0.75	1.22	0.55	1.67	0.83	1.76
	G ₂	1.68	4.50	1.58	4.50	1.50	4.37	1.59	4.46
	G ₃	2.35	6.50	2.22	6.08	2.02	5.83	2.21	6.14
	G ₄	2.50	6.52	2.35	6.37	2.12	5.98	2.32	6.28
	G ₅	1.87	5.05	1.77	4.92	1.62	4.55	1.25	4.84
Mean		1.92	5.00	1.73	4.62	1.57	4.48	1.74	4.70
		SE±		CD (5%)					
C		0.03	0.09	0.08	0.75				
G×C		0.06	0.19	0.18	0.55				

G x C x M	M ₁				M ₂				M ₃										
	C ₁		C ₂		C ₃		C ₁		C ₂		C ₃		C ₁		C ₂		C ₃		
DAP	30	90	30	90	30	90	30	90	30	90	30	90	30	90	30	90	30	90	
G ₁	1.25	2.35	1.15	2.40	1.10	3.25	1.30	2.50	1.10	2.00	0.55	1.75	1.05	2.35	-	-	-	-	
G ₂	1.90	5.00	1.80	4.70	1.75	4.45	1.60	4.25	1.50	4.10	1.40	4.00	1.55	4.15	1.45	4.10	1.35	3.75	
G ₃	2.80	6.00	2.55	5.90	2.35	5.70	2.25	5.60	2.15	5.50	2.00	5.35	2.00	5.30	1.95	5.15	1.80	4.70	
G ₄	2.90	6.10	2.65	5.95	2.45	5.85	2.45	5.75	2.35	5.65	2.05	5.40	2.15	5.50	2.05	5.45	1.85	4.85	
G ₅	2.00	5.20	1.90	5.10	1.80	4.90	1.85	4.90	1.75	4.65	1.60	4.40	1.75	4.60	1.65	4.50	1.45	4.35	
		G×C×M		SE±		CD (5%)													
				0.11		0.35		0.32		0.98									

G₁– Control	C₁ - Tip cutting	M₁ –Soil + Sand + FYM
G₂ – 250 ppm IBA	C₂- Middle cutting	M₂ - Soil + Sand + Vermicompost
G₃ – 500 ppm	C₃ – Basal cutting	M₃ - Soil + Sand + Coco peat
G₄ - 750 ppm IBA		
G₅ – 1000 ppm IBA		

Table.3 Effect of IBA, types of cutting and rooting media on length of root of kartoli at 30 and 90 DAP

		Media							
		M ₁		M ₂		M ₃		Mean	
DAP		30	90	30	90	30	90	30	90
IBA Concentration	G ₁	3.70	14.72	3.55	9.58	1.37	5.05	2.82	9.78
	G ₂	4.95	23.05	4.20	22.45	4.00	21.47	4.38	22.32
	G ₃	6.72	24.83	6.02	23.87	5.43	23.33	6.06	24.00
	G ₄	7.02	25.72	6.25	24.93	5.62	24.00	6.29	24.88
	G ₅	5.08	24.27	4.63	23.12	4.478	22.30	4.73	23.23
Mean		5.49	22.52	4.93	20.79	4.18	19.30	4.87	20.85
		SE±		CD (5%)					
G		0.08	0.48	0.24	1.37				
M		0.06	0.37	0.18	1.06				
G×M		0.14	0.83	0.41	2.37				

		Types of cutting							
		C ₁		C ₂		C ₃		Mean	
DAP		30	90	30	90	30	90	30	90
Media	M ₁	6.03	24.02	5.43	22.44	5.02	21.09	5.49	22.52
	M ₂	5.47	22.73	4.83	20.03	4.49	19.61	4.93	20.79
	M ₃	5.13	21.37	3.85	17.09	3.55	18.33	4.18	19.23
Mean		5.54	22.71	4.70	20.15	4.35	19.68	4.87	20.85
		SE±		CD (5%)					
M×C		0.11	0.65	0.32	1.84				

