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Evaluation of different doses of indole-3-butyric acid (IBA) on the rooting, survival and vegetative growth performance of hardwood cuttings of Flordaguard peach (*Prunus persica* L. Batch)

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Abstract: The present study was conducted on the evaluation of different doses of indole-3-butyric acid (IBA) on the rooting, survival and vegetative growth performance of hardwood cuttings of Flordaguard peach (*Prunus persica* L. Batch) during the years 2012-13 and 2013-14 at Punjab Agricultural University, Regional Research Station, Gurdaspur. The hardwood cuttings of 10 years old Flordaguard peach plant having 15-20cm in length and 0.8-1.2cm in diameter with 6-7 buds were prepared in the first fortnight of January .The basal portion of the cuttings was dipped in different doses of IBA *viz.* 1000ppm, 2000ppm, 3000ppm, 4000pppm, 5000ppm and control (without IBA treatment) for 1-2 minutes and planted in an open field conditions by following the recommended cultural practices for nursery raising. It was noticed that hardwood cuttings of Flordaguard peach treated with 3000ppm of IBA for 1-2 minutes significantly took the minimum number of days to sprouting (7.05), rooting (6.0) with highest sprouting percentage (98.45%), survival percentage (90.55%), plant height(195.45cm), plant girth(10.50cm), number of branches(13.50) ,number of leaves (260.4), leaf length (19.55cm), leaf breadth (4.12cm), leaf weight (2.0gm), percent rooting (94.45%), number of roots (75.83), root length (38.0cm), root girth (0.98 cm) and root weight (13.50gm).Therefore, the application of 3000 ppm IBA was found to be best in terms of rooting, survival and vegetative growth of hardwood cuttings of Flordaguard peach (*Prunus persica* L. Batch). The beneficial effect of present work develop protocol which can be reliably used to develop the rootstock plant of Flordaguard which is resistant to nematodes through cutting which become ready for budding/grafting in the field in one year instead of two years as raised through seed.

Keywords: Indole-3-butyric acid, Hardwood cuttings, Peach, Rooting, Survival, Vegetative growth

INTRODUCTION

Peach (*Prunus persica* L. Batch) belongs to family Rosaceae and sub-family Prunoidae is a winter deciduous stone fruit plant and is probably the most adapted temperate fruit to the warmer climate. Besides being cultivated in the temperate climate in the hills, it is also cultivated in the north Indian plains (sub-tropical climate) in the states of Punjab, Haryana, Rajasthan and Uttar Pradesh with the introduction of low chilled peaches. In Punjab, it is grown in an area of 1716 hectares with production of 30340 metric tonnes annually (Annonymous, 2015). Peach is a temperate zone fruit tree but it is possible to grow in the sub-tropical climate of Punjab plains because of availability of suitable low chilling cultivars. In Punjab, about 300 chilling hours are available and the cultivars whose chilling requirement is more than 300 hours shall not grow successfully. Peach cultivation is distributed throughout the state. Sub-tropical climate of Punjab is ideally suited for the cultivation of low chilling peaches (Annonymous, 2010). Peaches are highly valued as a table fruit for their attractive colour and palatability. Fruits contain about 8.0 percent sugar, 0.8 per cent minerals and 1.5 per cent proteins. Peaches can be processed as canned and dried products, frozen preserves, jam, nectar, juice, beverage and marmalade etc. Peaches are also good source of low calorific diet. The peach kernel oil is utilized in manufacturing of large number of cosmetics and pharmaceutical products. The subtropical peaches come in the market early in season (mid-April), growers can get higher returns due to scarcity of other fresh fruits. Its first commercial crop is obtained within three years of planting which is much earlier than majority of other temperate fruits (Annonymous, 2010). Peach trees are generally grown for commercial production as two genetically different components consisting of a scion either budded or grafted to a rootstock. In peaches, seeds of 'Sharbati' are generally used as a rootstock due to its easy availability and compatibility with commercial peach cultivars. But, this rootstock is highly susceptible to root-knot nematodes. Recently, PAU has released a new rootstock 'Flordaguard' for peach. This rootstock is resistant to root knot nematodes and is also compatible with all the peach cultivars. It can be clonally propagated through rooting of hard wood cutting and ready

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for grafting in short time as compared to propagated via seed. Propagation from cuttings (cloning) produces a plant with the same characteristics as the parent and thus maintains desirable fruiting traits (Hartmann and Kester, 1983). In comparison with other types of cuttings (semi-hardwood, softwood, and so on), hardwood cuttings are easy to take, handle, and store, which allows for flexibility in the preparation of the cutting and, in general, less precision than cuttings that include actively growing tissue (Hartmann *et al*., 2002).

