Pak. J. Agri. Sci., Vol. 56(4), 839-846; 2019
ISSN (Print) 0552-9034, ISSN (Online) 2076-0906
DOI: 10.21162/PAKJAS/19.9013
http://www.pakjas.com.pk

PRIMING COMPARISON OF CORTICATED AND DECORTICATED MANGO SEEDS FOR PRODUCTIVE SEEDLING ROOTSTOCKS

Farah Feroz Abbasi[1], Noor-un-Nisa Memon[1,*], Mujahid Hussain Laghari[1] and Mehrunisa Memon[2]

[1]Department of Horticulture, Sindh Agriculture University, Tandojam, Sindh, Pakistan;
[2]Department of Soil Science, Sindh Agriculture University, Tandojam, Sindh, Pakistan
[*]Corresponding author: norimemon@gmail.com

The non-availability of productive seedling rootstocks in nurseries and its dissemination within the area has been one of main constraints for collapse of the mango industry. In this regard container based experiment was conducted in 2015-2016. The seeds of mango fruits were obtained and divided into two lots i.e. corticated and decorticated followed by seed priming. The distilled water for hydropriming, gibberellic acid (GA_3) for hormonal and solo plant (NPK fertilizer) for nutripriming was used for seed priming. The unprimed seeds were treated as control. The soil had EC of (0.38 dSm^{-1}), pH (7.46), organic matter (0.89%), nitrogen (0.053 mg kg^{-1}), phosphorus (5.61 mg Kg^{-1}), potassium (209 mg Kg^{-1}), calcium (2713 mg Kg^{-1}) and magnesium (1243 mg Kg^{-1}). The data reveals that maximum mean seed germination (77.42%) was observed in 18.50 days in response to the hormonal primed seeds. Further hormonal primed seeds produced better results for germination index (11.65%), seedling vigor index (833.1), seedling height (33.82 cm) and stem diameter (9.66 mm) and chlorophyll content (48.18 rg) while leaf nitrogen (1.16%), phosphorus (0.14%), potassium (0.61%), calcium (1.89%) and magnesium (0.27%) content was observed maximum in response to the nutripriming. To compare corticated and decorticated seeds, decorticated seeds produced better results for seed germination (76.81%), germination index (11.97), seedling vigor index (3462.9), nitrogen (1.11%), phosphorus (0.14%), potassium (0.58%), calcium (1.81%) and magnesium (0.26%). It is concluded that decorticated seeds when primed with GA_3 produced better results for germination and seedling growth while nutrient content was well above or close the critical limits in nutriprimed seeds. This study suggests that the priming of the decorticated mango seeds is suitable to produce productive seedling rootstocks.
Keywords: sexual propagation, nursery raising, leaf nutrient content

INTRODUCTION

Mango, botanically named as *Mangifera indica* L., occupies a prominent place among the fruit crops in the world and is the best known important fruit possesses excellent taste, flavour and aroma. It belongs to the family Anacardiaceae and regarded as the king of the fruits in tropical and sub-tropical areas of the world (Kirshnan *et al*., 2009). In Pakistan it is grown as the second largest crop after citrus (Raza *et al*., 2017; Badar *et al*., 2019). The healthy and quality seedlings are the basic foundation for successful mango industry. Mango is generally multiplied by seed (sexual) or vegetative (asexual) means (Gholap and Polara, 2015; Pinto *et al*., 2018). The seed possess both characteristics of polyembryonic and monoembryonic. Polyembroynic seed is able to produce more than one embryo and they are zygotic (sexual) and nucellar seedlings which are identical to the parent plant (Ruiz *et al*., 2000; Bally, 2006; Ram and Litz, 2009; Khan *et al*., 2017). Monoembyonic varieties in nature may produce a single zygotic embryo which is a cross between maternal and parental parents. Though, both zygotic and nucellar seedlings may be used as a rootstock (Bally, 2006; Kolekar *et al*., 2017; Pinto *et al*., 2018).