		Types of cutting							
		C ₁		C ₂		C ₃		Mean	
DAP		30	90	30	90	30	90	30	90
IBA Concentration	G ₁	4.20	15.38	2.52	7.10	1.90	6.87	2.87	9.78
	G ₂	4.07	22.90	4.27	22.42	4.02	21.85	4.38	22.32
	G ₃	6.60	24.92	5.95	213.73	5.62	23.38	6.06	24.01
	G ₄	6.80	26.07	6.15	24.52	5.93	24.07	6.29	24.88
	G ₅	5.25	24.27	4.63	23.00	4.30	22.42	4.73	23.23
Mean		5.54	22.71	4.70	20.15	4.35	19.68	4.87	20.85
		SE±		CD (5%)					
C		0.06	0.37	0.18	1.06				
G×C		0.14	0.83	0.41	2.37				

G × C × M	M ₁				M ₂				M ₃									
	C ₁		C ₂		C ₃		C ₁		C ₂		C ₃		C ₁		C ₂		C ₃	
DAP	30	90	30	90	30	90	30	90	30	90	30	90	30	90	30	90	30	90
G ₁	4.30	14.85	3.85	14.90	2.95	14.40	4.20	16.15	3.70	6.40	2.75	6.20	4.10	15.15	-	-	-	-
G ₂	5.45	24.10	4.85	23.55	4.55	21.50	4.65	22.95	4.05	22.40	3.90	22.00	4.50	21.65	3.90	21.30	3.60	21.45
G ₃	7.35	26.95	6.56	24.55	6.25	23.00	6.50	24.55	5.95	23.80	5.60	23.25	5.95	23.25	5.35	22.85	5.00	23.90
G ₄	7.50	27.80	6.90	25.30	6.65	24.05	6.75	26.25	6.00	24.55	6.00	24.00	6.15	24.15	5.55	23.70	5.15	24.15
G ₅	5.55	26.40	5.00	23.90	4.70	22.50	5.25	23.75	4.45	23.00	4.70	22.60	4.95	22.65	4.46	22.10	4.00	22.15
				G×C×M	SE±		CD (5%)											
					0.20	1.44	0.71	4.11										

G ₁ – Control	C ₁ - Tip cutting	M ₁ – Soil + Sand + FYM
G ₂ – 250 ppm IBA	C ₂ - Middle cutting	M ₂ - Soil + Sand + Vermicompost
G ₃ – 500 ppm	C ₃ – Basal cutting	M ₃ - Soil + Sand + Coco peat
G ₄ - 750 ppm IBA		
G ₅ – 1000 ppm IBA		

Table.4 Effect of IBA, types of cutting and rooting media on number of roots per cutting of kartoli at 30 and 90 DAP