Propagation through hardwood cuttings is important, particularly in horticulture for mass production at faster rate of improved materials with in short time, cheapest and to perpetuate the characteristics of the parent plant (Hartmann and Kester,1983). Moreover, Indole-3-butyric acid is probably the best material for general use, because it is nontoxic to plants over a wide concentration range and is effective in promoting rooting of a large number of plant species (Hartmann and Kester, 1990).The most successful results have been obtained from IBA treatments including auxin hormone group. IBA has been found to be critical for both softwood and hardwood cuttings (Twor- koski and Takeda, 2007; Zenginbal and Ozcan, 2014; Zenginbal *et al*., 2014; Jana *et al*., 2015; Ibrahim *et al*.,2015; Lazaj *et al.*, 2015; Ibironke, 2016; Ari, 2016;). Indole Butyric Acid (IBA) and Naphthalene Acetic Acid (NAA) are synthetic rooting chemicals that have been found to be reliable in the promotion of rooting in cuttings more proficiently than Indole Acetic Acid (IAA) which is a native auxin (Tsipouridis, 2003). Howard (1980) found that different IBA concentrations were optimal for different species.

The objective of present investigation is to induced rooting and vegetative growth in the stem cuttings of Flordaguard rootstock of peach which is nematode resistant by treating its cutting with auxin type growth regulators is to cut short the time of development of rootstock of peach ready for budding/grafting in one year instead of two years as raised through seed.

MATERIALS AND METHODS

The present study was conducted at PAU, Regional Research Station, Gurdaspur during the years 2012-13 and 2013-14. The hardwood cuttings of 10 years old Flordaguard peach(*Prunus persica* L.Batch) plant having 15-20cm in length and 0.8-1.2cm in diameter with 6-7 buds were prepared in the first fortnight of January(2012-13 and 2013-14) .The basal portion of the cuttings was dipped in different doses of Indole-3-butyric acid (IBA)viz. 1000ppm, 2000ppm, 3000ppm, 4000ppm, 5000ppm and control (without IBA treatment) for 1-2 minutes .After these treatments, the hard wood cuttings were planted at a distance of 15 cm in rows, which are kept 30 cm apart in the well prepared nursery plots by following the recommended package of practices used for proper care of nursery plants. The data on sprouting, rooting, survival and different vegetative growth parameters was recorded and analyzed with Randomized Block Design as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The days taken to sprouting, days taken to rooting,

Table 1. Effect of different treatments of IBA on days to sprouting and rooting, sprouting and survival percentage, plant height and girth, number of branches and leaves.

Doses of IBA (ppm)	Days to sprouting	Days to rooting	Sprouting (%)	Survival (%)	Plant height (cm)	Plant girth (cm)	Number of branches	Number of leaves
1000	13.25	12.00	70.00	52.15	118.50	5.33	7.00	125.35
2000	10.33	9.15	75.33	75.00	142.25	6.85	10.23	160.00
3000	7.05	6.00	98.45	90.55	195.45	10.50	13.50	260.4
4000	12.50	10.33	48.25	40.25	120.00	4.50	6.55	105.75
5000	13.75	11.25	32.65	15.25	90.75	3.15	4.25	76.15
Control	24.50	21.20	10.00	4.00	32.50	2.15	2.35	22.00
CD(5%)	2.15	3.24	2.96	3.31	2.87	1.16	1.77	3.68
SE(mean)	0.67	1.01	0.93	1.04	0.89	0.36	0.56	1.15

Table 2. Effect of different treatments of IBA on the leaf length, leaf breadth, leaf weight, rooting percentage, number of roots, root length, root girth and root weight.