To raise seedling rootstocks, generally mango is propagated by seed/stones and seed takes time for germination. Hard seed coat is the main reason to take more time for germination. Impermeability to water and gases, physiological immaturity of embryo, deficiency of few endogenous growth promoters or excess of growth inhibitors are the other reasons for delay in germination (Thakriya *et al*., 2017). Besides mango stones are recalcitrant in nature and have poor viability. The viability of the seeds is usually reduced after fifteen days of the fruit harvest as reported by Pinto *et al*. (2008). The availability of the mango seed in semiarid regions is usually in during May to July and these are the drier months of the years because of which the germination percentage and vigour in these localities is very low. The synchronization and rapid seed emergence are the commonly reported benefits of pre-sowing applications on germination and seedling growth (Kumar *et al*., 2008; Patel *et al*., 2016; Patel *et al*., 2017). The removal of the endocarp (decorticated seed) is also considered one of the pre-sowing practices of the seed to accelerate germination of mango seed as reported by Marie (2001), Muralidhara *et al*. (2015) and Pinto *et al*. (2018). Marie (2001) observed more days to seed germination in intact endocarp than split endocarp. Seed priming is usually done before sowing and it is now considered as an effective way to enhance germination and rate of germination (Sivritepe, 2000). In case of mango, seeds usually loss their germination viability with the increasing passage of time. Stored seeds have a lower and slower rate of germination (Ramírez and Davenport, 2010) as compared to the seeds planted immediately after drying. Different seed priming practices have been in use, including hydro-priming, when soaking of the seeds takes place in water, osmo-priming, when the seeds are soaked in solutions of different organic osmotica, halo-priming (soaking in inorganic salt solutions), solid matrix priming (treatment of seed with solid matrices), thermo-priming (treatment of seeds with low or high temperatures), and bio-priming (hydration using biological compounds) (Ashraf and Foolad, 2005). Nutripriming is now recently focused by using macro or micronutrient enriched seeds as reported by Rehman *et al*. (2012) and Mirshekari (2012). Seed priming has been successfully confirmed to speed up germination and development of many crops (Mirshekari, 2012; Rehman *et al*., 2012; Jaskani *et al*., 2006). Very rare work has been reported in fruit crops and especially in mango fruit crop. In the present study comparison of corticated and decorticated was done in response to various seed priming treatments to explore their effects on germination, growth parameters and mineral nutrient content.

MATERIAL AND METHODS

The mango fruits were collected from non-grafted tree of the commercial orchard followed by ripening. The seeds were taken out from the fruits followed by drying in shade at room temperature for one week. The dried seeds were divided in two lots viz. corticated (with the endocarp) and decorticated (without endorcarp). To obtain decorticated seeds, the endocarp was removed with sharpened knife. Both corticated and decorticated seeds were used for priming. Three different methods of priming viz. hydropriming, hormonal priming and nutripriming were used in the present study. The distilled water for hydropriming, gibberellic acid (Sigma Company) for hormonal priming and solo plant (NPK fertilizer with 20:20:20 of Jaffer brothers) for nutripriming were used in the present study. The seeds were soaked in priming solutions for 48 hours and untreated seeds were treated as control. The treated mangoes were planted in plastic bags contained soil. The soil samples were taken and air dried in shade at room temperature followed by grinding. The dried samples were passed through sieve (2 mm) and packed in polythene bags for further laboratory analysis. The soil 3.5 kilograms were placed in the plantation bags. Before filling in the bags, electrical conductivity (EC) and pH of the soil were determined by taking 50 gram of air-dried soil in 100 mL of distilled water and placed for 30 minutes on an electrical shaker (Digital shaker, SHD 20, Daihan Scientific). The EC and pH of the soil-water extract was determined with pH and EC meter (WTW 3210). The organic matter of the soil samples was determined by Walkley-Black method (Walkley and Black 1934). The total nitrogen (N) by Kjeldahl's method. It was estimated by digesting the content in H_2SO_4 followed by distillation and finally titrating the distillate with acid (Bremner and Mulvaney, 1965). Soil available phosphorus (P) and potassium (K) were extracted by ammonium bicorboante diethylene penta acetic acid (AB-DTPA) extraction as given by Soltanpour and Schwab (1977). The amount of phosphorus in the extract was determined spectrophotometerically using ascorbic acid color development method as given by Murphy and Riley (1962). While K content was determined on flame photometer as described by Knudsen *et al*. (1982). The amount of calcium (Ca) and magnesium (Mg) in 1:2 soil extracts was determined by EDTA method as described by Richards (1954).

For mineral nutrient content of leaf, the recently fully mature leaves were obtained from grown seedlings and analyzed for nitrogen, phosphorus, potassium, calcium, and magnesium. The nitrogen (N) was analyzed by Kjeldahl's method. It was estimated by digesting the contents in H_2SO_4 followed by distillation and finally titrating the distillate with acid (Bremner, 1965). In case of P, K, Ca and Mg, the plant samples were digested in 1:5 perchloric ($HClO_4$) and nitric acid (HNO_3) mixture and left overnight. Next day, the contents were digested using hot plate (180-200°C) (Zarcinas *et al*., 1987; Estefan *et al*., 2013) until the white fumes appeared. After cooling the flask, the volume of each flask was raised to 50 ml and the digests were analyzed for P on spectrophotometer (ANA 75) by vanadomolybdo-phosphoric acid yellow colour method (Cottenie, 1980) and K on flame photometer as described by Knudsen *et al*. (1982). The Mg and Ca were done by titration method (EDTA) as described by versinate method (Richards, 1954).

The growth parameters viz. germination percentage, time, index, seedling vigor index, seedling height and stem diameter were recorded. The leaf chlorophyll, nitrogen, phosphorus, potassium, calcium and magnesium contents were also measured. The significance of the data was measured by using statistical software Statistix 8.1 (Statistix, 2006) and the treatment means were compared.

Seed germination was noted every week for up to one month of plantation and percentage of the germination was calculated by using Larsen and Andreasen (2004).

$$GP = \Sigma n / N \times 100$$

where n denotes number of seeds germinated at each count and N is total number of seeds per treatment.

