

International Journal of Agricultural Sciences Volume 17 | AAEBSSD | 2021 | 51-60

■ ISSN: 0973-130X

CP DOI:10.15740/HAS/IJAS/17-AAEBSSD/51-60 130X Visit us : www.researchjournal.co.in

Research Paper

Effect of different concentrations of Indole-3-butyric acid (IBA) concentrations and cutting size (length and diameter) on root growth of pomegranate (*Punica granatum* L.) cuttings

Basir Ahmad Ahmadi, G. M. Waghmare¹ and A. M. Bhosale* Department of Horticulture, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, (M.S.) India (Email: ambhosale78@gmail.com)

Abstract : The experiment was carried out during the year 2017-18 at Department of Horticulture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani on pomegranate (*Punica granatum* L.) cv. Bhagwa. The cuttings were taken from hardwood cuttings arising on trees of pomegranate cv. Bhagwa during the month of July. Experiment was laid out in Factorial Randomized Block Designed(FRBD) with 18 treatments and 3 factors which are replicated trice and no. of cuttings per treatment are 40. Result revealed that significantly maximum number of roots, highest length of roots, rooting percentage and weight of roots was recorded with treatment $D_2 i.e.$ (1.5 cm) and lowest values in $D_1 i.e.$ (1 cm diameter). Significantly maximum number of roots, highest length of roots, rooting percentage and weight of roots was recorded with treatment $L_3 i.e.$ (20 cm) and minimum values in $L_1 i.e.$ (10 cm length) and maximum number of roots, highest length of roots, rooting percentage and weight of roots was recorded with treatment $T_3 i.e.$ (IBA 5000 ppm) and minimum values were found in $T_1 i.e.$ (IBA 3000 ppm).

Key Words : Root, Indole-3-butyric acid, Length pomegranate, Cutting, Diameter

View Point Article : Ahmadi, Basir Ahmad, Waghmare, G. M. and Bhosale, A. M. (2021). Effect of different concentrations of Indole-3butyric acid (IBA) concentrations and cutting size (length and diameter) on root growth of pomegranate (*Punica granatum* L.) cuttings. *Internat. J. agric. Sci.*, **17** (AAEBSSD) : 51-60, **DOI:10.15740/HAS/IJAS/17-AAEBSSD/51-60.** Copyright@2021: Hind Agri-Horticultural Society.

Article History : Received : 10.07.2021; Accepted : 15.07.2021

INTRODUCTION

Pomegranate (*Punica granatum* L.) belongs to family Punicaceae is native to Asia especially to Iran, Afghanistan and Himalayan region. It is one of the oldest known edible fruit of tropical and sub-tropical region, known for its gustative, medicinal and ornamental. The tree is quite resistant to cold when dormant, withstanding temperatures down to 10° F. However, it is very sensitive to frost before it reaches full dormancy in late fall and

after buds have begun to swell in early spring. The best quality pomegranate fruits are produced in regions with cool winters and hot, dry summers.

Pomegranate is a shrub that naturally tends to develop multiple trunks and has a bushy appearance. When domesticated, it is grown as a small tree that grows up to 5m, leaves have an oblanceolate shape with an apex and acuminate base. Mature leaves are green, entire, smooth and hairless; the flowers can appear solitary, pairs or cluster. In the most cases, the solitary flowers will appear as spurs along the branches while the clusters are terminal (Levin, 2006). Fruit is globular, possessing a smooth outer rind with juicy arils (Mars, 2000).

Pomegranate could be propagated either sexually by seeds or vegetatively using stem cuttings and sometimes as layers or suckers or by grafting (Hartmann et al., 1997). However, in commercial propagation stem cuttings are widely used. (Antakya Hatay, 2009).

The length and diameter of stem cuttings have an impact on rooting rate and subsequent survival in the field after transplanting, determining optimal cutting length is essential as (1) a very long cutting larger than 12 cm will be waste of valuable coppice material, with limited or no benefit in rooting percentage, whereas, (2) a short cutting may not result in the development of sufficient roots (possibly due to lack of sufficient storage reserves) (Leakey, 2004).

Sprouting and rooting ability of cuttings is mainly depends upon the physiological maturity of the shoot and conditions where cuttings have been planted for sprouting and subsequent rooting (Purohit and Shekrappa, 1985) and various internal and external factors like seasons and concentration of endogenous and exogenous phytohormones (Arya et al., 1994). Plant growth regulators improve the rooting of cutting by stimulating the production of adventitious roots. Went (1934) first postulated that auxins initiate adventitious root formation in stem cuttings.

IBA is the most promising growth regulator inducing rooting quickly. Exogenous application of IBA accelerates the rate of rooting, increases final rooting percentage and number of roots. However, relatively high concentrations of IBA have been reported to be inhibitory to rooting (Leakey, 1990). It promotes root initiation, number of roots and shoots growth in number of ornamental and fruits plants. The rooting medium can have a major influence on the rooting capacity of cuttings (Hartmann et al., 2002).

MATERIAL AND METHODS

The experiment was carried out during the year 2017-18 at Department of Horticulture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani on pomegranate (Punica granatum L.) cv. Bhagwa". The cuttings were taken from hardwood cuttings arising on trees of pomegranate cv. Bhagwa during the month of July. Experiment was laid out in Factorial Randomized Block Designed (FRBD) with 18 treatments and 3 factors which are replicated trice and no. of cuttings per treatment are 40. Treatment Details:

Factors	5:				
Factor A	A:	Fac	tor B:		Factor C:
Length of cutting		Diamete	rofcutting	ΙBΑ	concentration
L1:	10 cm	D ₁ :	1 cm	T ₁ :	3000 ppm
L ₂ :	15 cm	D ₂ :	1.5 cm	T_2 :	4000 ppm
L3:	20 cm			T ₃ :	5000 ppm

Observation recorded:

Root observation:

Number of primary and secondary roots per cutting:

The five cuttings from each treatment were uprooted carefully after heavy irrigation and washed under the tap water gently and number of primary and secondary roots per cuttings was counted and mean number of roots per cuttings was calculated.

Length of root:

The length of longest root of fifteen labeled rooted cutting was measured by measuring scale in (cm) from the base to the tip of root and the mean length of root was calculated.

Percentage of cuttings rooted:

This parameter was calculated at 60 days after planting by taking the ratio of number of rooted cuttings to total number of cuttings planted and was multiplied by 100.

$$Percentage of cuttings rooted = \frac{No. of cuttings rooted}{Total no. of cuttings} x 100$$

Fresh and dry weight of roots:

All the roots of each selected fifteen cuttings from three replications were removed with the help of stainless steel knife. The separate roots were placed in brown paper bags, properly labeled, dried in oven at 60c° and after stabilization of weight, this stabilized weight (g) was recorded. From the fresh weight of root, we can find out the dry weight of root by using the following formula.

 $Dry matter of root = \frac{Fresh weight - Dry weight}{Fresh weight} x100$

RESULTS AND DISCUSSION

The results obtained during the experiment were

Effect of different concentrations of (IBA) concentrations and cutting size (length & diameter) on root growth of pomegranate cuttings

recorded and analysed statistically, presented under appropriate headings, sub-headings and discussed with available literature.

Root parameters:

Number of primary roots per cutting at 90DAP :

Data on number of primary roots per cutting of pomegranate as influenced by diameter of cutting (D), length of cutting (L), IBA concentrations (T) and their interaction are presented in Table 1.

Effect of cutting diameter (D):

Significantly highest number of primary roots (19.03) was recorded in treatment $D_2 i.e.$ (1.5 cm diameter), while minimum number of roots (16.50) were observed in D_1 *i.e.* (1 cm diameter).

Effect of cutting length (L):

Among the length of cuttings, the highest number of primary roots (20.83) per cutting was recorded in $L_3 i.e.$ (20 cm length) and minimum number of primary roots (15.11) per cutting was found in $L_1 i.e.$ (10 cm length). Highest diameter and length of cuttings have maximum roots because cuttings are prepared from mature stem and they provide sufficient food material for initiation of roots. Kaur and Kaur (2018).

IBA concentration (T):

In the present investigation the highest number of primary roots per cutting (20.86) was recorded in $T_3 i.e.$ (IBA 5000 ppm) and minimum number (15.16) of primary roots was registered in $T_1 i.e.$ (IBA 3000 ppm). IBA 5000 ppm produce maximum roots due to cell division and cell elongation, differentiation of cambial initial into root primordia and mobilization of reserve food material to sites of root initiation which increase number of primary roots. These results are in conformity with the findings of Sharma (1999) and Kamboj *et al.* (2017).

Interaction effect of $(L \times D)$:

Significant interaction between length and diameter of cutting was observed regarding number of primary roots per cutting. Highest number of primary roots (23.38) per cutting was observed in interaction of $L_3D_2i.e.$ (length 20 cm and 1.5 cm diameter). However, lowest number of primary root (13.88) was observed in interaction of $L_1D_1i.e.$ (length 10 cm and 1 cm diameter).