Doses of IBA (ppm)	Leaf length (cm)	Leaf breadth (cm)	Leaf weight (gm)	Rooting (%)	Number of roots	Root length (cm)	Root girth (cm)	Root weight (gm)
1000	15.50	3.00	0.70	55.55	45.50	20.50	0.55	7.00
2000	17.20	3.50	0.85	75.45	58.45	30.00	0.75	10.23
3000	19.55	4.12	2.00	94.45	75.33	38.00	0.98	13.50
4000	18.00	3.10	0.62	65.00	34.15	22.42	0.45	6.55
5000	16.52	2.75	0.50	60.25	25.00	16.25	0.32	4.25
Control	11.50	2.00	0.25	12.50	10.14	8.00	0.15	2.35
CD(5%)	2.63	1.22	0.49	2.98	2.83	3.39	0.16	1.77
SE(mean)	0.82	0.38	0.15	0.93	0.89	1.06	0.05	0.56

sprouting percentage, survival percentage, plant height, plant girth, number of leaves, leaf length, leaf breadth, leaf weight, rooting percentage, number of roots ,root length, root weight, root girth and number of branches Flordaguard peach (*Prunus persica* L. Batch) plant were influenced by different levels of IBA concentrations.

Days taken to sprouting and rooting; sprouting and survival percentage: It was observed from the table1 that the hardwood cutting treated with 3000 ppm IBA concentrations took minimum duration in sprouting (7.05days) and rooting(6.0days) where as these had taken longest duration in control. Similarly, the cutting treated with 3000ppm IBA gave highest sprouting (98.45%) and survival (90.55%) as compared to the rest of the treatments. It is due to more number of roots and these parameters decreases with increase in IBA concentrations above 3000ppm. These results are also supported by Ishtiaq *et al*. (1989) who observed the positive association relating to root formation and bud sprout in peach cultivar Peshawar local . These results supported the findings of Singh *et al*. (2011) who reported high sprouting percentage (100.0%) in cuttings of Bougainvillea when treated with 3000ppm IBA. Melgarejo *et al*. (2008) also showed that in pomegranate, the increment in the percentage of cuttings that rooted occurred in most of the clones using low IBA application concentration (3000 ppm). Similarly, Ari (2016) noted the 94.40% survival in native *Vitex agnus -castus* l. cuttings treated with 3000ppm IBA.

IBA 1000 ppm is more effective for inducing lesser number of days to sprouting (5.30) with more number of sprouts buds/cuttings (3.60) in *Bougainvillea spectabilis* cuttings reported by Mehraj *et al*.,(2013). Better rooting was associated with better survival rate in *Prunus cerasus* (Prizhmontas, 1991) and in peach cultivar Fertilia (Bertolini, 1994). The logical conclusion seems that large numbers of roots are associated with adequate nutrient absorption which account for ultimate survival. The highest survival percentage (90.0%) was observed on full-leaf cuttings of *Camellia sinensis* (L.) O. Kuntze treated with 6000 ppm IBA (Zenginbal *et al*., 2014).. Bougainvillea stem cuttings showed the maximum percentage of success (95.60%) when treated with 400 ppm IBA (Sultana *et al*., 2016). Sahariya *et al*. (2013) noted that in Bougainvillea (var. Thimma), IBA at 2000ppm concentration was found much better with 63.33 per cent success in stem cuttings.

Plant height, plant girth, number of branches, number of leaves, leaf length, leaf breadth and leaf weight: Plant height(118.50cm) was also significantly higher at 0.89% level in cuttings treated with IBA 3000ppm and decreased with increase in IBA concentration. While it was noticed lowest (32.50cm) in control(Table1). These results of the present study are in agreement with Noor *et al.* (1995), who reported that cuttings of apple rootstock M-26 and M-27 treated with IBA at 3000 ppm increased shoot length. Khajehpour *et al.* (2014) also noted that cutting of olive cultivar *coratina* treated with 3000ppm was found to be best in terms of number of roots(8.52), the percentage of rooted cuttings (84.50%), branch length (17.70cm) and root fresh weight (10.32gm) in cuttings of Olive (*Olea europaea* Var Manzanilla).