Germination time (days) was calculated by using formula of Ellis and Roberts (1981)

$$MGT = \sum Dn / \sum n$$

Where n denotes number of seeds germinated on day D and Dn is the number of days as counted from the beginning of germination.

Germination index (GI) was calculated by the formula given by the Association of Official Seed Analysts (1983)

$$GI = \frac{\text{Number of germinated seeds}}{\text{Days of first count}} + \ldots + \ldots + \frac{\text{Number of germinated seeds}}{\text{Days of last count}}$$

Seedling height = The seedling height from tip to the base of the seedling was taken from five randomly plants of each treatment at 30 days interval. The average height was determined.

Stem diameter (mm) was determined by using digital vernier caliper at the center, top and bottom of the stem and mean was calculated. The chlorophyll content of random leaves was determined with a portable chlorophyll meter using SPAD 502. The seedling height, stem diameter, chlorophyll content was determined from six months old seedlings.

RESULTS

The data in Table 1 reveals the soil characteristics, i.e. EC (0.38 dSm^{-1}), pH (7.46), organic matter (0.89%), nitrogen (0.053 mg kg^{-1}), phosphorus (5.61 mg Kg^{-1}), potassium (209 mg Kg^{-1}), Calcium (2713 mg Kg^{-1}) and magnesium (1243 mg Kg^{-1}).

Table 1. EC, pH, organic matter and nutrient content of soil.

Parameter	Mean results
EC	0.38 ± 0.020
pH	7.46 ± 0.030
Organic matter (%)	0.89 ± 0.020
Total nitrogen	0.05 ± 0.002
P (mg Kg^{-1})	5.61 ± 0.640
K (mg Kg^{-1})	209.00 ± 2.015
Ca (mg Kg^{-1})	2713.00 ± 84.74
Mg (mg Kg^{-1})	1243.00 ± 33.13

***Germination and growth of mango seedlings*:** Germination percentage and time of germination was significantly varied by the seed forms (corticated and decorticated seeds) and seed priming treatments (Table 2). The interaction of seed form and priming was also significantly different. The interaction depicts that decorticated hormonal primed seeds had the highest seed germination (80%) in 12 days. These results are at par with the results obtained from nutriprimed (78.80%) and hydroprimed (76.26%) seeds in 17 and 26.67 days, respectively. To compare means of the seed priming, unprimed seeds germinated within 30.5 days with germination percentage (69.03) and hydroprimed in 29 days with 67.80 germination percentage. The mean seed germination (77.42%) was measured maximum from hormonal primed seeds within 18.50 days. The decorticated seeds had the highest mean seed germination (76.81%) in

Table 2. Effect of seed priming and seed form on time of germination and germination (%) of mango.

Seed priming treatments	Germination time (days)		Mean	Seed germination (%)		Mean
	Corticated seeds	Decorticated seeds		Corticated seeds	Decorticated seeds	
No priming	33.00 a	28.00 b	30.50 A	65.85 c	72.21 b	69.03 B
Hydro-priming	31.33 a	26.67 b	29.00 A	59.35 d	76.26 ab	67.80 B
Hormonal priming	14.00 e	12.00 e	18.50 B	74.85 ab	80.00 a	77.42 A
Nutripriming	20.00 c	17.00 d	13.00 C	47.60 e	78.80 a	63.20 C
Mean	24.58 A	20.92 B		61.91 B	76.81 A	

Standard error for seeds (S) = 0.6719
Standard error for seed priming (P) = 0.9501
Standard error for Interaction S x P = 1.3437

Standard error for seeds (S) = 1.3586
Standard error for seed priming (P) = 1.9213
Standard error for Interaction S x P = 2.7171

Table 3. Effect of seed priming and seed form on germination index and seedling vigor index of mango.

Seed priming treatments	Germination index		Mean	Seedling vigor index		Mean
	Corticated seeds	Decorticated seeds		Corticated seeds	Decorticated Seeds	
No priming	8.41	10.14	9.28 B	2458.8 cd	2764.6 c	2611.7 C
Hydro-priming	10.67	11.62	11.14 A	2552.2 cd	3452.3 b	3002.2 B
Hormonal priming	10.14	13.16	11.65 A	3729.9 ab	3936.3 a	833.1 A
Nutripriming	9.98	12.95	11.46 A	2213.0 d	3698.5 ab	2955.8 B
Mean	9.80 B	11.97 A		2738.5 B	3462.9 A	

Standard error for seeds (S) = 0.5943
Standard error for seed priming (P) = 0.8405
Standard error for Interaction S x P = 1.1886

Standard error for seeds (S) = 94.784
Standard error for seed priming (P) = 134.05
Standard error for Interaction S x P = 189.57

20.92 days as compared to the corticated seeds (61.91%) in 24.58 days.

The germination index was determined significantly different by the seed form (corticated and decorticated seeds) and seed priming whereas interactive effect of the factors had no significant differences for the germination index. The mean results for seed germination index in Table 3 depicts that each priming treatment produced similar results for germination index except unprimed seeds (9.28). To compare means of corticated and decorticated seeds, decorticated seeds had germination index of 11.79 as compared to the corticated seeds (9.80).