Table 1:	Effect of cutting size and IBA concentration on number of	
	roots per cutting in pomegranate	

roots per cutt	ing in pomegranate	
Treatments	Number of primary roots per cutting	Number of secondary roots per cutting
	90DAP	90DAP
Diameter of cutting (D)		
D ₁	16.50	45.00
D ₂	19.03	47.53
S.E N±	1.02	1.02
C.D. at 5%	2.82	2.82
Length of cutting (L)		
L ₁	15.11	43.61
L ₂	17.36	45.86
L ₃	20.83	49.33
S.E N±	1.25	1.25
C.D. at 5%	3.46	3.46
IBA concentration (T)	5.10	5.10
T_1	15.16	43.63
T ₂	17.27	45.77
T ₂ T ₃	20.86	49.35
S.E N±	1.25	1.25
C.D. at 5%	3.46	3.46
Interaction (L x D)	5.40	5.40
L_1D_1	13.88	40.58
L_1D_1 L_2D_1	14.33	42.52
L_2D_1 L_3D_1	14.88	43.58
L_3D_1 L_1D_2	15.27	44.25
L_1D_2 L_2D_2	18.38	46.86
L_2D_2 L_3D_2	23.38	51.25
S.E N±	1.76	1.76
C.D. at 5%	4.89	4.89
Interaction (T x D)	4.09	т.07
T_1D_1	11.94	40.25
T_1D_1 T_1D_2	18.38	46.36
T_1D_2 T_2D_1	17.61	47.39
T_2D_1 T_2D_2	16.94	45.25
T_2D_2 T_3D_1	19.94	48.44
T_3D_1 T_3D_2	21.77	50.27
S.E N±	1.76	1.76
C.D. at 5%	4.89	4.89
Interaction (L x T)	90DAP	90DAP
T_1L_1	13.91	41.36
$T_1 L_1$ $T_1 L_2$	15.55	44.02
$T_1 L_2$ $T_1 L_3$	17.00	44.02
$T_1 L_3$ $T_2 L_1$	20.83	49.37
$T_2 L_1$ $T_2 L_2$	16.33	49.37
$T_2 L_2$ $T_2 L_3$	14.66	44.29
T_2L_3 T_3L_1	14.00	45.50
T_3L_1 T_3L_2	20.16	43.30 48.72
$T_3 L_3$ S F N+	24.66	53.89
S.E N±	2.16	2.16
C.D. at 5%	5.99	5.99

Table 1: Contd

Table 1: Contd Interaction (T x D x L)		
$\frac{\text{Interaction}(T \times D \times L)}{T_1 D_1 L_1}$	11.16	37.66
$T_1D_1L_2$	13.83	42.33
$T_1D_1L_3$	12.83	41.25
$T_1D_2L_1$	20.16	48.66
$T_1D_2L_2$	22.00	50.50
$T_1D_2L_3$	13.00	41.25
$T_2D_1L_1$	20.50	49.00
$T_2D_1L_2$	17.66	46.61
$T_2D_1L_3$	14.66	43.85
$T_2D_2L_1$	21.83	49.66
$T_2D_2L_2$	15.00	43.50
$T_2D_2L_3$	14.66	42.69
$T_3D_1L_1$	20.50	49.00
$T_3D_1L_2$	22.16	50.06
$T_3D_1L_3$	17.16	45.09
$T_3D_2L_1$	18.33	42.00
$T_3D_2L_2$	18.16	45.82
$T_3D_2L_3$	28.83	57.25
S.E N±	3.06	3.06
CD at 5%	8.48	8.48
Treatment details		
D ₁ -Diameter 1 cm	L ₁ - Length 10 cm	T ₁ - 3000 ppm IBA
	L ₂ - Length 15 cm	T ₂ - 4000 ppm IBA
D ₂ -Dimeter 1.5 cm	L ₃ - Length 20 cm	T ₃ - 5000 ppm IBA

Basir Ahmad Ahmadi, G. M. Waghmare and A. M. Bhosale

do not show significant variation on number of primary roots per cutting.

Number of secondary roots per cutting at 90DAP:

The effect of diameter of cutting (D), length of cutting (L), IBA concentrations (T) and their interactions on number of secondary roots per cutting presented in Table 1.

Effect of cutting diameter (D):

It has been reported that, the highest number of secondary roots per cutting (47.53) was recorded in $D_2 i.e.$ (1.5 cm diameter) and lowest number of secondary roots (45.00) per cutting was observed in $D_1 i.e.$ (1 cm diameter).

Effect of cutting length (L):

Significantly maximum number of secondary roots per cutting (49.33) was recorded in $L_3i.e.$ (20 cm length) and minimum number of secondary roots per cutting (43.61) was observed in $L_1i.e.$ (10 cm length). Significantly maximum number of secondary roots may be due to large size of cuttings which perform better in terms of all the rooting parameters examined in this study. This could be attributed to the fact that longer cuttings probably have higher food reserves, Islam *et al.* (2010).

IBA concentration (T):

With respect to IBA concentration significantly maximum number of secondary roots (49.35) for pomegranate cuttings was observed in treatment T_3 *i.e.* (5000 ppm IBA) and minimum number of secondary roots (43.63) was observed in T_1 *i.e.* (IBA 3000 ppm). It might be due to increased cell division and their differentiation under the influence of rooting chemicals and enhanced hydrolysis of nutritional reserves resulting into increased root formation zone. (Kaur and Kaur 2016). These findings are in agreement with the research work of Tripathi and Shukla (2004) in pomegranate.

Interaction effect of $(L \times D)$:

The interaction of length and diameter of cutting shows significant effect on number of secondary roots per cutting. Significantly highest number of secondary roots (51.25) per cutting was observed in interaction of $L_3D_2i.e.$ (length 20 cm and 1.5 cm diameter), whereas minimum number of secondary roots (40.58) were observed in interaction of $L_1D_1i.e.$ (length 10 cm and 1

Interaction effect of $(T \times D)$:

Significantly maximum number of primary roots (21.77) of pomegranate cuttings was observed in interaction of $T_3D_2i.e.$ (IBA 5000 ppm and 1.5 cm diameter) which was followed by interactions of T_3D_1 (19.94) and T_1D_2 (18.38). However, minimum number of primary roots (11.94) were observed in interaction of T_1D_1 *i.e.* (IBA 3000 ppm and 1 cm diameter).

Interaction effect of $(T \times L)$:

The interaction effect of length of cutting and IBA concentration on number of primary roots shows significant variation among the interactions. Interaction of T_3L_3 *i.e.* (IBA 5000 ppm and 20 cm length) recorded significantly highest number of primary roots (24.66), which was at par with interactions of T_2L_1 (20.83), T_3L_2 (20.16) and lowest number of primary roots (13.91) was observed in interaction of T_1L_1 *i.e.* (IBA 3000 ppm and 10 cm length), whereas the Interaction effect of IBA concentrations, diameter and length of cuttings (T×D×L)

Effect of different concentrations of (IBA) concentrations and cutting size (length & diameter) on root growth of pomegranate cuttings

cm diameter).

Interaction effect of $(T \times D)$:

Significantly maximum number of secondary roots (50.27) per cutting in pomegranate was observed in interaction of $T_3D_2i.e.$ (IBA 5000 ppm and 1.5 cm diameter) which was followed by interaction of T_3D_1 (48.44), while minimum number of secondary roots (40.25) were observed in interaction of $T_1D_1i.e.$ (IBA 3000 ppm and 1 cm diameter).

Interaction effect of $(T \times L)$:

The interaction effect of length of cutting and IBA concentration on number of secondary roots shows significant variation. The interaction of $T_3L_3i.e.$ (IBA 5000 ppm and 20 cm length) was recorded significantly maximum number of secondary roots (53.89) per cutting, which was statistically at par with interactions of T_3L_2 (48.72) and T_2L_1 (49.37) whereas minimum number of secondary roots (41.36) was observed in interaction of $T_1L_1i.e.$ (IBA 3000 ppm and 10 cm length). However, the interaction of IBA concentration, length and diameter of cuttings (T×D×L)wasfound to be non significant on number of secondary roots per cutting in pomegranate.

Root length (cm) at 90DAP:

The effect of diameter of cutting (D), length of cutting (L), IBA concentrations (T) and their interactions on root length per cutting of pomegranate are presented in Table 2.

Effect of cutting diameter (D):

The perusal of data in Table 10 reveals that, significantly maximum root length (19.24 cm) was recorded in $D_2 i.e.$ (1.5 cm diameter), while minimum root length (16.00 cm) was observed in $D_1 i.e.$ (1 cm diameter).

