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Effect of varieties on seed germination, growth of seedlings and budded plants of apple, *Malus* x *domestica* Borkh under protected conditions

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ABSTRACT

An experiment to assess the effect of seeds of different varieties on apple seed germination, growth and vigour of seedlings and budded plants was conducted at the experimental field of Department of Fruit Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, HP during 2013 and 2014. The seeds of crab apple and seven commercial varieties like Gold Spur, Granny Smith, Red Gold, Royal Delicious, Spartan, Winter Banana and Golden Delicious were used to raise the seedling rootstocks. The highest (92%) seed germination was recorded in crab apple whereas the lowest (84.10%) was observed in Golden Delicious. The crab apple seedling rootstocks attained maximum height (75.17 cm) and diameter (5.47 mm) whereas the minimum height (62.47 cm) and diameter (5.00 mm) were recorded in Winter Banana seedling rootstocks. The highest internodal length (1.75 cm) was recorded in seedling of variety Red Gold and the lowest (1.11 cm) in variety Golden Delicious. The seedlings of crab apple attained maximum leaf area (26.89 cm^2) and number of leaves per seedling (26.67) however the minimum leaf area (19.82 cm^2) and number of leaves per seedling (15.33) in seedlings of Winter Banana. The highest total root length (6.50 m) was observed in the seedlings of crab apple and the lowest (4.50 m) of Winter Banana. The maximum (32.00 g) biomass was recorded in seedlings raised of crab apple whereas the minimum (20.00 g) in Winter Banana. The highest buddable seedlings (83%), height of budded plants (92.67 cm), stock girth (7.64 mm) and scion girth (6.53 mm) were observed in crab apple. However the lowest number of buddable seedlings (74%), plant height (80.67 cm), stock girth (6.10 mm) and scion girth (5.11 mm) were attained by Winter Banana seedlings.

Keywords: Apple; nursery; protected conditions; seedling rootstocks

INTRODUCTION

Apple, *Malus* x *domestica* Borkh is the most important temperate fruit of the world and has emerged as the major remunerative fruit crop of Himachal Pradesh. In India apple is grown on commercial scale in the states of Jammu and Kashmir, Himachal Pradesh and Uttarakhand. In India it occupies an area

of 289000 ha with annual production of 2891000 MT (Anon 2013). In Himachal Pradesh it is commercially grown in high hills of Shimla, Kullu, Kinnaur, Sirmour, Lahaul Spiti and Mandi districts in an area of 101500 ha with annual production of 892000 MT (Anon 2013).

There has been a substantial increase in area under apple during last five decades and there is further scope for the expansion of area due to introduction of high yielding spur type, colour strains and low chill varieties which can be grown in areas which have become marginal for apple cultivation of traditional high chill cultivars due to climate change. Besides this most of apple orchards have become senile and plantation have outlived their life which needs replantation. Therefore the demand for nursery plants of apple is increasing consistently. At present the annual requirement of nursery plants of apple is about 10-12 lakhs in the state. To meet the demand both government and private nurseries are engaged in the production of quality nursery plants. The use of quality nursery plants in short time period is therefore the basic pre-requisite to meet the huge demand of nursery plants.

Apple is commercially propagated by grafting or budding of scion cultivars either on seedling or clonal rootstock which generally takes two years or sometimes three years in the open field conditions. With the inception of greenhouse technology the tremendous improvement in the production technology has been made. Due to higher temperature in polyhouse the growth of plants can be enhanced and prolonged (Ozongun et al 2002) and these growing conditions can be utilized for the fast growth of the rootstocks which attain buddable size in six months. Besides this the seed variety also exhibits significant effect on the germination and growth of the rootstocks. Keeping these points in mind the present study was conducted to assess the effect of seeds of different varieties on germination and growth of seedlings as well as budded plants under polyhouse conditions.

MATERIAL and METHODS

The seeds were extracted from fully ripened fruits of different apple varieties and then stored in cool place till mid of December. After that the seeds were stratified in alternate layers of moist sand for 60 days in wooden boxes at 3-4^{o}C under refrigerated condition in mid of December.