The vigor index of the seedlings was significantly affected by the seed form (corticated and decorticated seeds), seed priming and their interaction (Table 3). The interaction of seed form and seed priming depicted maximum seedling vigor index from decorticated hormonal primed seeds (3936.3). These results are at par with the results obtained from decorticated nutriprimed seeds (3698.5). To compare means of seed form, decorticated seeds had maximum vigor index of the seedlings (3462.9) in comparison to the corticated seeds (2738.5). The mean of the seed priming ranges from 2611.7 to 833.1 with maximum seedling vigor index from hormonal primed seeds (833.1).

The seedling height was significantly affected by the seed priming treatments while seed form and its interaction with seed priming treatments had no significant effect on the seedling height. The data in Table 4 depicts that maximum mean seedling height of the seedlings was observed from hormonal primed seeds (33.82 cm) followed by nutriprimed seeds (31.75 cm). The unprimed seeds produced seedlings with minimum seedling height (22.08 cm) followed by hydroprimed seeds (27.95 cm). The mean of the corticated and decorticated seeds had also no significant differences for seedling height.

The stem diameter of the seedlings was affected significantly by the seed priming treatments (Table 4). However, corticated and decorticated seeds had no significant differences for the stem diameter. The interaction was also at par. Unprimed seeds produced seedlings with minimum stem diameter (6.31 mm). However hormonal (9.66 mm) and nutriprimed (9.07 mm) seeds produced seedlings with similar diameter (Table 4).

The seed priming and seed form along with their interaction had significant differences for leaf chlorophyll content. On the basis of interaction, decorticated seeds produced seedlings with maximum chlorophyll content (52.36 rg) under the response of hormonal priming (Table 5). These results are non-significantly different with the results determined from decorticated seeds (49.15) in response to the nutripriming treatment. To compare mean value of the seed priming, hormonal and nutriprimed seeds produced seedlings with similar and maximum mean chlorophyll content (48.18; 48.07 rg). These results are significantly different from hydro (42.14) and unprimed (36.09) seeds. On the basis of seed form, corticated (42.50) and decorticated (44.74) seeds produced seedlings with similar leaf chlorophyll content.

***Mineral nutrient content of the seedlings*:** The leaf nutrient content such as nitrogen (N), phosphorus (P), potassium,

Table 5. Effect of seed priming and seed form on leaf chlorophyll content (rg) of mango seedlings.

Seed priming treatments	Lea chlorophyll content		Mean
	Corticated seeds	Decorticated Seeds	
No priming	38.00 de	34.19 e	36.09 C
Hydro-priming	41.00 cd	43.28 bcd	42.14 B
Hormonal priming	44.00 bcd	52.36 a	48.18 A
Nutripriming	47.00 abc	49.15 ab	48.07 A
Mean	42.50	44.74	

Standard error for seeds (S) = 1.4298
Standard error for seed priming (P) = 2.0220
Standard error for Interaction of S x P = 2.8595

Table 4. Effect of seed priming and seed form on height and stem diameter of mango seedlings.

Seed priming treatments	Plant height (cm)		Mean	Stem diameter (mm)		Mean
	Corticated seeds	Decorticated seeds		Corticated seeds	Decorticated seeds	
No priming	21.76	22.41	22.08 C	6.22	6.40	6.31 C
Hydro-priming	27.54	28.37	27.95 B	7.87	8.10	7.98 B
Hormonal priming	33.32	34.32	33.82 A	9.52	9.81	9.66 A
Nutripriming	31.28	32.22	31.75 A	8.94	9.21	9.07 A
Mean	28.47	29.33		8.13	8.38	

Standard error for seeds (S) = 0.7906
Standard error for seed priming (P) = 1.1180
Standard error for Interaction S x P = 1.5812

Standard error for seeds (S) = 0.2262
Standard error for seed priming (P) = 0.3200
Standard error for Interaction S x P = 0.4525

Table 6. Effect of seed priming and seed form on nitrogen and phosphorus content (%) of mango leaf tissue.

Seed priming treatments	Nirtogen (%)			Phosphorus (%)		Mean
	Corticated seeds	Decorticated seeds	Mean	Corticated seeds	Decorticated seeds	
No priming	1.02 d	1.07 c	1.05 B	0.07 c	0.13 b	0.10 C
Hydro-priming	1.03 d	1.08 c	1.05 B	0.13 b	0.14 b	0.13 B
Hormonal priming	1.04 d	1.09 c	1.06 B	0.13 b	0.14 ab	0.13 B
Nutripriming	1.13 b	1.19 a	1.16 A	0.14 ab	0.15 a	0.14 A
Mean	1.06 B	1.11 A		0.12 B	0.14 A	

Standard error for seeds (S) = 7.169 E-03
Standard error for seed priming (P) = 0.0101
Standard error for Interaction S x P = 0.0143

Standard error for seeds (S) = 2.764E-03
Standard error for seed priming (P) = 3.909E-03
Standard error for Interaction S x P = 5.528E-03

Table 7. Effect of seed priming and seed form on potassium and calcium content (%) of mango leaf tissue.