Effect of cutting length (L):

Significantly maximum root length (20.61 cm) was recorded with treatment $L_3i.e.$ (20 cm length) and minimum root length (15.63 cm) was observed in $L_1i.e.$ (10cm length). A reduction in root length was observed with reduction in cutting size due to inadequate supply of nutrients and leaching of nutrients in shorter cuttings resulted in poor performance in rooting. The length of longest root may be due to better physiological maturity of the cuttings along with the mobilization of secondary

 Table 2: Effect of cutting size and IBA concentration on length of root in pomegranate

root in pomegra nate		
Treatments	Length of root (cm)	
	90DAP	
Diameter of cutting (D)		
D ₁	16.00	
D_2	19.24	
S.E N±	0.46	
C.D. at 5%	1.28	
Length of cutting (L)		
L ₁	15.63	
L ₂	16.61	
L ₃	20.61	
S.E N±	0.56	
C.D. at 5%	1.57	
IBA concentration (T)		
T ₁	16.30	
T ₂	17.63	
T ₃	18.91	
S.E N±	0.56	
C.D. at 5%	1.57	
Interaction (L x D)		
L ₁ D ₁	13.55	
L_2D_1	16.66	
L_3D_1	17.77	
L_1D_2	15.72	
L_1D_2 L_2D_2	16.55	
L_2D_2 L_3D_2	23.44	
S.E N±	0.80	
C.D. at 5%	2.22	
	2.22	
Interaction (T x D)	14.72	
T ₁ D ₁	14.72	
T_1D_2	17.05	
T_2D_1	15.55	
T_2D_2	19.55	
T ₃ D ₁	17.72	
T_3D_2	20.69	
S.E N±	0.80	
C.D. at 5%	2.22	
Interaction (L x T)	90DAP	
T_1L_1	14.25	
$T_1 L_2$	16.33	
T ₁ L ₃	18.33	
$T_2 L_1$	20.33	
$T_2 L_2$	17.25	
T_2L_3	15.33	
$T_{3}L_{1}$	17.33	
$T_3 L_2$	16.25	
T ₃ L ₃	23.16	
S.E N±	0.98	
C.D. at 5%	2.72	
	Table 2: Contd	

Table 2: Contd		
Interaction (T x D x L)		
$T_1D_1L_1$		12.16
$T_1D_1L_2$		18.16
$T_1D_1L_3$		16.33
$T_1D_2L_1$		20.33
$T_1D_2L_2$		14.50
$T_1D_2L_3$		16.33
$T_2D_1L_1$		15.66
$T_2D_1L_2$		15.00
$T_2D_1L_3$		13.50
$T_2D_2L_1$		23.08
$T_2D_2L_2$		19.50
$T_2D_2L_3$		17.16
$T_3D_1L_1$		23.08
$T_3D_1L_2$		16.83
$T_3D_1L_3$		15.00
$T_3D_2L_1$		17.66
$T_3D_2L_2$		15.66
$T_3D_2L_3$		25.00
S.E N±		1.39
CD at 5%		3.86
Treatment details		
D ₁ -Diameter 1 cm	L ₁ - Length 10 cm	T ₁ - 3000 ppm IBA
	L ₂ - Length 15 cm	T ₂ - 4000 ppm IBA
D ₂ -Dimeter 1.5 cm	L ₃ - Length 20 cm	T ₃ - 5000 ppm IBA

Basir Ahmad Ahmadi, G. M. Waghmare and A. M. Bhosale

metabolites towards better root formation and hence, more number of roots and highest root length, Pooja *et al.* (2013).

IBA concentration (T):

The data presented in Table 2 indicated that, length of root was significantly influenced by IBA concentration. Significantly maximum root length (18.91 cm) was observed in treatment $T_3 i.e.$ (IBA 5000 ppm). However, minimum root length (16.30 cm) was observed in treatment $T_1 i.e.$ (IBA 3000 ppm). The increased in length of roots might be due to auxin hormone which plays an important role in metabolic activity and cell division process of cuttings, resulting into increased growth of roots. Edmond *et al.* (1997).

Interaction effect of $(L \times D)$:

The interaction of length and diameter of cutting shows significant effect on root length. Significantly

highest root length (23.44 cm) was observed in interaction of $L_3D_2i.e.$ (length 20 cm and 1.5 cm diameter). However, lowest root length (13.55cm) was observed in interaction of $L_1D_1i.e.$ (length 10 cm and 1 cm diameter).

Interaction effect of $(T \times D)$:

Significantly maximum root length (20.55 cm) of pomegranate cuttings was observed in interaction of $T_2D_2i.e.$ (IBA 4000 ppm and 1.5 cm diameter) which was followed by interaction of T_3D_2 (20.11 cm), T_3D_1 (17.72 cm) and minimum root length (14.72 cm) was observed in interaction of T_1D_1 *i.e.* (IBA 3000 ppm and 1 cm diameter).

Interaction effect of $(T \times L)$:

The interaction effect of length of cutting and IBA concentration on root length shows significant variation. The interaction $T_3L_3i.e.$ (IBA 5000 ppm and 20 cm length) was recorded significantly highest root length (23.16 cm) which was statistically at par with the interactions of T_2L_1 (20.33 cm), T_1L_3 (18.33 cm) and lowest root length (14.25 cm) was observed in interaction of $T_1L_1i.e.$ (IBA 3000 ppm and 10 cm length).

Interaction effect of $(T \times D \times L)$:

The data presented in Table 2 indicate that, length of root was significantly influenced by IBA concentration, diameter and length of cuttings. The data in respect to root length per cutting was recorded significantly maximum (25.00 cm) in interaction of $T_3D_2L_3$ which was followed by interactions of $T_2D_2L_1$ (23.08 cm) and $T_1D_2L_1$ (20.33 cm). However, minimum root length (12.16 cm) was observed under interaction of $T_1D_1L_1$.

Rooting percentage :

The effect of cutting diameter (D), length of cutting (L), IBA concentrations (T) and their interactions on rooting percentage of pomegranate cutting are presented in Table 3.

Effect of cutting diameter (D):

With respect to diameter, highest percentage of rooting (68.79 %) was recorded in treatment $D_2 i.e.$ (1.5 cm diameter) and lowest rooting percentage (62.37 %) was observed in treatment D_1 *i.e.* (1 cm diameter). This might be due to maximum storage food for root initiation as compared to small cutting size. These results are in conformity with the findings of Naidu and Jone (2009).

Effect of cutting length (L):

The length of cutting has significant effect on rooting percentage. The highest rooting percentage (69.47 %) was observed in L₃ *i.e.* (20 cm length), whereas the lowest rooting percentage (60.75 %)was observed in L₁ *i.e.* (10 cm length). It might be due to better physiological maturity of the stem cuttings along with the mobilization of secondary metabolites towards better root formation and hence, more number of roots and highest root length. Pooja *et al.*(2013). These results coincide with the findings of Nicoloso *et al.* (2001) in Pfaffia glomerata and Jadhav *et al.* (2003) in patchouli.

IBA concentration (T):

The result from the study indicate that IBA concentration have positive effect on rooting percentage of pomegranate cutting. The highest rooting percentage (66.02 %) was recorded in treatment $T_3 i.e.$ (IBA 5000 ppm) and lowest rooting percentage (62.58 %) was observed in treatment $T_1 i.e.$ (IBA 3000 ppm).

It might be due to increase in cell division and their differentiation under the influence of rooting chemicals, enhanced hydrolysis of nutritional reserves resulting into increased root formation zone. Shukla *et al.*(2010). These findings are in agreement to the report of Prati *et al.* (1999) in lime and Tripathi and Shukla (2004) in pomegranate.

Interaction effect of $(L \times D)$:

The interaction of length and diameter of cutting shows significant effect on rooting percentage. Significantly highest rooting percentage (74.55 %) was observed in interaction of $L_3D_2i.e.$ (length 20 cm and diameter 1.5 cm) and lowest rooting percentage (57.31 %) was observed in interaction of $L_1D_1i.e.$ (10 cm length and 1 cm diameter).

Interaction effect of $(T \times D)$:

Significantly highest rooting percentage (69.77%) of pomegranate cutting was observed in interaction of $T_3D_2i.e.$ (IBA 5000 ppm and 1.5 cm diameter) which was closely followed by interactions of T_1D_2 (66.22%) and T_2D_2 (65.40%). However, lowest rooting percentage (57.55%) was observed in interaction of T_1D_1 *i.e.* (IBA 3000 ppm and 1 cm diameter).

Interaction effect of $(T \times L)$:

The interaction effect of length of cutting and IBA

concentration on rooting percentage shows significant variation. Significantly highest rooting percentage of cutting (70.75 %) was recorded by interaction of $T_3L_3i.e.$ (IBA 5000 ppm and 20 cm length) which was statistically at par with interactions of T_1L_2 (67.00 %) and T_2L_2 (66.50 %) and lowest rooting percentage (56.50 %) of cuttings was observed in $T_1L_1i.e.$ (IBA 3000 ppm and 10 cm length). However, the interaction of IBA concentrations, length and diameter of cuttings (T×D×L)shows non significant effect on rooting percentage of pomegranate cuttings.

Fresh weight of root (g):

Data regarding fresh weight of root per cutting in pomegranate as influenced by diameter of cutting (D), length of cutting (L), IBA concentrations (T) and their interaction are presented in Table 4 and graphically illustrated in Fig. 29 and 30.

Effect of cutting diameter (D):

Significantly, maximum weight of fresh root (0.50g) was recorded in treatment $D_2i.e.$ (1.5cm diameter) and minimum weight of fresh root (0.38g) was observed in $D_1i.e.$ (1cm diameter). This might be due to reserve food material available for rooting and development of roots at initial stage. Early rooting helps to absorbs nutrients from media and used for growth and development. Similar results were also observed by Singh *et al.* (2014).

Effect of cutting length (L):

The results clearly indicated that, maximum weight of fresh root (0.53g) was recorded with treatment $L_3 i.e.$ (20 cm length) and minimum weight of fresh root (0.35g) was observed in $L_1 i.e.$ (10 cm length). Significantly maximum weight of fresh roots might be due to highest length and maximum number of roots per cuttings. Zhang *et al.* (2010).

IBA concentration (T):

There was significant variation in the application of IBA concentration. As per data, weight of fresh root per cutting was recorded maximum (0.56g) in $T_3 i.e.$ (IBA 5000 ppm) and minimum weight of fresh root (0.34g) was observed in $T_1 i.e.$ (IBA 3000 ppm). Maximum weight of roots might be due to the fact that Auxin is for initiation and growth of roots. This might be also due to the reserved food in the cuttings. Kamboj (2017).