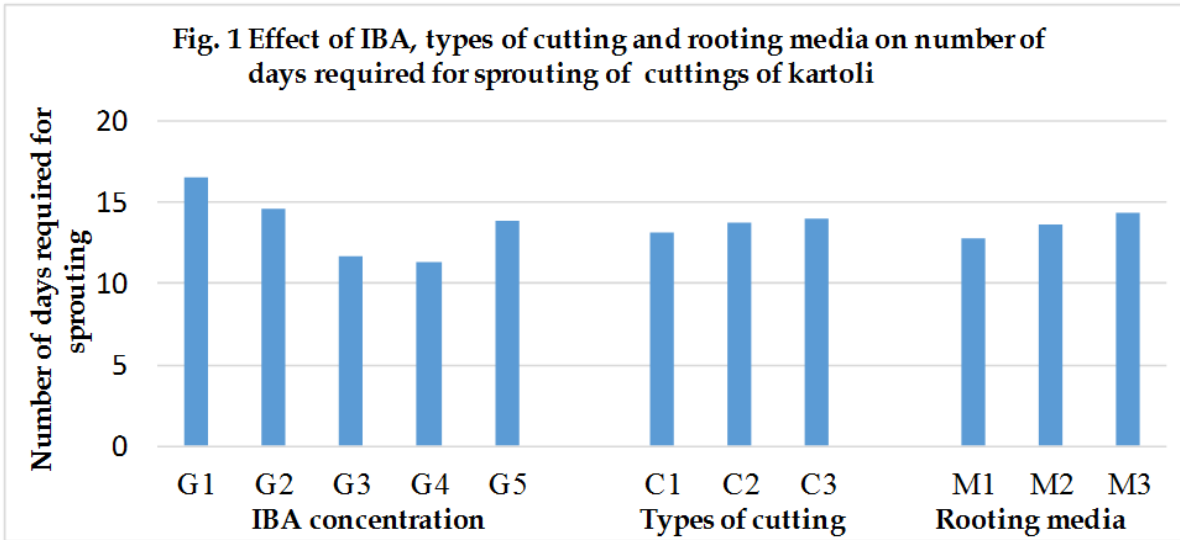
		Media							
		M ₁		M ₂		M ₃		Mean	
DAP		30	90	30	90	30	90	30	90
IBA Concentration	G ₁	8.40	69.78	8.13	43.47	5.38	25.37	7.31	46.21
	G ₂	15.35	117.30	13.63	101.92	13.05	97.77	14.01	105.66
	G ₃	18.08	128.42	17.20	124.50	16.58	121.83	17.29	124.92
	G ₄	18.70	129.97	17.42	126.37	16.88	123.20	17.67	126.51
	G ₅	16.67	119.62	15.90	107.63	15.38	105.77	16.01	111.01
Mean		15.44	113.02	14.47	100.78	13.46	94.79	14.46	102.86
		SE±		CD (5%)					
G		0.19	1.89	0.65	5.39				
M		0.15	1.47	0.43	4.18				
G×M		0.34	3.28	0.96	9.37				

		Types of cutting							
		C ₁		C ₂		C ₃		Mean	
DAP		30	90	30	90	30	90	30	90
Media	M ₁	11.19	116.40	15.69	112.42	14.44	110.23	15.44	113.01
	M ₂	15.25	111.35	14.74	96.31	13.42	94.67	14.47	100.77
	M ₃	14.71	107.74	14.19	89.03	11.47	87.59	13.96	94.79
Mean		15.38	111.83	14.87	99.25	13.11	97.50	14.46	102.86
		SE±		CD (5%)					
M×C		0.26	2.54	0.74	7.24				

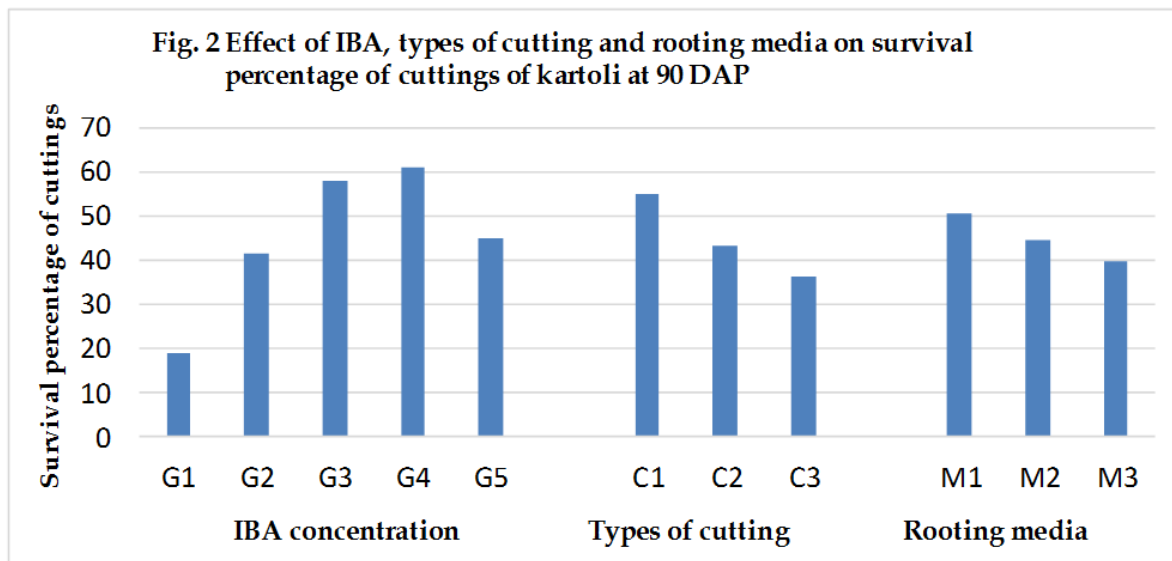
		Types of cutting							
		C ₁		C ₂		C ₃		Mean	
DAP		30	90	30	90	30	90	30	90
IBA Concentration	G ₁	8.40	78.20	8.27	30.62	4.85	29.80	7.31	46.20
	G ₂	15.02	108.22	14.52	105.28	12.50	103.48	14.01	105.66
	G ₃	18.17	127.73	17.65	124.55	16.05	122.47	17.29	124.91
	G ₄	18.50	129.40	18.00	126.17	16.50	123.97	17.67	126.51
	G ₅	16.43	115.60	15.93	109.65	15.65	107.77	16.01	111.00
Mean		15.38	111.83	14.87	99.25	13.11	97.50	14.46	102.86
		SE±		CD (5%)					
C		0.15	1.47	0.43	4.18				
G×C		0.34	3.28	0.96	9.34				