Seed priming treatments	Potassium (%)			Calcium (%)		Mean
	Corticated seeds	Decorticated seeds	Mean	Corticated seeds	Decorticated Seeds	
No priming	0.42 c	0.56 ab	0.49 C	1.29 c	1.75 ab	1.52 C
Hydro-priming	0.54 b	0.57 ab	0.55 B	1.68 b	1.76 ab	1.72 B
Hormonal priming	0.55 b	0.57 ab	0.56 AB	1.70 b	1.78 ab	1.74 B
Nutripriming	0.59 ab	0.62 a	0.61 A	1.84 ab	1.94 a	1.89 A
Mean	0.52 B	0.58 A		1.63 B	1.81 A	

Standard error for seeds (S) = 0.0164
Standard error for seed priming (P) = 0.0232
Standard error for Interaction S x P = 0.0329

Standard error for seeds (S) = 0.0489
Standard error for seed priming (P) = 0.0692
Standard error for Interaction S x P = 0.0979

calcium (Ca) and magnesium (Mg) was significantly affected by the seed form (corticated and decorticated seeds) and seed priming treatments. The interaction of the seed form and seed priming was also observed significant. The pattern of the results was observed almost similar for each nutrient content. The mean nitrogen (1.16%), phosphorus (0.14%), potassium (0.61%), calcium (1.89%) and magnesium (0.27%) content were observed maximum from nutripriming (Table 6-8). On the basis of interaction, maximum nitrogen (1.19%), phosphorus (0.15%), potassium (0.62%), calcium (1.94%) and magnesium (0.28%) content was observed from decorticated seeds in response to the nutripriming. Based on seed form, decorticated seeds produced seedlings with mean maximum nitrogen (1.11%), phosphorus (0.14%), potassium (0.58%), calcium (1.81%) and magnesium (0.26%).

Table 8. Effect of seed priming and seed form on magnesium content (%) of mango leaf tissue.

Seed priming treatments	Magnesium (%)		Mean
	Corticated Seeds	Decorticated seeds	
No priming	0.16 e	0.25 bcd	0.20 C
Hydro-priming	0.24 cd	0.25 bcd	0.25 B
Hormonal priming	0.23 d	0.25 bc	0.24 B
Nutripriming	0.26 ab	0.28 a	0.27 A
Mean	0.22 B	0.26 A	

Standard error for corticated and decorticated seeds (S) = 0.00408
Standard error for seed priming (P) = 0.00577
Standard error for Interaction of S x P = 0.008165

DISCUSSION

Various seed priming treatments were applied to the corticated and decorticated seeds of mango. Among them, hormonal primed seeds where GA_3 at 100 ppm was applied had the best results for seed germination (%), germination time and germination index, seedling height and stem diameter. This may be due to GA_3 as gibberellins are important for seed germination as they encourage the synthesis and production of amylase that hydrolase starch into endosperm and provides sugars to stimulate germination of seeds (Rajmanickam *et al.*, 2004; Wang *et al.*, 2005; Matilla and Matilla-Vazquez, 2008). Besides, signaling pathway of gibberellins can stimulate germination by weakening of endosperm and expansion of embryo cell (Liu *et al.*, 2005; Voegel *et al.*, 2011). The present study results are also in accordance with the results of Kolekar *et al.* (2017). They recorded GA_3 at 100 ppm the best treatment to achieve germination of mango in less number of days (12.53), maximum germination percentage (85.67%) and germination vigor index (4.05). Shaban (2010) observed GA_3 @ 100 or 200 ppm the best treatment for seed germination. Kumar *et al.* (2008) also observed GA_3 at 100 ppm the best germination index (4.46). Venkat and Reddy (2005) observed GA_3 at 200 ppm was the best treatment which recorded the maximum germination percentage (85.5%). Few scientists used higher level of GA_3 i.e. 500 to 1000 ppm. Abbas *et al.* (2015) reported the highest germination at 500 ppm of GA_3 while Vidya *et al.* (2015) reported that GA_3 500 ppm for ten minutes has better effects on germination related attributes. There is lot of variation in the concentration of gibberellins and time of soaking used by the different scientists and this may be due to varietal variations.

On the basis of corticated and decorticated seeds, later seeds have better results for seed germination, lesser time to germination, and germination index. This is because mango seeds have a stony endocarp which inhibits germination (Deepak *et al.*, 2018; Pinto *et al*., 2018). While the practice of endocarp removal enhances seed germination and also encourages the emergence of number of erect seedlings which progresses the graft quality. Muralidhara *et al*. (2015) conducted a study on the effect of seed coat removal on seed germination and vigor of mango seedlings. They found that removal of seed coat stones gave superior response in all initiation of germination, germination percent extent of polyembryony, plant height, stem girth, number of leaves per plant, leaf area, fresh and dry weight and vigor index as compared stones their coats were not removed. Shaban (2010) reported that husking mango seed and soaking them in GA_3 prior to sowing improved germination and seedling growth. Germination percentage and number of seedlings per seed increased with seed husking and soaking in GA_3 at 100 or 200 ppm concentrations for 48 hours.