$\begin{array}{c c c c c c c c c c c c c c c c c c c $	Table 3 : Effect of cutting size and IBA concentration on rooting percentage of pomegranate cuttings		Table 3: Contd Interaction (T x D x L)		
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Treatments		$T_1D_1L_1$	·	50.83(33.18)
D 62.37 (38.77) TDL 68.16 (44.00) D 68.79 (43.64) TDJ.1 69.85 (44.70) SE N4 1.13 TDJ.2 66.60 (4.80) CD at 5% 3.39 TDJ.3 69.85 (4.70) Lungth of cutting (L) 60.75 (77.64) TDJ.2 66.19 (41.90) La 60.75 (77.64) TDJ.2 65.16 (40.07) La 66.19 (41.90) TDJ.2 65.16 (40.07) La 66.19 (41.90) TDJ.2 65.16 (47.90) SE Na 0.75 TDJ.1 60.83 (37.83) C.D at 5% 2.35 TDJ.2 73.16 (47.95) BA concentration (T) TDL2 65.00 (40.02) 55. Ti 64.25 (83.65) TDJ.1 67.83 (43.26) SE NA 1.15 TDJ.2 65.00 (40.02) Ti 64.50 (40.48) TDL2 65.00 (40.82) CD at 5% 3.45 TDJ2 73.33 (52.48) LD 57.31 (55.61) TDD2 78.33 (52.48) LD 63.38 (39.67)	Diameter of cutting (D)		$T_1D_1L_2$		67.33 (43.45)
D 68.79 (43.64) T.D.L. 69.85 (44.70) SE N ⁴ 1.13 T.D.L. 63.83 (93.01) Length of cuting (L) TD.L. 63.39 (73.64) T.D.L. Length of cuting (L) TD.L. 64.16 (40.69) L 66.75 (37.64) T.D.L. 64.16 (40.69) L 66.19 (41.89) T.D.L. 62.66 (38.41) La 69.47 (43.99) T.D.L. 62.66 (38.41) SE Nk 0.75 T.D.L. 62.86 (38.41) C.D at 5% 2.35 T.D.L. 66.83 (49.22) Ti 62.83 (88.56) T.D.L. 66.83 (49.22) Ti 62.83 (88.56) T.D.L. 65.80 (41.02) Ti 64.30 (40.48) T.D.L. 67.33 (43.26) SE Nk 1.15 T.D.L. 67.33 (43.26) La 1.15 T.D.L. 67.33 (43.26) La 1.15 T.D.L. 73.00 (48.12) Interaction (L x D) 57.31 (25.61) T.D.L. 73.00 (48.12) La 1.15 T.D.L.		62.37 (38.77)	$T_1D_1L_3$		68.16 (44.00)
SEN± 1.43 T,D_4L_2 65.66 (41.80) C.D. at 55% 3.39 T,D_4L_3 63.33 (20.01) Length of cutting (L) TD,L_1 64.16 (40.69) L_2 66.19 (41.98) TD,L_2 65.15 (41.79) L_3 66.47 (43.99) TD,L_4 62.66 (38.41) SE N± 0.75 TD,L_2 73.16 (47.95) IBA concentration (T) TD,L_4 68.83 (49.27) T1 62.58 (38.56) TD,L_4 68.83 (49.27) T2 64.59 (40.48) TD,L_4 65.06 (41.02) T4 66.02 (41.12) TD,L_4 65.06 (41.02) T5 66.02 (41.12) TD,L_4 65.06 (41.02) T4 66.02 (41.12) TD,L_4 65.06 (41.02) T5 66.02 (41.12) TD,L_4 65.06 (41.02) T4.5 TD,L_4 65.06 (41.02) 73.00 (48.12) Interaction (L D) T3.01 (55.61) TD,L_4 73.00 (48.12) LD 63.83 (93.67) To at 5% NS LD2 67.27 (42.63) D, +D anot 1 cm T- 3000 ppm IBA LD2 65.36 (40.64)					69.85 (44.70)
C.D. at 5% 3.39 T,D,L_1 61.33 (39.01) Length of curting (L) T,D,L_1 64.16 (40.69) La 60.75 (37.66) T,D,L_1 65.15 (41.79) L3 66.19 (41.98) T,D,L_2 65.16 (41.79) L3 69.47 (43.99) T,D,L_3 66.63 8.41) L4 60.83 (37.38) C.D. at 5% 2.35 T,D,L_3 66.03 (47.57) RA concentration (T) T,D,L_3 67.83 (42.92) 71.16 (46.75) Ti 64.50 (40.48) T,D,L_4 66.84 (1.92) Ti 66.02 (41.12) T,D,L_3 67.83 (43.26) SE N* 1.15 T,D,L_4 60.16 (39.85) C.D at 5% 3.45 T,D,L_4 60.16 (39.85) LD1 65.11 (41.22) SE N* 4.30 LD2 63.88 (39.57) Treatment details 78.33 (22.48) LD2 63.88 (39.57) Treatment details 1.2^2 Longth 15 cm T, 3000 ppm IBA LD2 63.88 (39.57) Treatment details 1.2^2 Longth 15 cm T, 3000 ppm IBA LD2 63.88 (39.67) Treatment details 1.2^2 Longth 15 cm					
$\begin{array}{c c c c c c c c c c c c c c c c c c c $. ,
	Length of cutting (L)				
L2 66.19 (41.98) T_D,L_1 62.66 (38.41) L5 69.47 (43.99) T_D,L_1 60.83 (7.38) SE N# 0.75 T_D,L_2 73.16 (47.96) BA concentration (T) T_D,L_3 67.83 (42.2) T_1 62.58 (88.56) T_D,L_1 68.83 (44.92) T_2 64.50 (40.48) T_D,L_2 65.00 (41.02) T_5 66.02 (41.12) T_D,L_1 67.83 (43.26) SE N# 1.15 T_D,L_2 73.00 (84.12) Interaction (L x D) T_D,L_3 78.33 (62.48) L5D 57.31 (35.61) T_D,L_3 78.33 (62.48) L5D 73.33 (35.61) T_D,L_3 78.33 (62.48) L5D 65.11 (41.32) SE N & 43.0 L_2 Length 10 cm T_r 3000 pm IBA L5D 77.27 (42.63) D_r-Dianeter 1 cm L_r Length 10 cm T_r 3000 pm IBA L5D L5D 75.5 (55.40) D_r-Dianeter 1 cm L_r Length 20 cm T_r 5000 pm IBA	Lı	60.75 (37.64)			
13 69.47 (43.99) TD2L1 60.83 (37.38) CD. at 5% 2.35 TD2L2 73.16 (47.96) IBA concentration (T) TD2L3 71.16 (46.75) T1 62.58 (38.56) TDD4.1 68.83 (44.92) T2 64.50 (40.48) TD4.1 68.83 (44.92) T3 66.02 (41.12) TD1.1 67.83 (43.26) SE N± 1.15 TD2.1 67.83 (43.26) CD at 5% 3.45 TD2.1 73.00 (48.12) Interaction (L x D) TD2.1 73.30 (48.12) LD1 65.311 (41.32) SE N± 4.30 LD2 67.27 (42.63) D_1-Diameter 1 cm L ₂ Lengh 10 cm T ₁ - 3000 pm IBA LD2 74.55 (68.62) L ₂ Lengh 10 cm T ₁ - 3000 pm IBA LD2 75.55 (55.40) Thetarction of L cond 2.0 pm IBA T ₁ figures in parenthesis inducate the are sine values TD1 57.55 (55.40) The interaction of L cond 2.0 pm or IBA T ₁ figures in accenter of cutting the set sine values TD2 66.00 (41.08) shows significant effect of (L × D): The interaction of L on Q pm or IBA TD2 66.00 (41.08)	L ₂	66.19 (41.98)			
3.0.1.2 0.0.3 T,D,L_2 73.16 (47.96) BA concentration (T) T,D,L_1 71.16 (46.75) T1 62.28 (38.56) T,D,L_1 68.83 (4.92) T2 64.50 (40.48) T,D,L_1 68.83 (4.92) T3 66.02 (41.12) T,D,L_1 67.83 (43.26) SEN± 1.15 T,D,L_1 67.83 (43.26) SEN± 1.15 T,D,L_2 73.00 (48.12) Intenction (L x D) 57.31 (35.61) S.E.N± 43.0 L,D_1 63.38 (99.67) Treatment details 1.25 L,D_2 63.38 (99.67) Treatment details 1.2 Log In 15 cm 1.7.900 ppm IBA L,D_2 74.55 (48.62) Ly Length 10 cm T, 900 ppm IBA L,D_2 74.55 (48.62) Ly Length 10 cm T, 900 ppm IBA S.E N± 1.48 D-Dimter 1.5 cm Ly Length 10 cm T, 900 ppm IBA S.E N± 1.48 D-Dimter 1.5 cm Ly Length 10 cm T, 900 ppm IBA T,D_2 65.04 (41.65) weight of fresh root (0.60g) per cutting was observed in T,D_2 65.04 (41.65) weight of fresh root (0.23g) was observed in	L ₃	69.47 (43.99)			
BA concentration (T) Table and the second seco	S.E N±	0.75			. ,
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	C.D. at 5%	2.35			. ,
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	IBA concentration (T)		$T_2D_2L_3$		71.16 (46.75)
T ₁ 66.02(41.12) T ₂ D ₁ L ₃ 67.83 (43.26) SE N± 1.15 T ₂ D ₁ L ₃ 67.83 (43.26) Interaction (L x D) T ₂ D ₁ L ₃ 60.16 (39.85) L ₂ D ₁ 57.31 (35.61) T ₂ D ₂ L ₃ 73.00 (48.12) L ₂ D ₁ 65.11 (41.32) SE N± 4.30 L ₂ D ₁ 65.38 (39.67) Teatment details 1.8 L ₂ D ₂ 63.88 (39.67) Teatment details 1.8 L ₂ D ₂ 67.27 (42.63) D ₁ -Diameter 1 cm L ₁ - Length 10 cm T ₁ - 3000 pm IBA L ₂ D ₂ 67.27 (42.63) D ₁ -Diameter 1 cm L ₁ - Length 20 cm T ₂ - 3000 pm IBA L ₂ D ₂ 67.55 (35.40) T ₁ - Length 10 cm T ₁ - 5000 pm IBA T _{1D₂} 66.00 (41.08) The interaction of length and diameter of cutting T _{1D₂} 65.40 (41.65) shows significant effect of (L×D): T _{1D₂} 65.40 (41.65) shows significant effect on weight of fresh root. Highest T _{1D₂ 65.40 (41.65) shows significant effect on weight of fresh root. Highest T_{1D₂ 65.40 (41.65) shows significant effect on weight of fresh root. (0.33g) was observed in}}		62.58 (38.56)	$T_3D_1L_1$		68.83 (44.92)