A polyhouse of 20 m x 10 m size was used for the present study. Soils were well prepared by repeated ploughing and well rotten FYM @ 60 kg/m^2 area was mixed in the soil at the time of preparation of beds. The nursery beds of 2 m x 2 m size were prepared and stratified seeds of different varieties were sown in these beds at a distance of 10-15 cm and 15-20 cm apart in rows in mid of February. The nursery

beds were mulched with dry grass and light irrigation was given. As the seeds started germinating the mulch material was removed. Nursery operations like irrigation and weeding were done at regular intervals. The observations on length, breadth and thickness of 100 seeds of each variety were made with the help of digital vernier calliper. The seeds were weighed on a top pan electronic balance to record the weight of seed. The number of seeds was counted and average number of seeds per kg was worked out. The data on seed germination was recorded daily after sowing till the time further emergence of seedlings stopped. The seeds were considered germinated when the plumule just emerged on the soil surface. The observations on height of randomly selected 100 seedlings per replication were recorded one week before budding (in first week of July) with the help of measuring tape. Similarly the diameter of 100 seedlings per replication of each variety was measured 15 cm above from ground level with the help of digital vernier calliper in first week of July. Ten seedlings per replication were uprooted in the first week of July before budding. The roots were separated from the seedlings, washed with tap water and the length of primary and secondary roots (up to 2 mm in diameter) was measured with the help of measuring tape. The length of tertiary roots and root hair was recorded in Comair root length scanner. After recording the root length the roots were dried in an oven at a temperature of 65°C for about 48 hours until the constant weight of sample was obtained. Total dry weight of roots was taken on top pan electronic balance. The shoot and root portion of the seedlings used for recording data on biomass of seedlings was cut into small pieces and dried in an oven at a temperature of 65°C for about 48 hours. The dry weight of seedlings was recorded on top pan electronic balance. The total dry weight of shoot and roots of each seedling was added to work out the total biomass of seedlings. The intermodal length was calculated by dividing the seedling height with the total number of nodes. The diameter of the seedlings at 10 cm height from the ground level was recorded in the first week of July. The rootstock seedlings having the diameter of 5 mm or above were considered as buddable. The proportion of such seedlings was calculated on per cent basis. After the cessation of growth (December) the height of plants was measured with the help of measuring tape. The height was measured from the surface of soil to the terminal bud of the main axis. The stock girth of plants was recorded 5 cm below the graft union at cessation of growth in December with the help of vernier calliper. The scion girth of plants was recorded 5 cm above the graft union at the cessation of growth in December with the help of vernier calliper. The data on leaf number was recorded during the month of November before the onset of leaf fall. All the leaves irrespective of their size were counted and average number of leaves per plant was calculated. Twenty fully expanded

leaves were collected at random from each plant in the first week of October and the area of leaves was measured with the help of leaf area meter (LI-COR Model-3100). Leaf samples were collected from middle of plant during second week of September. After the end of season all the plants were uprooted. The plants with a height of 90 cm or more were considered to be fit for sale and the number of such saleable plants was counted in each treatment. The two years data obtained from the present investigation were pooled and subjected to statistical analysis as per procedure described by Gomez and Gomez (1983).

RESULTS and DISCUSSION

Effect on seed characteristics

A significant difference in seed characteristics (size, weight and number of seeds/kg) was observed among different varieties under present investigation. The highest seed length (7.80 mm) was recorded in Royal Delicious and minimum (6.99 mm) in Golden Delicious. The data for seed breadth revealed that variety Red Gold had the highest (4.06 mm) seed breadth and the lowest (3.84 mm) was recorded in variety Golden Delicious. Seed thickness varied from 2.08 to 2.60 mm and the highest seed thickness (2.60 mm) was recorded in Granny Smith and minimum (2.08 mm) in Winter Banana. The data recorded in present investigation for the trait seed length and breadth was contradictory but similar for the trait seed thickness to the findings of Kumar (2013) who reported maximum seed length (8.53 mm) and breadth (4.50 mm) in variety Gold Spur and maximum seed thickness in variety Granny Smith.

The data on weight of seeds indicate that seed weight was significantly affected by varietal difference with a range of 31.28 to 39.09 mg/seed. The maximum seed weight of 39.09 mg per seed was recorded in variety Royal Delicious and the minimum (31.28 mg) in Golden Delicious. The maximum seeds per kg (32430) were recorded in Golden Delicious followed by Gold Spur and the minimum (26,390) in Royal Delicious. The weight of seeds depends upon the length, breadth and thickness of seeds. Larger the size of the seed the greater is the weight. The larger seed size in Royal Delicious and Red Gold might have accounted for the lesser number of seeds per kg. In the present study the seed size and weight of Golden Delicious and Gold Spur were recorded lesser as compared to other varieties which may have accounted for more number of seeds per kg.