Plant girth(10.50cm) was also significantly higher in the cuttings treated with 3000ppm IBA (Table1). Highest plant diameter (2.40 mm), numbers of leaves (16.26) and leaf area (36.42 cm^2) were observed in the treatment IBA 5000 ppm in semi-hard wood cuttings of Olive (Thakur *et al*.,2016). Survival percentage of cuttings (71.57 %) was also highest in semi-hard wood cuttings of Olive treated with IBA @ 5000 ppm (Thakur *et al*.,2016).

Number of branches (13.50), number of leaves (260.40), leaf length (19.55cm), leaf breadth (4.12cm) and leaf weight (2.0gm) were also significantly higher at 3000ppm IBA treatments and these above said parameters decreased with increase in IBA concentration above 3000ppm (Table1 and Table 2). Similarly IBA 3000 mg per litre is significantly superior in producing leaf number (9.56 leaf/plant), shoots number (3.92 shoot/plant), and vegetative dry weight (2.82 g/plant) in stem cutting of *Ligustrum ovalifolium* (Hammo *et al*., 2015).

In Bougainvillea (var. Thimma), IBA at 2000ppm increased the length of shoots per cutting after one month (3.07cm) and length of shoots per cutting after two month (14.73cm) (Sahariya *et al*., 2013).These results are in conformity with the findings of Panchal *et al*. (2014) that maximum plant height (16.70cm), root length (18.97cm), number of leaves (14.67),number of branches (3.53) and leaf area (14.80 cm^2) were observed in cutting of Khirni (*Manilkara Hexandra*) with 2000ppm IBA. This may be due to IBA that produced healthier lengthy roots and hence absorbed more nutrients and water contents that have great influence on the number of leaves produced by the plant.

Similarly, Lalramhluna and Prasad(2016 reported that with the application of IBA 2000ppm to the air layers of Lemon (*Citrus limon* L. Burm.) produced high number of bud initiation (17.33), number of leaves (107.33), leaf area (38.37cm^2), number of branches (6.33), length of branches (106.33 cm) and canopy of plants (73.33 cm).

The increase in shoot diameter might be due to more number of leaves and it may be due to vigorous root system which enhanced the absorption of minerals and water from the soil resulted in more carbohydrate production and assimilation and enhanced vegetative growth. The increase in leaf area in terms of length and breadth, increases the photosynthetic activity resulting into increased carbohydrates which results in high

growth. Shahab *et al.* (2013) also reported that IBA (10%) promotes leaf area (26.03cm^2) in terms of length and breadth, sprout length (18.09cm), stem diameter(14.44mm), number of roots (15.61), root diameter(3.41mm), number of leaves (17.27), root (14.24cm) and survival percentage (70%) in hardwood cuttings of Alstonia. Mehraj *et al*. (2013) reported that *Bougainvillea spectabilis* stem cuttings treated with 1000ppmIBA was performed as the best in terms of minimum number of days taken to first rooting (4.0) and with highest number of leaves/cutting (35.20), length of sprout (15.0 cm) and number of branches/ cutting (4.70). Similarly, maximum survival (95.6%) and shoot length (55.50cm)were observed in hardwood cuttings of *Ficus religiosa* L. treated with 1000ppm of IBA (Salmi and Hesami,2016).

Similar results were found in Rose cuttings treated with 1000ppm of IBA had shown significant positive effects on shoot fresh weight (2.05gm) and shoot dry weight(0.61gm), leaf number (56.50)and shoot length (14.4cm)(Yeshiwas *et al*., 2015).