G×C xM	M ₁				M ₂				M ₃									
	C ₁		C ₂		C ₃		C ₁		C ₂		C ₃		C ₁		C ₂		C ₃	
DAP	30	90	30	90	30	90	30	90	30	90	30	90	30	90	30	90	30	90
G ₁	8.95	80.00	8.45	65.65	7.80	63.70	9.10	78.50	8.55	26.20	6.75	25.70	8.35	76.10	-	-	-	-
G ₂	16.70	116.35	16.20	119.23	13.15	116.31	14.40	107.75	13.90	99.75	12.60	93.25	13.95	100.55	13.45	96.85	11.75	95.90
G ₃	18.95	131.00	18.45	127.77	16.85	126.40	18.00	127.75	17.50	123.95	16.10	121.80	17.57	124.45	17.00	121.84	15.20	119.20
G ₄	19.35	132.80	18.46	129.75	17.90	127.35	18.30	129.25	17.80	125.96	16.15	123.90	17.85	126.15	17.35	122.80	15.45	120.65
G ₅	17.00	121.85	16.50	119.60	16.50	117.39	16.45	113.50	15.95	105.70	15.50	103.70	15.86	111.46	15.37	103.65	14.95	102.20
				G×C×M	SE±		CD (5%)											
					0.58	5.68	1.66	16.18										

G ₁ – Control	C ₁ - Tip cutting	M ₁ – Soil + Sand + FYM
G ₂ – 250 ppm IBA	C ₂ - Middle cutting	M ₂ - Soil + Sand + Vermicompost
G ₃ – 500 ppm	C ₃ – Basal cutting	M ₃ - Soil + Sand + Coco peat
G ₄ - 750 ppm IBA		
G ₅ – 1000 ppm IBA		



G₁– Control		M₁ –Soil + Sand + FYM
G₂ – 250 ppm IBA	C₁ - Tip cutting	M₂ - Soil + Sand + Vermicompost
G₃ – 500 ppm	C₂- Middle cutting	M₃ - Soil + Sand + Coco peat
G₄ - 750 ppm IBA	C₃ – Basal cutting	
G₅ – 1000 ppm IBA		



G₁– Control		M₁ –Soil + Sand + FYM
G₂ – 250 ppm IBA	C₁ - Tip cutting	M₂ - Soil + Sand + Vermicompost
G₃ – 500 ppm	C₂- Middle cutting	M₃ - Soil + Sand + Coco peat
G₄-750 ppm IBA	C₃ – Basal cutting	
G₅ – 1000 ppm IBA		

Number of shoots per cutting

The data presented in Table 2 clearly indicated that, IBA at 750 ppm recorded significantly maximum number of shoots per cutting i.e. 2.32 and 6.28 followed by 500 ppm of IBA i.e. 2.21 and 6.14 whereas minimum number of shoots per cutting were recorded in untreated control (0.83 and 1.760) at 30 and 90 DAP, respectively.