SE N± 1.15 TD/L 0.7.0 (r0.20) CD. a 5% 3.45 TD/L 60.16 (39.85) Interaction (L x D) TD/L 73.00 (48.12) LD1 57.31 (35.61) TD/L 78.33 (52.48) Lp1 65.11 (41.32) SE N± 4.30 Lp2 63.88 (39.67) Treatment details Lp2 67.27 (42.63) D ₁ -Diameter 1 cm L ₁₇ Length 10 cm T ₁₇ 3000 ppm IBA Lp2 74.55 (48.62) L ₂₇ Length 15 cm T ₂₇ 4000 ppm IBA Ls2 75.55 (55.40) D ₁ -Diameter 1.5 cm L ₂₇ Length 20 cm T ₂₇ 5000 ppm IBA K C.D at 5% 4.44 * figures in parenthesis indicate the arc sine values Interaction (T x D) 77.55 (55.40) Interaction of Length 20 cm T ₂₇ 5000 ppm IBA T ₂ D ₁ 65.40 (41.65) weight of fresh root (0.60g) per cutting was observed in interaction of L [0, 1 / 2 / 2 / 2 / 2 / 2 / 2 / 2 / 2 / 2 /	T ₂		$T_3D_1L_2$		65.00 (41.02)
C. D. at 5% 3.45 1, D_{2L_1} 00.16 (35.83) Interaction (L x D) T, D_{2L_2} 73.00 (48.12) L, D_1 57.31 (35.61) T, D_{2L_3} 78.33 (62.48) L_3D_1 65.11 (41.32) S.E N± 4.30 L_3D_2 63.38 (39.37) CD at 5% NS L_3D_2 67.27 (42.63) D_1-Diameter 1 cm T_1 -Length 10 cm T_1 -2000 ppm IBA L_3D_2 67.27 (42.63) D_1-Diameter 1.5 cm L_2 -Length 15 cm T_2 -4000 ppm IBA S.E N± 1.48 D_2-Dimeter 1.5 cm L_2 -Length 20 cm T_2 -5000 ppm IBA S.E N± 1.48 D_2-Dimeter 1.5 cm L_2 -Length 20 cm T_2 -5000 ppm IBA T_3D_1 65.26 (41.08) Interaction effect of (L $\times D$): The interaction of length and diameter of cutting shows significant effect on weight of fresh root. Highest T_3D_1 63.38 (39.72) The interaction of L_0, <i>i.e.</i> (length 10 cm and diameter 1.5 cm) L_2 i.e. T_3D_1 63.89 (39.72) weight of fresh root (0.60g) per cutting was observed in in interaction of L_0, <i>i.e.</i> (length 10 cm and diameter 1.5 cm) T_3D_2 69.77 (43.40) interaction of L_0, <i>i.e.</i> (length 10 cm and diameter 1.5 cm)			$T_3D_1L_3$		67.83 (43.26)
Interaction (L x D) TJDL2 73.00 (48.12) LD1 57.31 (35.61) TJDL3 78.33 (52.48) L2D1 65.11 (41.32) SE N± 4.30 L4D1 63.38 (39.37) CD at 5% NS L4D2 63.88 (39.67) Treatment details L3D2 67.27 (42.63) D ₁ -Diameter 1 cm L ₁₇ Length 10 cm T ₁ - 3000 ppm IBA L5D2 74.55 (48.62) L ₂₇ Length 15 cm T ₂ - 4000 ppm IBA L5D2 75.55 (35.40) L ₂₇ Length 10 cm T ₁ - 5000 ppm IBA L5D2 66.00 (41.08) The interaction of length and diameter of cutting TD1 57.55 (35.40) The interaction of length and diameter of cutting TD2 66.00 (41.68) The interaction of length and diameter of cutting TJD2 65.40 (41.65) weight of fresh root (0.60g) per cutting was observed in TJD2 69.77 (43.40) interaction of L ₁ D ₁ <i>i.e.</i> (length 20 cm and diameter 1.5 TJD2 69.77 (43.40) interaction of L ₁ D ₁ <i>i.e.</i> (length 20 cm and diameter 1.5 TJD2 69.77 (43.40) interaction of L ₁ D ₁ <i>i.e.</i> (length 20 cm and diameter 1.5 TJD2 69.77 (43.40) interactio			$T_3D_2L_1$		60.16 (39.85)
$\begin{array}{llllllllllllllllllllllllllllllllllll$		3.45	$T_3D_2L_2$		73.00 (48.12)
LD1 57.31 (5.81) Lp1 65.11 (41.32) SE N± 4.30 Lp1 63.38 (9.37) CD at 5% NS Ld2 63.88 (9.67) Treatment details Lp- Length 10 cm Tr- 3000 ppm IBA LsD2 67.27 (42.63) D ₁ -Diameter 1 cm Lp- Length 10 cm Tr- 3000 ppm IBA LsD2 74.55 (48.62) Lp- Length 10 cm Tr- 3000 ppm IBA SEN± 1.48 D ₁ -Diameter 1.5 cm Lp- Length 20 cm Tp- 3000 ppm IBA C.D. at 5% 4.44 * figures in parenthesis indicate the arc sine values TiD1 57.55 (35.40) Interaction of length and diameter of cutting shows significant effect on weight of fresh root. Highest weight of fresh root (0.60g) per cutting was observed in interaction of L_3D_3 i.e. (length 20 cm and diameter 1.5 TsD2 65.40 (41.65) shows significant effect on (0.33g) was observed in interaction of L_3D_3 i.e. (length 10 cm and diameter 1.5 TsD2 69.77 (43.40) interaction of L_1D_1 i.e. (length 10 cm and diameter 1.5 SEN± 1.48 cm) and lowest weight of fresh root (0.33g) was observed in interaction of L_1D_1 i.e. (length 10 cm and diameter 1.5 TsD4 65.03 (42.01) have not affected significantly on weight of fresh root. TsL4					78.33 (52.48)
Lapt CD at 5% NS L ₁ D ₂ 63.38 (39.37) CD at 5% NS L ₁ D ₂ 63.88 (39.37) Treatment details L ₂ D ₂ 67.27 (42.63) D ₁ -Diameter 1 cm L ₁ - Length 10 cm T ₁ - 3000 ppm IBA L ₂ D ₂ 67.27 (42.63) D ₁ -Diameter 1 cm L ₁ - Length 15 cm T ₂ - 4000 ppm IBA L ₂ D ₂ 67.27 (42.63) D ₂ -Dimeter 1.5 cm L ₂ - Length 12 cm T ₂ - 5000 ppm IBA C.D at 5% 4.44 D ₂ -Dimeter 1.5 cm L ₂ - Length 20 cm T ₃ - 5000 ppm IBA Interaction (T x D) 57.55 (35.40) Interaction effect of (L × D): The interaction of length and diameter of cutting shows significant effect on weight of fresh root. Highest weight of fresh root (0.60g) per cutting was observed in interaction of L ₁ D ₂ <i>i.e.</i> (length 10 cm and diameter 1.5 T ₁ D ₂ 69.77 (43.40) in theraction of L ₁ D ₂ <i>i.e.</i> (length 10 cm and diameter 1.5 SE N± 1.48 in interaction of L ₁ D ₂ <i>i.e.</i> (length 10 cm and diameter 1.5 C.D at 5% 4.45 in interaction of L ₁ D ₁ <i>i.e.</i> (length 10 cm and diameter 1.5 SE N± 1.48 in interaction of L ₁ D ₁ <i>i.e.</i> (length 10 cm and diameter 1.5 T ₁ L ₂ 67.00 (42.89) in interaction					. ,
LD263.88 (39.67)Treatment detailsL2D267.27 (42.63) D_1 -Diameter 1 cm L_1 -Length 10 cm T_1 -3000 ppm IBAL3D274.55 (48.62) L_2 -Length 15 cm T_2 -4000 ppm IBASE N±1.48 D_2 -Dimeter 1.5 cm L_2 -Length 20 cm T_2 -5000 ppm IBAInteraction (T x D)57.55 (35.40)Interaction effect of $(L \times D)$:T1D157.55 (35.40)The interaction of length and diameter of cuttingT2D166.00 (41.08)The interaction of length and diameter of cuttingT3D265.40 (41.65)weight of fresh root (0.60g) per cutting was observed inT3D269.77 (43.40)interaction of L_3D_2 i.e. (length 10 cm and diameter 1.5SE N±1.48cm) and lowest weight of fresh root (0.33g) was observedC.D at 5%4.45in interaction of L_3D_2 i.e. (length 10 cm and diameter 1Interaction (L x T)90DAPcm). However, Application of IBA and cutting diameterT1La65.50 (34.10)have not affect of $(T \times L)$:T1La65.50 (42.75)The interaction of T_3L_4 i.e. (IBA 5000 ppm and 20T_1La65.25 (41.56)Interaction effect of $(T \times L)$:T2L165.50 (42.75)cm length) was recorded significantly maximum weightT3L265.50 (42.20)of fresh root (0.59g), which was statistically at par withT3L470.75 (45.38)3000 ppm and 10 cm length). The weight of fresh root					