Percentage rooting, number of roots, root length, root girth and root weight: Percent rooting (94.45%) and average number of roots(75.33) were significantly higher in 3000 ppm IBA as compared to the rest of the treatments (Table 2).These results are supported with the findings of Rufato and Kersten (2000), who noted that 3000pm IBA gave the highest percentage (70.54%) of rooted cuttings of Esmeralda peach. These results are in agreement with Swedan *et al.* (1993), where they reported that hard wood cuttings of plum, peach and GF677 peach rootstock treated with 3000 ppm IBA gave the highest rooting percentage (100%). Similarly, 3000 ppm IBA increased the number of roots (8.52), the percentage of rooted cuttings (84.50), branch length (17.70cm), and root fresh weight (10.32gm).in cuttings of Olive (*Olea europaea* var. Manzanilla) (Khajehpour *et al*., 2014). Singh *et al*. (2011) also reported the maximum rooting (100.0%),sprouting (100.0%), length of sprout (18.77cm) and number of roots (21.22) in cutting of *Bougainvillea glabra* at 3000ppm IBA. Tajbakhsh *et al*. (2009) also reported that highest rooting percentage(31.50%) in apple cuttings was in 3000 ppm IBA. Similarly,the hardwoods cutting of *Bougainvillea glabra* variety Torch Glory were treated with 3000 mg per litre IBA induced maximum sprouted cutting (100.0%),rooting (100.0%), length of sprout/cutting (18.77 cm) and number of roots/cutting (21.22) (*Singh et al*.,2011). Similarly, Mirabdulbaghi *et al*. (2011), also observed that concentration of IBA 3000 ppm was found to be best to promote the rooting (60.0%) in the hardwood cuttings of natural plum apricot hybrid.

Mehraj *et al*.(2013) found that treatment of IBA 1000ppm in *Bougainvillea spectabilis* stem cuttings increased the number of root/cutting (64.20), number of sub root/cutting (25.80), root length (33.20 cm), root diameter (0.51 mm), rooting (100.0%) and survival (100.0%) of rooted cuttings. Similarly, maximum rooting (98%) was observed in hardwood cuttings of *Ficus religiosa* L. treated with 1000ppm of IBA (Salmi and Hesami,2016). The highest rooting (79.56%), number of roots (8.33), root fresh and dry weights (361.80 and 244.74 mg, respectively), number of buds (5.00) were recorded in Kurdistan 5 genotype of Damask Roses (*Rosa damascena* Mill.) with 1000 mg per litre IBA. (Nasri *et al*., 2015). Similarly, Rose cuttings treated with 1000ppm of IBA had shown significant positive effects on most of the root and shoot parameters including root length (11.29cm), number of root per cutting (54.2), root fresh weight (0.79gm) and root dry weight (0.21gm) (Yeshiwas *et al*., 2015).

Number of sprouted cuttings (6.29), length and diameter of sprout(23.77cm and 1.52cm, respectively), number of sprouts, number of leaves and number of roots/ cutting(17.77 and 23.00 and 52.42, respectively), and average maximum length and diameters of roots (26.33cm and 1.33cm,respectively) were noticed maximum in treatment with 2000ppm IBA in *Citrus limon* cv. Pant Lemon (Singh *et al*., 2013). Similarly, in Bougainvillea (var. Thimma), IBA at 2000ppm increased the number of rooted cuttings (6.33), percentage of rooted cuttings (63.33%), number of roots per cutting (30.0), length of roots (12.85cm) and dry weight of the roots (0.43g) (Sahariya *et al*., 2013). Application of IBA with 2000 ppm concentration to pomegranate (*Punica granatum* L.) air layers produced highest rooting (91.60%), number of roots (37.29), root length (8.04cm),root diameter(1.54mm) and survival (97.67%) (Tomar and Tomar,2012). Maximum number of branches per plant (8.55), number of roots per plant (23.00), root length (19.62 cm), root weight (13.25 g) and plant survival (85.71%) were observed in Peach cuttings treated with 2000 mg per litre IBA (Pervez *et al*., 2007).

The highest root length (114.40 cm) and root weight (0.41gm) were observed in Honeysuckle (*Lonicera japonica*) cuttings treated with 3500 mg per lit IBA (AliKarimian and Bidarnamani, 2015).

Auxin induces root formation by breaking root apical dominance induced by cytokinin (Cline,2000). Seyedi *et al* .(2014) noted that stem cuttings of *Bougainvillea glabra* L.treated with IBA hormone concentrations 4000ppm induced maximum rooting (93%), root length(36.0cm) and root number(9.0). Similarly, the highest number of roots per cutting (43.00), length of roots per cutting (9.28 cm), diameter of root per cutting (1.67 mm), percentage of rooted cutting (88.0%), number of sprouts per cuttings (4.34) and the minimum (20.66) days taken to callus formation were noticed in IBA 4gm per litre in Duranta Golden cuttings (Singh *et al*., 2014). Similarly, maximum sprouting (43.70%) leaves per plant (63.0), plant height (37.46cm), shoots per plant (13.0), leaf area (19.33

cm^2), shoot thickness (0.57 cm), root length (11.5 cm) and roots per cutting (13.0) were recorded in cuttings treated with 4000 ppm IBA in stem cuttings of *Ficus Hawaii* (Siddiqui and Hussain, 2007). Galavi *et al*. (2013) also reported that IBA 4000 ppm enhanced the maximum number of roots (8.27), root length (60.05cm), root fresh(0.19gm) and dry weight (0.11gm) in grape cuttings.