To compare seed priming treatments, the seedling height, stem diameter and number of leaves of the seedlings was observed maximum where seeds were primed in GA_3 at 100 ppm. This beneficial effect of the gibberellins was possibly due to elongation and quicker multiplication of the cells (Mobli and Baninasab, 2008; Venkat and Reddy, 2005). Dalal *et al*. (2002) reported that GA_3 proved the best for maximum seed germination and increased plant height and number of leaves in Aonla, mango, lime etc. The gibberellins also increase the plant height by increase in size of meristematic region and it is also significantly enhance the girth, number of leaves as reported by El-zaher (2008). Venkat *et al.* (2006) observed maximum height of the seedling (55.34 cm) and stem girth (0.996 cm) in varieties Alphonso and Bappakai in GA_3 at 100 ppm. Venkat *et al.* (2006) observed maximum height of the seedling (55.34 cm) and stem girth (0.996 cm) in varieties Alphonso and Bappakai in GA_3 at 100 ppm. Kolekar *et al*. (2017) also recorded better plant height and number of leaves in response to the GA_3 at 100 ppm. In contrast to this, Shaban (2010) recorded maximum seedling length, stem diameter and number of leaves in Zebda, Sukkary, Sabre and 13-1 rootstocks in response to the soaking of seeds in GA_3 solution at 200 ppm concentration for 48 hours.

Rootstocks have greater influence on the nutrient content of the leaves even if they are cultivated in the same growing conditions (Bergmann, 1992; Marschner, 1995; Zuazo, 2006; Kucukyumuk and Erdal, 2011). Besides, rootstock and scion compatibility also have greater influence on mineral nutrient content of leaf as reported by Zuazo (2006). He observed higher major nutrient content (N, P, K, Ca, Mg) in mango leaves of cv. Keitt (scion) on Gomera 3 in comparison to Gomera 1 rootstocks.

By comparing nutrient content with the critical levels as mentioned by Samra *et al.* (1978), each nutrient content was in the range of critical levels. Samra *et al.* (1978) mentioned critical levels for nitrogen ranges from 0.95-1.45, phosphorus 0.03-0.12, potassium 0.40-0.77, calcium 1.74-3.45 and magnesium 0.22-0.75. Our results are also well above the critical levels as mentioned by Catchpole and Bally (1995) and Poffley and Owens (2005).

***Conclusions*:** It is concluded that decorticated seeds when primed with GA_3 produced better results for germination, seedling growth and nutrient composition of leaf tissue. However nutrient content was well above or close the critical limits was also observed in nutripriming. This study suggests that the priming of the decorticated mango seeds is suitable to produce productive seedling rootstocks.

REFERENCES

Ashraf, M. and M.R. Foolad. 2005. Pre-sowing seed treatment a shotgun approach to improve germination, plant growth and crop yield under saline and non-saline conditions. Adv. Agron. 88:223-271.

Abbas, M. T., M. I. Seif, A. M. Gomma and E. E. M. Nada. 2015. Effect of seed husk, GA_3, KNO_3 and seed orientation in seed bed on germination character of white succary mango seeds. Hort. Sci. J., 3:55-60.

Association of Official Seed Analysts. 1983. Seed vigor testing handbook, Assoc. Official Seed Analysts, Contribution No. 32.

Bally, I.S.E. 2006. *Mangifera indica* (mango): Species Profiles for Pacific Island Agroforestry. Available online at www.agroforestry.net/tti/Mangifera-mango.pdf

Badar, H., A. Ariyawardana and R. Collins. 2019. Dynamics of mango value chains in Pakistan. Pak. J. Agri. Sci. 56:523-530.

Bergmann, W. 1992. Colour Atlas. Nutritional disorders of plants. Gustav Fischer Verlag Jena.

Bremner, J. M. 1965. Total nitrogen. In "Methods of Soil Analysis". Eds. C. A. Black; D. D. Evans; J. L. White; L. E. Ensminger; F. E. Clark. American Soc. Agron., Monograph No.9 Madison, Wisconsin: 1149-78.

Bremner, J.M. and C.S. Mulvaney. 1965. Total nitrogen. In: C.A. Black, D.D. Evans, J.L. White, L.E. Ensminger and F.E. Clark. (eds.), Methods of Soil Analysis, Part 2, 1st Ed. ASA, Madison, WI; pp.1149-1178.

Catchpole, D.W. and I.S.E. Bally. 1995. Nutrition of mango trees: a study of relationship between applied fertilizer, leaf elemental composition, and tree performance (flowering and fruit yield). In: R. Holmes (ed.)

Marketing seminar and Production workshop. Queensland, Australia, pp.91-104.

Cottenie, A. 1980. Soil and plant testing as a basis of fertilizer recommendation. FAO Soils Bulletin No. 38. Rome, Italy.

Dalal, S.R., S.R. Patil, V.S. Gonge and R.B. Athawale. 2002. Effect of GA_3 and urea on growth of Rangpur lime seedlings in nursery. Indian J. Citricultrue 1:121-124.