L_2D_2 67.27 (42.63) D_1 -Diameter 1 cm L_1 - Length 10 cm T_1 - 3000 ppm IBA L_3D_2 74.55 (48.62) L_2 - Length 15 cm T_2 - 4000 ppm IBA $S.E N\pm$ 1.48 D_2 -Dimeter 1.5 cm L_2 - Length 20 cm T_3 - 5000 ppm IBA $C.D$ at 5%4.44 P_2 -Dimeter 1.5 cm L_2 - Length 20 cm T_3 - 5000 ppm IBAInteraction (T x D) T_1D_1 57.55 (35.40)Interaction effect of $(L \times D)$: T_1D_1 66.00 (41.08)Interaction of length and diameter of cutting T_2D_2 65.40 (41.65)weight of fresh root ($0.60g$) per cutting was observed in T_3D_2 69.77 (43.40)interaction of L_3D_2 .e. (length 20 cm and diameter 1.5 $S.E N\pm$ 1.48cm) and lowest weight of fresh root ($0.33g$) was observed in $C.D$ at 5%4.45in interaction of L_3D_2 .i.e. (length 10 cm and diameter 1Interaction (L x T)90DAPm. However, Application of IBA and cutting diameter T_1L_1 56.50 (41.00)Hoteware and affected significantly on weight of fresh root. T_1L_4 56.50 (42.75)The interaction of T_3L_3 .e. (IBA 5000 ppm and 20 T_2L_1 63.00 (39.25)The interaction of T_3L_3 .e. (IBA 5000 ppm and 20 T_3L_2 65.50 (42.02)of fresh root ($0.52g$). However, minimum weight T_3L_4 58.12 (36.25)of fresh root ($0.52g$). However, minimum weight T_3L_4 70.75 (45.38) 3000 ppm and 10 cm length). The weight of fresh root					113
LaD:74.55 (48.62)Law the first of the second parameter of the secon				T T (110	T 2000 DA
S.E N±1.48 D_2 -Dimeter 1.5 cm D_2 -Length 20 cm T_3 - 5000 ppm IBAC.D. at 5%4.44 $\frac{1}{2}$ figures in parenthesis indicate the arc sine valuesTrD157.55 (35.40)TrD266.00 (41.08)T_2D164.27 (40.48)T_3D265.40 (41.65)T_3D269.77 (43.40)S.E N±1.48C.D. at 5%4.45T_1D269.77 (43.40)T_1D265.50 (41.05)S.E N±1.48C.D. at 5%4.45Interaction of $L_3D_2i.e.$ (length 20 cm and diameter 1.5S.E N±1.48C.D. at 5%4.45Interaction (L x T)90DAPcm). However, Application of IBA and cutting diameter 1T_1L_265.00 (42.03)T_1L_365.25 (41.56)T_1L_465.25 (41.56)Interaction of $T_3L_4i.e.$ (IBA 5000 ppm and 20T_1L_465.50 (42.75)T_1L_465.50 (42.75)T_1L_465.50 (42.22)T_1L_465.50 (42.02)T_1L_465.50 (42.02)T_1L_465.			D_1 -Diameter I cm	Ū.	
C.D. at 5%4.44D_2-Diffed F1.5 dffList regin 20 cm1 st - 500 ppm rbAInteraction (T x D)* figures in parenthesis indicate the arc sine valuesT_1D_157.55 (35.40)T_1D_266.00 (41.08)T_3D_164.27 (40.48)T_3D_265.40 (41.65)T_3D_269.77 (43.40)SE N±1.48C.D. at 5%4.45Interaction (L x T)9DDAPT_1L_267.00 (42.89)T_1L_365.25 (41.56)T_1L_465.25 (41.56)T_1L_465.25 (41.56)T_1L_465.25 (41.56)T_1L_465.25 (41.56)T_1L_465.25 (41.56)T_1L_465.25 (41.56)T_1L_465.25 (41.56)T_1L_465.25 (42.25)T_1L_465.50 (42.75)T_2L_266.50 (42.75)T_2L_465.50 (42.02)T_1L_460.23 (39.25)T_1L_467.75 (45.38)T_1L_470.75 (45.				-	
Interaction (T x D)Ti,D157.55 (35.40)Ti,D266.00 (41.08)T_3D164.27 (40.48)T_3D265.40 (41.65)Tb163.89 (39.72)Tb269.77 (43.40)Tb269.77 (43.40)Tb11.48C,D at 5%4.45Theraction (L x T)90DAPTi,L265.00 (42.89)Ti,L365.25 (41.56)Ti,L465.05 (34.10)Ti,L365.25 (41.56)Ti,L465.05 (42.75)Ta,L465.05 (42.75)Ta,L465.50 (42.75)Ta,L558.12 (36.25)Ta,L460.23 (39.25)Ti,L570.75 (45.38)Ta,L570.75 (45.38)Ta,L570.				-	
T ₁ D ₁ 57.55 (35.40)Interaction effect of $(L \times D)$:T ₁ D ₂ 66.00 (41.08)The interaction of length and diameter of cutting shows significant effect on weight of fresh root. Highest weight of fresh root (0.60g) per cutting was observed in interaction of L ₃ D ₂ <i>i.e.</i> (length 20 cm and diameter 1.5 			* figures in parenthesi	is indicate the arc sine va	lues
T ₁ D ₂ 66.00 (41.08)The interaction effect of $(L \times D)$.T ₂ D ₁ 64.27 (40.48)The interaction of length and diameter of cuttingT ₃ D ₂ 65.40 (41.65)shows significant effect on weight of fresh root. HighestT ₃ D ₂ 69.77 (43.40)interaction of L ₃ D ₂ <i>i.e.</i> (length 20 cm and diameter 1.5S.E N±1.48cm) and lowest weight of fresh root (0.33g) was observedC.D. at 5%4.45in interaction of L ₁ D ₁ <i>i.e.</i> (length 10 cm and diameter 1Interaction (L x T)90DAPcm). However, Application of IBA and cutting diameterT ₁ L ₂ 67.00 (42.89)interaction effect of $(T \times L)$:T ₁ L ₂ 65.00 (41.05)Interaction of T ₃ L ₃ <i>i.e.</i> (IBA 5000 ppm and 20T ₁ L ₂ 66.50 (42.75)cm length) was recorded significantly maximum weightT ₃ L ₂ 65.50 (42.02)of fresh root (0.59g), which was statistically at par withT ₃ L ₃ 70.75 (45.38)3000 ppm and 10 cm length). The weight of fresh root		57.55 (35.40)	T		
T_3D164.27 (40.48)The interaction of length and diameter of cuttingT_3D265.40 (41.65)shows significant effect on weight of fresh root. HighestT_3D163.89 (39.72)weight of fresh root (0.60g) per cutting was observed inT_3D269.77 (43.40)interaction of $L_3D_2i.e.$ (length 20 cm and diameter 1.5S.E N±1.48cm) and lowest weight of fresh root (0.33g) was observedC.D. at 5%4.45in interaction of $L_1D_1i.e.$ (length 10 cm and diameter 1Interaction (L x T)90DAPcm). However, Application of IBA and cutting diameterT_1L156.50 (34.10)have not affected significantly on weight of fresh root.T_1L267.00 (42.89)The interaction of $T_3L_3i.e.$ (IBA 5000 ppm and 20T_2L266.50 (42.75)The interaction of $T_3L_3i.e.$ (IBA 5000 ppm and 20T_2L358.12 (36.25)of fresh root (0.59g), which was statistically at par withT_3L460.23 (39.25)interaction of $T_3L_2(0.52g)$. However, minimum weightT_3L370.75 (45.38)3000 ppm and 10 cm length). The weight of fresh root					1
T_2D_2 65.40 (41.65)shows significant effect on weight of fresh root. Highest T_3D_1 63.89 (39.72)weight of fresh root (0.60g) per cutting was observed in T_3D_2 69.77 (43.40)interaction of $L_3D_2i.e.$ (length 20 cm and diameter 1.5S.E N±1.48cm) and lowest weight of fresh root (0.33g) was observedC.D. at 5%4.45in interaction of L_1D_1 i.e. (length 10 cm and diameter 1Interaction (L x T)90DAPcm). However, Application of IBA and cutting diameter T_1L_1 56.50 (34.10)have not affected significantly on weight of fresh root. T_1L_2 67.00 (42.89)The interaction of $T_3L_3i.e.$ (IBA 5000 ppm and 20 T_2L_2 66.50 (42.75)cm length) was recorded significantly maximum weight T_2L_3 58.12 (36.25)of fresh root (0.59g), which was statistically at par with T_3L_4 60.23 (39.25)interaction of T_3L_2 (0.52g). However, minimum weight T_3L_3 70.75 (45.38)3000 ppm and 10 cm length). The weight of fresh root				-	-