Among the effect of different rooting media on number of shoots per cutting, Soil + Sand + FYM recorded maximum number of shoots per cutting i.e. 2.02 and 5.20 followed by Soil + Sand + Vermicompost i.e. 1.73 and 4.70 at 30 and 90 DAP, respectively. Superiority of potting mixture of Soil + Sand + FYM might be attributed to the better physical and nutritional status of the media. Similar results were reported by Parulekar (1994) in kartoli.

Among effect of types of cutting on number of shoots per cutting, the tip cutting recorded significantly maximum number of shoots per cutting i.e. 1.92, 3.11 and 5.00 followed by middle cutting i.e. 1.73 and 4.62 at 30 and 90 days respectively. The maximum number of roots in IBA treated cuttings might be due to its effect on cell wall plasticity, which accelerates cell division stimulates callus development and root growth. Auxins enhanced the transport of carbohydrates to basal portion of the cuttings (Devi, *et al.*, 2016).

The interaction between types of cutting and IBA concentrations, tip cutting treated with 750 ppm IBA showed maximum number of shoots per cutting i.e. 2.50 and 6.52 followed by tip cutting treated with IBA at 500 ppm i.e. 2.35 and 6.50 at 30 and 90 DAP, respectively. The interaction between rooting media and type of cuttings, the tip cuttings planted in Soil + Sand + FYM showed maximum number of shoots per cutting i.e. 2.17 and

5.28 followed by Soil + Sand + Vermicompost i.e. 1.89 and 5.04 at 30 and 90 DAP, respectively.

The interaction of G₄C₁M₁ recorded the highest number of shoots per cutting i.e. 2.90 and 6.10 cm at 30 and 90 DAP as compared with remaining treatment combinations. The more number of shoot formation with the growth regulators might be due to the vigorous root system which increased nutrient uptake under the influence of IBA application which affected the cell division in the vascular cambium, cell expansion and control of differentiation into different types of cambial resulting in increase in number of shoots (Devi *et al.*, 2016). Results of present findings are in agreement with findings reported by Dhillon and Sharma (1992) in Pomegranate and Kumar *et al.*, (2004) in sweet lime.

Length of root

The data presented in Table 3 clearly indicated that, the length of root was found to be significantly influenced by IBA at different concentrations. The highest root length was notice i.e. 6.29 and 24.88 cm in the treatment of IBA at 750 ppm IBA followed by 500 ppm of IBA i.e. 6.06 and 24.01 cm, respectively whereas minimum length of roots i.e. 2.87, 5.39 and 9.78 cm was recorded in untreated control at 30 and 90 DAP, respectively. The purpose of treating cuttings with auxin was to increase the percentage of rooting, root initiation, number of roots, and uniformity of rooting (Al-Barazia nd Schwabe, 1982).

Among the effect of different rooting media on length of roots, Soil + Sand + FYM recorded maximum length of root i.e. 5.49 and 22.52 cm followed by Soil + Sand + Vermicompost i.e. 4.93 and 20.79 cm whereas the minimum length of root was recorded in Soil + Sand + Cocopeat (4.18 and

19.23 cm) at 30 and 90 DAP, respectively. This might be due to proper drainage, adequate nutrient supply and sufficient water holding capacity providing congenial conditions for root growth might have contributed in production of more root length. Similar findings were also reported by Sawant (1993) in kartoli.

Among effect of types of cutting on length of root, the tip cutting recorded significantly maximum length of root i.e. 5.54 and 22.71 cm followed by middle cuttings of 4.70 and 20.15 cm at 30 and 90 DAP, respectively. Araya (2005) reported that the major influencing factor for rooting success of bush tea cuttings was cutting position (apical or basal) which affected the root development, root number and root length of the cuttings. Cutting position had a highly significant effect on rooting of bush tea; with better rooting percentage, root length and root number from apical than basal cuttings. Similar findings were also recorded by Ismail and Hussian (2017) in ficus.