Deepak, G.N., U. Jeevan, C. Singh, H.L. Priyanka and S. Jaganath. 2018. Stone characterization, media analysis and its influence on polyembryonic rootstock germination of mango (*Mangifera indica* L.). Int. J. Curr. Microbiol. App. Sci. 7:1728-1736.

Ellis, R.H. and E.H. Roberts. 1981. The quantification of ageing and survival in orthodox seeds. Seed Sci. Technol. 9:373-409.

El-Zaher, M.H.A. 2008. Using the grafting for propagation the jackfruit and producing the rootstocks for the grafting. American-Eurasian J. Agric. Environ. Sci. 3:459-473.

Estefan, G., R. Sommer and J. Ryan. 2013. Methods of soil, plant and water analysis. A manual for the West Asia and North Africa region, 3rd Ed. ICARDA, Beirut, Lebanon.

Gholap, S.S. and N.D. Polara. 2015. Effect of growing media and storage of stone on the growth and development of mango (*Mangifera indica* L.) rootstock cv. Local. HortFlora Res. Spectrum 4:236-240.

Jaskani, M.J., S.W. Kwon and D.H. Kim. 2006. Seed treatments and orientation affects germination and seedling emergence in tetraploid watermelon. Pak. J. Bot. 38:89-98.

Khan, B., S. Tawab, N. Ali, S. Ali, M.M. Anjum and W. Zaman. 2017. Effect of different growing media on the growth and germination of mango. Int. J. Eviorn. Sci. Nat. Resour. 4:555-636.

Krishnan, A.G., T.K. Nailwal, A. Shukla and R.C. Pant. 2009. Mango (*Mangifera indica*. L) malformation an unsolved mystery. Researcher 1:20–36.

Knudsen, D., G.A. Peterson and P.F. Pratt. 1982. Lithium, Sodium and Potassium. In: A.L. Page (ed.), Methods of Soil Analysis, Part 2: Chemical and microbiological properties. American Soc. Agron. Madison, WI, USA; pp.229-230.

Kolekar, S.N., A.S. Kadam and D.G. Gend. 2017. Effect of different organics and chemicals treatments on germination, growth and success of softwood grafting in mango during nursery stage. Int. J. Chem. Stud. 5:880-884.

Kucukyumuk, Z. and I. Erdal. 2011. Rootstock and cultivar effect on mineral nutrition, seasonal nutrient variation and correlations among leaf, flower and fruit nutrient concentrations in apple trees. Bulgarian J. Agric. Sci. 17:633-641.

Kumar, H.S.Y., G.S.K. Swamy, C.P. Patil, V.C. Kanamadi and P. Kumar. 2008. Effect of pre-soaking treatments on the success of softwood grafting and growth of mango grafts. Karnataka J. Agric. Sci. 21:471-472.

Larsen, S.U. and C. Andreasen. 2004. Light and heavy turf-grass seeds differ in germination percentage and mean germination thermal time. Crop Sci. 44:1710-1720.

Liu, P.P., N. Koizuka, T.M. Homrichhausen, J.R. Hewitt, R.C. Martin and H. Nonogaki. 2005. Large-scale screening of Arabidopsis enhancer-trap lines for seed germination associated genes. Plant J. 41:6-944.

Marie, C.P. 2001. Dwarfing potential of indigenous mango varieties. M.Sc. thesis, Kerala Agric. Univ., Thrissur.

Marschner, H. 1995. Mineral nutrition of higher plants, 2nd Ed. Academic Press. San Diago, USA.

Matilla, A.J. and M.A. Matilla-Vazquez. 2008. Involvement of ethylene in seed physiology. Plant Sci. 175:87-97.

Mirshekari, B. 2012. Seed priming with iron and boron enhances germination and yield of dill (*Anethum graveolens*). Turk. J. Agric. For. 36:27-33.

Mobli, M. and B. Baninasab. 2008. Effects of plant growth regulators on growth and carbohydrate accumulation in shoots and roots of two almond rootstock seedlings. Fruits (Paris) 63:363-370.

Muralidhara, B.M., Y.T.N. Reddy, V. Srilatha and H.J. Akshitha. 2015. Effect of seed coat removal treatments on seed germination and seedling attributes in mango varieties. Int. J. Fruit Sci. 16:1-9.

Murphy, J. and J.P. Riley. 1962. A modified single solution method for determination of phosphates in natural waters. Anal. Chem. Acta 27:31-36.

Patel, R.J., T.R. Ahlawat, A.I. Patel, J.J. Amarcholi, B.B. Patel and K. Sharma. 2017. Growth of mango (*Mangifera indica* L.) rootstocks as influenced by pre-sowing treatments. J. Appl. Nat. Sci. 9:582-586.

Patel, R.J., T.R. Ahlawat, A. Singh, S.K. Momin and G. Chaudhri. 2016. Effect of pre-Sowing treatments on stone germination and shoot growth of mango (*Mangifera indica* L.) seedlings. Inter. J. Agric. Sci. 8:2437-2440.

Pinto, A.C.de Q., V.G. Sauco, S.K. Mitra and F.R. Ferreira. 2018. Mango propagation. Rev. Bras. Frutic. Jaboticabal 40:1-13.