T_3D_1 $63.89 (39.72)$ weight of fresh root $(0.60g)$ per cutting was observed in interaction of $L_3D_2i.e.$ (length 20 cm and diameter 1.5 $S.E N\pm$ 1.48 interaction of $L_3D_2i.e.$ (length 20 cm and diameter 1.5 $C.D. at 5\%$ 4.45 in interaction of L_1D_1 i.e. (length 10 cm and diameter 1Interaction (L x T)90DAPcm). However, Application of IBA and cutting diameter T_1L_1 $56.50 (34.10)$ have not affected significantly on weight of fresh root. $T_1 L_2$ $67.00 (42.89)$ Interaction effect of $(T \times L)$: T_2L_1 $63.00 (39.00)$ The interaction of $T_3L_3i.e.$ (IBA 5000 ppm and 20 T_2L_2 $66.50 (42.75)$ cm length) was recorded significantly maximum weight T_3L_4 $65.25 (41.66)$ Interaction of $T_3L_2(0.52g)$. However, minimum weight T_3L_4 $70.75 (45.38)$ of fresh root $(0.32g)$ was observed in T_1L_1 i.e. (IBA T_3L_4 $70.75 (45.38)$ 3000 ppm and 10 cm length). The weight of fresh root			•	•	•
SE N±1.48cm) and lowest weight of fresh root $(0.33g)$ was observed in interaction of L_1D_1 <i>i.e.</i> (length 10 cm and diameter 1 cm). However, Application of IBA and cutting diameter have not affected significantly on weight of fresh root.T_1L_156.50 (34.10)have not affected significantly on weight of fresh root.T_1L_267.00 (42.89)Interaction effect of $(T \times L)$:T_2L_163.00 (39.00)The interaction of T_3L_3 <i>i.e.</i> (IBA 5000 ppm and 20T_2L_266.50 (42.75)cm length) was recorded significantly maximum weightT_3L_160.23 (39.25)of fresh root (0.59g), which was statistically at par with interaction of T_3L_2 (0.52g). However, minimum weightT_3L_370.75 (45.38)3000 ppm and 10 cm length). The weight of fresh root		63.89 (39.72)	-		-
C.D. at 5%4.45in interaction of L_1D_1 <i>i.e.</i> (length 10 cm and diameter 1Interaction (L x T)90DAPcm). However, Application of IBA and cutting diameter T_1L_1 56.50 (34.10)have not affected significantly on weight of fresh root. $T_1 L_2$ 67.00 (42.89)Interaction effect of $(T \times L)$: $T_1 L_3$ 65.25 (41.56)Interaction of T_3L_3 <i>i.e.</i> (IBA 5000 ppm and 20 $T_2 L_2$ 63.00 (39.00)The interaction of T_3L_3 <i>i.e.</i> (IBA 5000 ppm and 20 $T_2 L_2$ 66.50 (42.75)cm length) was recorded significantly maximum weight $T_3 L_1$ 60.23 (39.25)of fresh root (0.59g), which was statistically at par with $T_3 L_2$ 65.50 (42.02)of fresh root (0.32g) was observed in $T_1 L_1$ <i>i.e.</i> (IBA $T_3 L_3$ 70.75 (45.38)3000 ppm and 10 cm length). The weight of fresh root	T_3D_2	69.77 (43.40)			
Interaction (L x T)90 DAPcm). However, Application of IBA and cutting diameter have not affected significantly on weight of fresh root. $T_1 L_2$ $65.0 (34.10)$ have not affected significantly on weight of fresh root. $T_1 L_2$ $67.00 (42.89)$ Interaction effect of $(T \times L)$: $T_2 L_1$ $63.00 (39.00)$ The interaction of $T_3 L_3 i.e.$ (IBA 5000 ppm and 20 $T_2 L_2$ $66.50 (42.75)$ cm length) was recorded significantly maximum weight $T_2 L_3$ $58.12 (36.25)$ of fresh root $(0.59g)$, which was statistically at par with $T_3 L_1$ $60.23 (39.25)$ interaction of $T_3 L_2 (0.52g)$. However, minimum weight $T_3 L_3$ $70.75 (45.38)$ 3000 ppm and 10 cm length). The weight of fresh root	S.E N±	1.48			
T_1L_1 56.50 (34.10)have not affected significantly on weight of fresh root. T_1L_2 67.00 (42.89) T_1L_3 65.25 (41.56) T_2L_1 63.00 (39.00) T_2L_2 66.50 (42.75) T_2L_3 58.12 (36.25) T_3L_4 60.23 (39.25) T_3L_2 65.50 (42.02) T_3L_3 70.75 (45.38) $S \in N++$ 2.04	C.D. at 5%	4.45			
$T_1 L_2$ $67.00 (42.89)$ $T_1 L_3$ $65.25 (41.56)$ $T_2 L_1$ $63.00 (39.00)$ $T_2 L_2$ $66.50 (42.75)$ $T_2 L_3$ $58.12 (36.25)$ $T_3 L_1$ $65.25 (41.56)$ $T_2 L_3$ $58.12 (36.25)$ $T_3 L_2$ $65.50 (42.02)$ $T_3 L_3$ $70.75 (45.38)$ $S E N + $ 2.04	Interaction (L x T)	90DAP			-
$T_1 L_3$ 65.25 (41.56)Interaction effect of $(T \times L)$: $T_2 L_1$ 63.00 (39.00)The interaction of $T_3 L_3 i.e.$ (IBA 5000 ppm and 20 $T_2 L_2$ 66.50 (42.75)The interaction of $T_3 L_3 i.e.$ (IBA 5000 ppm and 20 $T_2 L_3$ 58.12 (36.25)cm length) was recorded significantly maximum weight $T_3 L_1$ 60.23 (39.25)interaction of $T_3 L_2 (0.52g)$. However, minimum weight $T_3 L_3$ 70.75 (45.38)of fresh root (0.32g) was observed in $T_1 L_1 i.e.$ (IBA $S E N +$ 2.043000 ppm and 10 cm length). The weight of fresh root	T_1L_1	56.50 (34.10)	have not affected	significantly on v	veight of fresh root.
T_2L_1 63.00 (39.00)The interaction of $T_3L_3i.e.$ (IBA 5000 ppm and 20 T_2L_2 66.50 (42.75)cm length) was recorded significantly maximum weight T_2L_3 58.12 (36.25)of fresh root (0.59g), which was statistically at par with T_3L_1 60.23 (39.25)interaction of T_3L_2 (0.52g). However, minimum weight T_3L_2 65.50 (42.02)of fresh root (0.32g) was observed in $T_1L_1 i.e.$ (IBA T_3L_3 70.75 (45.38)3000 ppm and 10 cm length). The weight of fresh root	$T_1 L_2$	67.00 (42.89)			
T_2L_2 66.50 (42.75)cm length) was recorded significantly maximum weight T_2L_3 58.12 (36.25)of fresh root (0.59g), which was statistically at par with T_3L_1 60.23 (39.25)interaction of T_3L_2 (0.52g). However, minimum weight T_3L_2 65.50 (42.02)of fresh root (0.32g) was observed in T_1L_1 <i>i.e.</i> (IBA T_3L_3 70.75 (45.38)3000 ppm and 10 cm length). The weight of fresh root			Interaction effec	et of $(T \times L)$:	
T_2L_3 58.12 (36.25)of fresh root (0.59g), which was statistically at par with interaction of T_3L_2 (0.52g). However, minimum weight of fresh root (0.32g) was observed in T_1L_1 <i>i.e.</i> (IBA 3000 ppm and 10 cm length). The weight of fresh root		63.00 (39.00)	The interaction of T ₃ L ₃ <i>i.e.</i> (IBA 5000 ppm and 20		A 5000 ppm and 20
T_3L_1 $60.23 (39.25)$ interaction of $T_3L_2 (0.52g)$. However, minimum weight T_3L_2 $65.50 (42.02)$ of fresh root (0.32g) was observed in T_1L_1 <i>i.e.</i> (IBA T_3L_3 $70.75 (45.38)$ 3000 ppm and 10 cm length). The weight of fresh root					tly maximum weight
T_3L_2 $65.50 (42.02)$ interfaction of T_3L_2 (0.52g). However, infinitum weight T_3L_3 $70.75 (45.38)$ of fresh root (0.32g) was observed in T_1L_1 <i>i.e.</i> (IBA SEN_+ 2.04 3000 ppm and 10 cm length). The weight of fresh root					
$T_3 L_2$ 65.50 (42.02)of fresh root (0.32g) was observed in $T_1 L_1$ <i>i.e.</i> (IBA $T_3 L_3$ 70.75 (45.38)3000 ppm and 10 cm length). The weight of fresh root					
$\frac{1_3 L_3}{S E N+}$ $\frac{70.75 (45.38)}{2.04}$ $3000 \text{ ppm and } 10 \text{ cm length}$. The weight of fresh root					
SEN+ 204					
was found to be non significant as influenced by IBA			was found to be non significant as influenced by IBA		
$\frac{C.D. at 5\%}{Table 3 : Contd}$ concentrations, diameter and length of cutting (T×D×L).	C.D. at 5%				