Seed germination and seedling growth

Significant variation was observed for the trait seed germination among different varieties. The highest (92%) seed germination was recorded in crab apple seeds which was statistically at par with Granny Smith (90%) and the lowest (84.10%) in Golden Delicious. The seed

Table 1. Seed characteristics, number of seeds per kg and seed germination of different varieties of apple

Variety	Seed parameter						
	Size of seed		Thickness (mm)	Seed weight (mg/seed)	# seeds/kg	Seed germination (%)	# seedlings/ kg
	Length (mm)	Breadth (mm)					
Crab apple	7.36	3.91	2.19	35.33	2,9630	92.00 (9.64)	27,259.6
Gold Spur	7.06	3.92	2.39	32.25	3,1050	85.00 (9.27)	26,392.5
Granny Smith	7.30	4.04	2.60	34.59	3,0190	90.00 (9.54)	27,171.0
Red Gold	7.78	4.06	2.30	39.00	2,6800	85.00 (9.27)	22,780.0
Royal Delicious	7.80	4.05	2.11	39.09	2,6390	85.67 (9.31)	22,608.3
Spartan	7.36	4.04	2.23	34.87	2,9640	89.40 (9.51)	26,498.2
Winter Banana	7.50	4.01	2.08	36.37	2,8350	88.30 (9.45)	25,033.1
Golden Delicious	6.99	3.84	2.13	31.28	3,2430	84.10 (9.23)	27,273.6
$CD_{0.05}$	0.26	0.13	0.14	2.33	150.94	(0.21)	131.5

Figures in parentheses are square root transformed values

germination depends on the viability of the seeds. Kumar (2013) showed higher seed viability in the seeds of crab apple and Granny Smith in comparison to other varieties which might have accounted for higher seed germination. The data on seedling height varied from 62.47 to 75.17 cm. The maximum height (75.17 cm) and diameter (5.47 mm) were recorded in seedlings of crab apple whereas the seedlings of Winter Banana attained minimum height (62.47 cm) and diameter (5.00 mm). The diploid cultivars (Golden Delicious, Granny Smith, Red Gold) are generally preferred because they have better seed content and larger seeds which give better seed germination and seedling growth (Chadha 1962, Kanwar 1987).

The observations on internodal length of seedlings indicate that the highest internodal length of 1.75 cm was recorded in Red Gold adn lowest (1.11 cm) in variety Golden Delicious. The seedlings of rootstock of crab apple attained maximum leaf area (26.89 cm^2) and number of leaves per seedling (26.67) whereas the minimum leaf area (19.82 cm^2) and number of leaves (15.33) were recorded in Winter Banana. The maximum seedling biomass (32 g) and buddable seedlings (83%) were found in crab apple followed by Red Gold and minimum biomass (20.00 g) and buddable seedlings (74%) were recorded in Winter Banana. The possible explanation for high biomass and production of more buddable seedlings in crab apple may be due to better seedling and root growth. The present findings are contradictory to that of Kumar (2013) who reported maximum seedling height in Spartan and maximum biomass in Golden Delicious. This difference in height

Table 2. Vegetative growth parameters of seedlings of different apple varieties

Treatment	Seedling growth parameter				
	Seedling height (cm)	Seedling diameter (mm)	Internodal length (cm)	Leaf area (cm^2)	# leaves
Crab apple	75.17	5.47	1.25	26.89	26.67
Gold Spur	68.33	5.20	1.11	21.34	20.67
Granny Smith	73.90	5.39	1.43	23.85	25.67
Red Gold	74.93	5.40	1.75	23.35	26.33
Royal Delicious	73.63	5.27	1.42	23.19	25.00
Spartan	71.50	5.25	1.25	24.57	23.33
Winter Banana	62.47	5.00	1.25	19.82	15.33
Golden Delicious	71.00	5.21	1.11	26.84	20.67
$CD_{0.05}$	3.57	0.22	0.21	0.91	5.95