The highest number of roots (25.38) and longest root (23.53cm) were obtained with 400 ppm IBA in Bougainvillea stem cuttings (Sultana *et al*., 2016). It could be due to the effect of IBA as it increases cell wall plasticity and cell division stimulates callus development and root growth (Weaver, 1972).

In other studies, IBA 3500ppm and 2500 ppm also promotes the rooting(74.58%) and 86.10% in the hardwood cuttings in olive (Maghsudlu *et al*., 2013) and in peach rootstock GF-655 (Ahmed *et al.,* 2003) respectively. Similarly, 3000 ppm IBA significantly increased the root length (38.0cm), root girth (0.98cm) and root weight (13.50gm). The values of these growth parameters were decreased with increase in IBA concentration above 3000 ppm (Table 2). Similarly, Hammo *et al*. (2015) observed that the 3000 mg per litre IBA causes significantly increase in rooting percentage (68.42%), roots number (5.91 root/plant), longest root (3.36 cm), roots dry weight (0.31g) in stem cutting of *Ligustrum ovalifolium* . Eri (2016) also noted about 62.20% rooting in native *Vitex agnus-castus* cuttings treated with 3000ppm of IBA. Ahmed Aziz *et al*. (2010) also reported similar findings in olive, to obtain the most number of rooted cuttings(60.0%), the IBA @3000 ppm was found to be best.

The stem cuttings of *Rosa centifolia* treated with IBA 450 ppm concentration produced maximum shoot length (10.67 cm), shoot dry weight (3.02 g), number of roots (14.00), root length (11.90 cm) and root dry weight (0.50 g) (Akhtar *et al*., 2015).

Zenginbal *et al*.(2014) obtained the best results for rooting (78.30%), root length (14.77cm), root diameter (1.30mm) and number of roots (6.37)with cuttings of *Camellia sinensis* (L.) O. Kuntze treated with 6000 ppm IBA.

IBA promotes the cell elongation which helped in increase in root length. The increase in root girth may be due to more vegetative growth and accumulation of carbohydrates. The increase in root weight is due to more number of roots, highest root girth and length of the roots. IBA helps in mobilizing reserved food material elongation of meristematic cells and differentiation of cambial initials into root primordial (Nanda, 1975). Certain level of endogenous auxin is already present in the cuttings, therefore treating cuttings with IBA could optimize the auxin level in the cutting and consequently improves the percentage of cuttings that rooted (Melgarejo *et al*., 2008; Saroj *et al*., 2008; Polat and Caliskan, 2009).

IBA concentration with 2500 mg per litre was recommended for the rooting(31.48%), root length (5.88 cm) and number of roots (7.0) of Azayesh apple rootstocks (Dvin *et al*., 2011).Increased root length treated with IBA due to the enhanced hydrolysis of carbohydrates, synthesis of new proteins, cell enlargement and cell division induced by the auxins (Strydem and Hartman, 1960).The percentage of rooted cuttings were increased which might be due to the application of proper IBA concentrations resulted high carbohydrate and low nitrogen level lead to more root formation (Carlson, 1929).