The length of root was significantly influenced by the interaction between IBA, types of cutting and rooting media (Table 3). The interaction between types of cutting and IBA concentrations, tip cuttings with 750 ppm IBA concentration showed maximum length of root i.e. 6.80 and 26.07 cm followed by tip cutting treated with IBA at 500 ppm of 6.60 and 24.92 cm at 30 and 90 DAP, respectively. The interaction between rooting media and types of cutting, the tip cuttings planted in media i.e. Soil + Sand + FYM showed significantly maximum length of root i.e. 6.03 and 24.02 cm followed by Soil + Sand + Vermicompost (5.47 and 22.73 cm) at 30 and 90 DAP, respectively. The maximum length of root was noticed in the treatment combination of G₄C₁M₁ (7.50 and 27.80 cm) at 30 and 90 DAP, respectively which was significantly superior over the remaining

treatment combinations. The results of present findings are in close conformity with findings of Richardson and Humphries (1982) in *Hedera helix*, Mishra and Sahu (1983), Ali *et al.*, (1991), Taslim *et al.*, (1992) and Mali (1998) in kartoli.

Number of roots per cutting

It is clearly seen from the data presented in Table 4 that the number of roots per cutting was found to be influenced significantly by the different concentrations of IBA. The maximum number of roots per cutting i.e. 17.67 and 126.51 were recorded in IBA at 750 ppm closely followed by 500 ppm of IBA of 17.29 and 124.92 which were significantly superior over the control. Weaver (1972) reported that, auxins promote adventitious root formation by their ability to promote the initiation of lateral roots and also enhanced the transport of carbohydrates to basal portion of the cuttings. The maximum number of roots in IBA treated cuttings might be due to its effect on cell wall plasticity, which accelerates cell division stimulates callus development and root growth.

Among the effects of different rooting media on number of roots per cutting, Soil + Sand + FYM recorded maximum number of roots per cutting (15.44 and 113.02) at 30 and 90 DAP, respectively. The superiority of Soil + Sand + FYM (1:1:1) which provide favorable conditions for rooting and sprouting. Addition of sand facilitated proper drainage and aeration for exchange of gases. Similar findings were reported by Sawant (1993) and Mali (1998) in kartoli. The tip cutting recorded significantly maximum number of roots per cutting i.e. 15.38 and 111.83 followed by middle cutting i.e. 14.87 and 99.25 at 30 and 90 DAP, respectively. The difference in rooting percentage of apical and basal cutting due to high concentration of endogenous root promoting substances in the

apical cutting which arise from the terminal buds and also more cell which are capable of becoming meristematic (Hartmann and Kester, 1990).

The interaction between types of cutting and IBA concentrations, tip cutting with 750 ppm IBA concentration showed maximum number of roots per cutting i.e. 18.50 and 129.04 at 30 and 90 DAP, respectively. The interaction between rooting media and types of cutting, the tip cuttings planted in Soil + Sand + FYM showed maximum number of roots per cutting i.e. 16.19 and 116.40 at 30 and 90 DAP, respectively. The number of roots per cutting were found to significantly influenced by interaction of $G_4C_1M_1$ and recorded the maximum number roots per cutting (19.35 and 132.50) followed by $G_3C_1M_3$ (18.95 and 131.00) at 30 and 90 DAP, respectively.

The results of present findings are comparable with the results reported by Taslim *et al.*, (1992), Sawant (1993) and Mali (1998) in kartoli, Deen and Mahmud (1996) in rosemary and Ofori *et al.*, (1996) in *Milicia excels*.

From the present study it is concluded that the tip cuttings of kartoli with three nodes and one leaf treated with IBA @ 750 ppm and planted in polyethylene bags containing Soil + Sand + FYM in 1:1: 1: proportion was found to be the best treatment for induction of rooting, maximum survival percentage (80%), minimum number of days required for sprouting (10.15), maximum shoot length (153.15 cm), number of shoots (6.10), maximum root length (27.80 cm) and number of roots (132.80) per cutting at the end of 90 DAP.

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