Table 3. Root growth and biomass of seedlings of different apple varieties

Variety	Parameter						
	Length of primary root (cm)	Secondary root number	Secondary root length (cm)	Total root length (m)	Root dry weight (g)	Seedling biomass (dry weight basis) (g)	Buddable seedlings (%)
Crab apple	28.00	2.87	6.67	6.50	4.23	32.00	83.00 (9.17)
Gold Spur	23.17	2.90	3.50	5.20	3.44	25.00	76.00 (8.78)
Granny Smith	27.17	1.50	6.00	6.40	3.87	29.50	80.00 (9.00)
Red Gold	31.50	2.83	5.67	6.09	3.93	30.00	80.50 (9.03)
Royal Delicious	26.83	3.60	5.63	5.91	3.82	29.00	79.33 (8.96)
Spartan	24.50	2.00	5.13	5.95	3.59	28.00	78.10 (8.89)
Winter Banana	19.67	2.22	4.30	4.50	3.17	20.00	74.00 (8.66)
Golden Delicious	24.50	1.88	4.13	5.50	3.55	27.00	77.50 (8.86)
$CD_{0.05}$	5.62	0.98	1.31	0.23	0.17	3.38	(0.15)

Table 4. Effect of seedling rootstocks of different apple varieties on growth of budded plants and percentage of saleable plants

Variety	Parameter			
	Height of budded plants (cm)	Stock girth (mm)	Scion girth (mm)	Saleable plants (%)
Crab apple	92.67	7.64	6.53	81.00 (9.04)
Gold Spur	82.00	6.20	5.21	72.17 (8.55)
Granny Smith	90.00	6.90	5.93	79.00 (8.94)
Red Gold	92.00	7.15	6.20	80.67 (8.95)
Royal Delicious	89.00	6.75	5.49	78.23 (8.90)
Spartan	87.00	6.65	5.44	77.03 (8.83)
Winter Banana	80.67	6.10	5.11	70.00 (8.43)
Golden Delicious	85.33	6.55	5.36	75.89 (8.72)
$CD_{0.05}$	5.25	0.24	0.24	(0.14)

Figures in parentheses are square root transformed values

and biomass of seedlings may be due to different genetic makeup of the seedlings and growing conditions.

Root parameters

Among the eight varieties studied the maximum primary root length (31.50 cm) was found in Red Gold and minimum (19.67 cm) in Winter Banana. Maximum number of secondary roots (3.60) per seedling was recorded in Royal Delicious followed by crab apple and minimum (1.50) in Granny Smith. The maximum secondary root length (6.67 cm) was recorded in seedlings of crab apple and minimum (3.50 cm) in Gold Spur.

Seedlings of different varieties exhibited significant effect on total root length which ranged from 4.50 to 6.50 m. The highest root length (6.50 m) and root dry weight (4.23 g) were observed in the seedlings of crab apple and lowest total root length (4.50 m) and root dry weight (3.17 g) in Winter Banana. Crab apple has extensive and well developed root system which might help in absorption of water, minerals and nutrients resulting in increased tap root length, total root length, secondary root number and length (Chadha 1962). The variation in root parameters may be due to different genetic makeup of the seedling rootstocks as they were raised from the seeds having different genetic makeup.

Growth of budded plants

Seedling rootstocks of different varieties exerted a significant effect on height of budded plants which ranged from 80.67

to 92.67 cm. The maximum plant height (92.67 cm) was recorded in crab apple seedling rootstock which was statistically at par with the seedling rootstocks of Red Gold. Minimum height of budded plants was recorded on Winter Banana seedlings. Maximum stock girth of 7.64 mm and scion girth of 6.53 mm were found in crab apple rootstock and minimum stock girth (6.10 mm) and scion girth (5.11 mm) in Winter Banana. Rootstocks affect vigour of scion cultivars budded on them according to their potential of absorption of water and nutrients from the soil. Crab apple rootstock had extensive and well developed root system which might have helped in absorption of more water, minerals and nutrients thus resulting in increased growth of plants.

Saleable plants

The proportion of saleable plants varied with the type of seedling rootstock used. The highest saleable plants (81%) were obtained from Crab apple seedling rootstock which was statistically at par with Red Gold and Granny Smith. Lowest saleable plants (70%) were recorded in Winter Banana. The better growth of budded plants on Crab apple, Red Gold and Granny Smith seedling rootstocks in the present study might have accounted for production of more saleable plants on these rootstocks.

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