Pinto, P.A.C., M.M. Choudhury, J.A. Lins, S. Homma, A.C.C. Pinto, C.P. Silva and R.S. Oliveira. 2008. Qualidade póscolheita de frutos de mangueira (*Mangifera indica* L.) var. 'Tommy Atkins' sob sistema orgânico no submédio São Francisco (Brasil). Recursos Rurais 1:5-12.

Poffley, M. and G. Owens. 2005. Mango leaf and soil analysis. Agnote No. D241. Published by the Northern Territory Government, Australia.

Rajamanickam, C., S. Anbu and K. Balakrishnan. 2004. Influence of seed treatments on seedling vigour in amla (*Emblica officinalis* G.). South Indian Hort. 52:324-327.

Ram, S. and R. Litz. 2009. Crop Production: Propagation. In: R.E. Litz (ed.), The mango, Botany, Production and Uses. Wallingford: CAB International; pP.367- 403.

Ramírez, F. and T.L. Davenport. 2010. Mango (*Mangifera indica* L.) flowering physiology. Sci. Hortic. 126:65-72.

Raza, S.A., A.S. Khan, I.A. Khan, I.A. Rajwana, S. Ali, A.A. Khan and A. Rehman. 2017. Morphological and physic-chemical diversity in some indigenous mango (*Mangifera indica* L.) germplasm of Pakistan. Pak. J. Agri. Sci. 54:287-297.

Rehman, A.U., M. Farooq, Z.A. Cheema and A. Wahid. 2012. Seed priming with boron improves growth and yield of fine grain. Plant Growth Regul. 68:189-201.

Richards, L.A. 1954. Diagnosis and improvement of saline-alakali soils. Agricultural Handbook, USDA; p.60.

Ruiz, C., M.P. Breto and M.J. Asins. 2000. A quick methodology to identify sexual seedlings in citrus breeding programs using SSR markers. Euphytica 112:89-94.

Samra, J.S., R.S. Thakur and K.L. Chadha. 1978. Evaluation of existing critical limits of leaf nutrient standards in mango. Sci. Hortic. 8:349-355.

Shaban, A.E.A. 2010. Improvement in seed germination and seedlings (growth of some mango rootstocks). American-Eurasian J. Agric. Environ. Sci. **7**:535-541.

Sivritepe, H.O. 2000. The effects of osmotic conditioning treatments on salt tolerance of onion seeds. III. National Symp. Vegetable Production, Isparta, Turkey; pp.475-481.

Soltanpour, P.N. and A.P. Schwab. 1977. A new soil test for simultaneous extraction of macro and micro nutrients in alkaline soils. Commun. Soil Sci. Plant Anal. 8:195-207.

Statistix. 2006. Statistics 8 User Guide, version 1.0. Analytical software, P.O. Box 12185, Tallahassee FL 32317 USA; Copyright @ 2006 by Analytical Software.

Thakriya, H.R., V. Singh, D.R. Bhanderi, J.R. Paramar and A. Unnati. 2017. Influence of mango rootstock by different soaking treatments on germination percentage and growth. Int. J. Chem. Stud. 5:1275-1277.

Venkat, R. and Y.T.N. Reddy. 2005. Effect of osmopriming on germination seedling growth and vigour of mango stones. Karnatka J. Hort. 1:29-35.

Venkat, R., Y.T.N. Reddy, N. Srinivas and M. Shiragur. 2006. Growth of mango (*Mangifera indica* L.) seedlings as influenced by stone treatments. J. Asian-Hort. 2:160-165.

Vidya, A., G.S.K. Swamy, N.B. Prakash, P.M. Ganghadarappa, R.C. Jagadeesha, S.L. Jagadeesh and L.C. Mukesh. 2015. Effect of chemicals, organic and gibberellic acid on germination, growth and graft-take in mango (*Mangifera indica*). Mysore J. Agric. Sci. 49:13-18.

Voegel, A., A. Linkies, K. M¨uller and G. Leubner-Metzger. 2011. Members of the gibberellin receptor gene family GID1 (Gibberellin Insensitive Dwarf1) play distinct roles during *Lepidium sativum* and *Arabidopsis thaliana* seed germination. J. Exp. Bot. 155:1851-1870.

Walkley, A. and I.A. Black. 1934. An examination of the method for determining soils organic matter and a proposed modification of the chromic acid titration method. Soil Sci. 37:29-38.

Wang, A.X., X.F. Wang, Y.F. Ren, X.M. Gong and J.D. Bewley. 2005. Endo-b-mannanase and b-mannosidase activities in rice grains during and following germination, and the influence of gibberellin and abscisic acid. Seed Sci. Res. 15:219-227.

Zuazo, V.H.D. 2006. Rootstock influence on fruit yield, growth and mineral nutrition of mango (*Mangifera indica* L. cv. Keitt). European J. Hortic. Sci. **7**:102-108.

Zarcinas, B.A., B. Cartwright and L.P. Spauncer. 1987. Nitric acid digestion and multi-element analysis plant material by inductively coupled plasma spectrometry. Commun. Soil Sci. Plant Anal. 18:131-147.