Internat. J. agric. Sci. | Jan., 2021 | Vol. 17 | Issue 1 | 51-60 [58] Hind Agricultural Research and Training Institute

Dry weight of root (g):

The effect of cutting diameter (D), length of cutting (L), IBA concentrations (T) and their interactions on weight of dry root per cutting of pomegranate are presented in Table 4.

Effect of cutting diameter (D):

The maximum weight of dry root (0.30g) was recorded in $D_2 i.e.$ (1.5 cm diameter) and minimum weight of dry root (0.23g) was observed in $D_1 i.e.$ (1 cm diameter). A significant increase in root biomass is correlated with increase in diameter of cuttings in Feijoa sellowiana. This was possibly because of early root initiation in large sized cuttings which provided longer time for their growth and development. Zhang *et al.* (2010)

Effect of cutting length (L):

Maximum weight of dry roots (0.32g) was recorded with treatment of $L_3 i.e.$ (20 cm length) and minimum weight of dry roots (0.210g) in $L_1 i.e.$ (10 cm length). The higher food reserve in large sized cuttings could be a reason for their better growth and development of the cuttings. Kaur and Kaur (2018).

IBA concentration (T):

Significantly highest weight of dry root (0.33g) per cutting was recorded in treatment $T_3i.e.$ (IBA 5000 ppm) and lowest weight of dry root (0.21g) was observed in treatment $T_1i.e.$ (IBA 3000 ppm). Themaximum root weight was attributed to the fact that auxins naturally occuring or exogeneously applied are for initiation and growth of roots. Low auxin activity and its slow degradation by Auxin destroying enzyme lead to the reserved food in the cuttings Singh *et al.* (2013).

Interaction effect of $(L \times D)$:

Significantly maximum weight of dry root (0.31g) was observed in interaction of $L_3D_2i.e.$ (length 20 cm and diameter 1.5 cm) and minimum weight of dry root (0.19g) was observed in interaction of L_1D_1 *i.e.* (length 10 cm and diameter 1 cm). However, interaction effectof IBA concentration and cutting diameteron dry weight of root was found to be non significant.

Interaction effect of $(T \times L)$:

The interaction of T₃L₃*i.e.* (IBA 5000 ppm and 20

Table 4: Effect of cutting size and IBA concentration on weight of roots per cutting of pomegranate

roots per cutting of pomegranate				
T i i	Fresh weight of root	Dry weight of root		
Treatments	(g) 90DAP	(g) 90DAP		
Diameter of cutting (D)	JODIN	JODIN		
D_1	0.38	0.23		
D ₁ D ₂	0.50	0.30		
S.E N±	0.032	0.021		
C.D. at 5%				
Length of cutting (L)	0.090	0.059		
	0.35	0.21		
L ₁				
L ₂	0.44	0.26		
L ₃	0.53	0.32		
S.E N±	0.040	0.026		
C.D. at 5%	0.11	0.072		
IBA concentration (T)				
T ₁	0.34	0.21		
T ₂	0.42	0.26		
T ₃	0.56	0.33		
S.E N±	0.040	0.026		
C.D. at 5%	0.11	0.072		
Interaction (L x D)				
L_1D_1	0.33	0.19		
L_2D_1	0.42	0.24		
L_3D_1	0.36	0.21		
L_1D_2	0.35	0.22		
L_2D_2	0.51	0.29		
L_3D_2	0.60	0.31		
S.E N±	0.056	0.036		
C.D. at 5%	0.15	0.10		
Interaction (T x D)				
T_1D_1	0.30	0.18		
T_1D_2	0.38	0.24		
T_2D_1	0.36	0.22		
T_2D_2	0.48	0.28		
T_3D_1	0.48	0.26		
T_3D_2	0.55	0.31		
S.E N±	0.056	0.036		
C.D. at 5%	NS	NS		
Interaction (L x T)	90DAP	90DAP		
T_1L_1	0.32	0.18		
$T_1 L_2$	0.33	0.20		
$T_1 L_3$	0.36	0.23		
$T_2 L_1$	0.43	0.23		
$T_2 L_2$	0.46	0.26		
T_2L_2 T_2L_3	0.37	0.23		
T_2L_3 T_3L_1	0.36	0.21		
T_3L_2	0.52	0.24		
T_3L_2 T_3L_3	0.59	0.29		
S.E N±	0.069	0.045		
C.D. at 5%	0.19	0.12		
		le 4: Contd		

Table 4: Contd		
Interaction (T x D x L)	-
$T_1D_1L_1$	0.21	0.13
$T_1D_1L_2$	0.25	0.14
$T_1D_1L_3$	0.43	0.27
$T_1D_2L_1$	0.50	0.04
$T_1D_2L_2$	0.41	0.26
$T_1D_2L_3$	0.23	0.15
$T_2D_1L_1$	0.41	0.23
$T_2D_1L_2$	0.31	0.22
$T_2D_1L_3$	0.36	0.20
$T_2D_2L_1$	0.46	0.25
$T_2D_2L_2$	0.61	0.26
$T_2D_2L_3$	0.38	0.24
$T_3D_1L_1$	0.62	0.29
$T_3D_1L_2$	0.52	0.28
$T_3D_1L_3$	0.29	0.16
$T_3D_2L_1$	0.44	0.28
$T_3D_2L_2$	0.51	0.22
$T_3D_2L_3$	0.71	0.32
S.E N±	0.098	0.064
CD at 5%	NS	NS
Treatment details		
D ₁ -Diameter 1 cm	L ₁ - Length 10 cm	T ₁ - 3000 ppm IBA
	L ₂ - Length 15 cm	T ₂ - 4000 ppm IBA
D ₂ -Dimeter 1.5 cm	L ₃ - Length 20 cm	T ₃ - 5000 ppm IBA

cm length) was recorded significantly maximum weight of dry root (0.29g) which was statistically at par with the interactions of T_2L_2 (0.26g) and T_3L_2 (0.24g) while, minimum weight of dry root (0.18g) was observed with interaction of T_1L_1 *i.e.* (IBA 3000 ppm and 10 cm length). However, interaction effect of IBA concentrations, diameter and length of cutting (T×D×L)on weight of dry root was found to be non significant.

Significantly maximum weight of dry roots is due to maximum length and highest number of roots. This might be due to reserve food material available for rooting and development of roots, shoots. Similar results were also reported by Singh *et al.* (2014).

Conclusion:

Table 4 · Contd

Pomegranate cuttings when treated with treatment combination of $T_3D_2L_3$ *i.e.* (IBA 5000 ppm, 1.5 cm diameter and 20 cm length) was found better on root parameters in respect tomaximum number of roots, highest length of roots, rooting percentage and weight of roots of pomegranate cutting.

REFERENCES

Hartman, Kester and Davies (1990). *Plant propagation; principles and practices*. 5th edition Prince-Hall, London, 727.

Hartman, Kester, Davies and Geneva (2002). *Plant* propagation; principles and practices. 6th edition Prince-Hall International editions, Englewood Cliffs, New Jersey, USA.

Kamboj, Singh, K., Singh, S. and Gandhi, N. (2017). Effect of Indole Butyric Acid on rooting and vegetative parameters of pomegranate (*Punica granatum* L.) cuttings. *Int. Conf. on Recent Innovations in Sci. Agri. Eng. & Management* ISBN: 978-93-86171-80-1.

Kaur and Kaur (2018). Determination of suitable cutting size for rooting of Pear cuttings *cv*. Patharnakh. *International Journal of Agriculture Science*, **10** (12): 6445-6448.

Leaky, R.R.B. and Mohammed, H.R.S.(1985). The effect of stem length on root initiation in sequential single node cuttings of Triplochitonsleroxylon K. chum. *J. Horticultu. Sci.*, **60**(5): 431-437.

Levin, G.M. (2006). *Pomegranate roads:a Soviet botanist's exile from Eden*. pp. 15–183. B.L.Baer (ed.), Floreat Press, Forestville, CA.

Mar, M. (2000). Pomegranate plants materials. Genetics resources and breeding, a review options Mediterranean's series A. *Seminnaires Mediterranean's*, 42: 55-62.

Naidu, R.D. and Jones, N.B. (2009). The effect of cutting length on rooting and growth of subtropical *Eucalyptus* hybrid clones in South Africa. *Southern Forests*, **71** (4): 297-301.

Pooja, H.M., Vasundhara, M., Diwarkar, Y., Sreeramu, B.S., Harisha and Rajshekar (2013). Standardization of length of cuttings for vegetative propagation of Japanese honeysuckle (*Lonicera japonica*). *The Asian Journal of Horticulture*, **8** (1): 21-23.

Shukla, H.S., Tripathi, V.K., Awasthi, R.D. and Tripathi, A.K. (2010). Effect of IBA, PHB and Boron on rooting and shoot growth of hard wood stem cuttings of peach. *International Journal of Applied Agricultural Research.* 5 (4): 467-473.

Singh, K.K., Choudhary, T. and Kumar, A. (2014). Effect of various concentrations of IBA and NAA on the rooting of stem cuttings of Mulberry (*Morus Alba* L.) under mist house condition in Garhwal hill region. *Indian Journal of Hill Farming*, **27** (1): 125-131.

Zhang, M., Wang, D., Ren, S., Fan, L. and Liu, R. (2010). Effects of Feijoa diameter on seedling quality. *Agric. Journal*, 5 (3): 139-141.