The increase of IBA concentration was accompanied by the decreased rooting percentage, suggesting that high IBA concentrations were not suitable for the root formation process (Singh *et al.,* 2003). Although IBA increases the elasticity of cell wall, accerating division, excessive concentration of hormones may inhibit this process (Rahman *et al*., 2000).Exogenous auxin application in layers during period of active growth(high edogenous auxin levels) could raise the hormone levels above optimal concentrations, leading to decrease in rooting(Moreira *et al*., 2009). A similar trend was obtained in air layers of *Macleania rupestris* where concentration higher than 1500 mg per litre. IBA resulted in reduction of dry and fresh weight of roots. (Duran Casas *et al*., 2013). Researchers believe that high concentrations of auxin can cause damage to the cutting base. Auxin can be effective to rooting cuttings in a certain concentration (not more than 10,000 ppm), depending on the crop and cultivar, and will have an inhibition effect at higher concentrations observed in Stevia (Cerveny and Gibson, 2005). In Azayesh apple rootstocks, rooting decreased by 11.11% by increasing IBA concentration at 3500 mg per litre (Dvin *et al*.,2011). Karakurt *et al*. (2009) reported that the best concentration of IBA for rooting (20%) was 1000 mg per litre for MM106 apple rootstock but by increasing IBA concentration to 2000 mg per litre and 4000 mg per litre, no rooting occurred. Babashpour-Asl *et al.* (2012) in evaluating the effect of Indole-3-butyric acid 2000ppm on the rooting ability of semi-hardwood Bougainvillea (*Bougainvillea glabra*) cuttings found highest number of roots (8.67) with root length (151.42mm).

The hardwood cuttings of Phalsa treated with IBA at 200 ppm concentration recorded the highest values for root and shoot parameters, viz., minimum number of days taken for sprouting (9.34), maximum number of sprouts per cutting (5.30), number of leaves per cutting (8.50), leaf area per cutting (15.72 cm^2), leaf chlorophyll content per cutting (49.78 mg), fresh and dry weight of the shoot (25.36 g and 12.82 g), percentage of rooted cuttings (60.0), number of roots per rooted cutting (42.0), length of the longest root per rooted cutting (26.08 cm), survival percentage of rooted cuttings (50.0%), fresh and dry weight of the root (3.69 g

and 1.08 g) and percentage of establishment of rooted cuttings in the main field (45.0) (Ratnamala *et al*., 2014).

Maximum number of sprouted cuttings (7.33), average length of sprout (20.53 cm), average number of leaves (25.33), percentage of rooted cutting (73.33), number of primary roots (29.26), and average length of roots (24.88 cm) were noticed in 5 gm per litre concentration of IBA in pomegranate (*Punica granatum* L.) cultivar Ganesh (Singh, 2014). Similarly, in semi-hard wood cuttings of olive, percent rooted cuttings (53.33), number of primary roots (6.58) and secondary roots (8.53) and diameter (0.46 mm) were maximum with cuttings treated with IBA at 5000 ppm (Thakur *et al*., 2016).

IBA promote cell elongation which helped in increase in root length. The increase in root diameter may be due to more vegetative growth and accumulation of carbohydrates. In the grafting trial of four rootstocks, viz. Sharbati peach (*Pnunus persica*), Kabul Green Gage, Kala Amritsari plum (*Prunus salicina*), and wild apricot (*Prunus armeniaca*), IBA 3000ppm enhanced the rooting and survival(88.30%) in the hardwood cutting of these rootstocks (Bal and Sandhawalia, 2000). There is a strong correlation between number of roots and survival of plants (Ahmed, 2003).

Conclusion

From the present study it is concluded that the hardwood cuttings of peach cv. Flordaguard treated with 3000ppm of IBA for 1-2 minutes took the minimum number of days to sprouting (7.05) and rooting (6.0) with highest sprouting percentage (98.45%), survival percentage (90.55%), plant height (195.45cm), plant girth (10.50cm), number of branches(13.50cm), number of leaves (260.4), leaf length (19.55cm), leaf breadth (4.12cm), leaf weight (2gm), percent rooting (94.45%), number of roots (75.33), root length (38.0cm), root girth (0.98cm) and root weight (13.50). Therefore, by following this treatment, the plants produced from the hardwood cuttings of Flordaguard rootstock of peach become ready for budding or grafting in the next year .Rooting of hardwood cutting has been successfully tried on the cuttings of other peach cultivar. But, no information is available on the newly released peach rootstock 'Flordaguard' by PAU,Ludhiana which is highly resistant to root knot nematodes disease. Therefore, keeping in view the resistance of 'Flordaguard' rootstock against root knot nematodes and its need in promoting the fast upcoming peach industry, so the protocol is developed to raise the rootstock plant of Flordaguard through cutting which become ready for budding/grafting in the field in one year instead of two years as raised through seed.

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