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Seedling vigour of *Prosopis cineraria* (L.) in response to different growth media and polybag sizes in arid climatic conditions

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Abstract
Prosopis cineraria is a multipurpose tree of Thar desert with immense significance in sustaining the livelihoods of people. Successful tree growing in dry arid conditions necessitates development of vigorous seedlings. For faster and successful raising of healthy and uniform seedlings growing media and container sizes are more critical factors. With aim to find suitable polybag size and the growing media for faster and healthy seedling production, a repetitive study was carried out in 2014 and 2015 at Central Nursery of Central Arid Zone Research Institute, Jodhpur and the performance of *P. cineraria* seedlings was compared for various seedling vigour related traits. Both the media and polybag size significantly influenced different shoot and root parameters. Interaction effect among media and polybag was also observed for seedling height, root collar diameter and root length. A high positive correlations ($r>0.80$) were found between height of seedlings and root length, shoot fresh and dry weight, and root fresh and dry weight. The regression analysis ($R^2>80\%$) also proved the strong relationship between these parameters. The overall performance of seedlings was highest in media composed of sand: vermicompost (VC): clay soil in 2:1:1 ratio and bigger sized polybags P5 (20 × 15 cm) and P6 (25 ×15 cm).

Keywords: Desert, Growth, Media, Nursery, Polybag, *Prosopis cineraria*, Seedling

Introduction

Prosopis cineraria (*Khejri*) is known as Kalpvriksh of Rajasthan (the largest state of India) and lifeline of Indian desert (Thar) owing to its adaptability to the inhospitable edapho-climatic conditions of the region. It spreads over about two-thirds of the total geographical area of the State and is of immense significance culturally and economically. The species is also distributed in the parts of Haryana, the plains of Uttar Pradesh, Gujarat, North Karnataka, Tamil Nadu, Madhya Pradesh, Delhi, Maharashtra and Punjab. This tree has supported the economy of rural people (Manga and Sen, 1995) like no other vegetation has done in the tracts of Thar desert by providing food, fodder, fuel and fibre. Consequently, farmers also promote its establishment often on lands cleared for settlement or along with crops on their fields and thus it is a vital component of the traditional agro-forestry systems (Bhatnagar *et al*., 2016).

There is heavy pressure on this species due to over grazing, heavy lopping; fuel wood collection etc. (Singh and Bishnoi, 2012). *P. cineraria* has traditionally been a naturally growing tree but in present times its natural regeneration is being hampered by mechanized farming and therefore, planting of seedlings of *khejri* has become essential to conserve this important native tree (Toky and Harris, 2004). Although natural regeneration occurs in *khejri* but it is mostly in moist places and that too is very slow. Additionally, Central Institute for Arid Horticulture, Bikaner has recently developed superior type budded *khejri* for vegetable purpose (green tender pod) named 'Thar Shobha', which yield 4.25 kg *sangri* (edible pods) and 6.25 kg of fodder in a year (Samadia, 2015); it starts bearing pods at the age of 3-4 years whereas normal *khejri* takes 7-8 years for bearing pods. Due to its popularity, it is in high demand among the farmers. Thus to produce true to type plants and quicker bearing, vegetative propagation (budding) needs to be done. Whether, it is for *khejri* tree plantation in fields or for producing root stocks for budded *khejri*, the healthy seedlings are raised in same manner at nursery level. The quality of seedlings at nursery level often determines the graft success and post seedling transplantation success in field. Therefore, there is need to produce the quality planting material at nursery stage to attenuate the above said concerns. Soil media and container size

are among the main factors which affect the production of quality planting material in nursery conditions. Slow growing nature of seedlings is the major limiting factor for successful seedling production in tree nurseries, which can be enhanced by use of appropriate growing medium for nursery containers (Navamaniraj *et al*., 2008). Besides this, the poor survival in the nursery and field can be addressed by the use of a balanced potting mixture (Abad *et al*., 2002) and by using an optimum type and size of container (Annapurna *et al*., 2004; Landis *et al*., 2010). Accordingly, selection of potting medium to grow quality seedlings in nursery is of paramount importance.

Similarly the primary function of any container is to hold a discrete supply of growing medium, which in turn supplies water, air, mineral nutrients and the physical support (Abugre and Oti-Boateng, 2011). The concept that size of container influences the different properties of plant development and quality will help the nursery growers to choose the best containers accordingly. Optimum container size is related to the species, target plant size, growing density, length of the growing season, and growing medium used.

The studies conducted earlier mainly focused on germination of seeds, irrigation regimes, seed traits, role of plant growth regulators on performance of seedlings of *P. cineraria*. There are limited studies available so far which evaluated the performance of seedlings in different media and container sizes. Therefore, the present study was formulated to evaluate the effect of different growth media and polybag sizes on the growth performance of *P. cineraria* seedlings.

Materials and Methods

Planting material and experimental design: The study was carried out in the Central Nursery of Central Arid Zone Research Institute (CAZRI), Jodhpur, Rajasthan (26º 15' N latitude, 72º 59' E longitude) during March to July, 2014 and repeated during March to July, 2015. Fresh and mature pods were collected in brown paper bags from healthy and vigorous trees (25-30 years age) identified in campus of CAZRI, Jodhpur during the months of May-July in 2013 and 2014. Pods were dried and seeds were extracted and kept in fumigated air tight containers under ambient temperature until sowing. *P. cineraria* seeds remain viable for 2-4 years. Since the seeds have hard coat they were treated with 50% sulphuric acid for 10-15 minutes after that washed adequately with water for removal of excess acid and shade dried for 24 hours before sowing. The six sizes of polybags (fresh virgin 50 microns black colour) were selected for study *viz*., 20 X 10 cm (P1), 25 X 10 cm (P2), 20 X 12 cm (P3), 25 X 12 cm (P4), 20 X 15 cm (P5) and 25 X 15 cm (P6). These polybags were filled with three different substrate mixtures *viz*., sand: FYM (Farm yard manure) (5:1) (M1), sand: FYM: clayey soil (2:1:1) (M2) and sand: vermicompost (VC): clayey soil (2:1:1) (M3). The sandy soil contains 0.15% organic carbon, 0.007% available nitrogen, 0.001% available phosphorus and 0.026% available potassium. FYM used in the study contained 37.6 % carbon, 0.5-1.3% nitrogen, 0.015% phosphorus and 0.9% potassium. The VC contained 20-25% organic carbon, 1.5-2% nitrogen, 0.5-1% phosphorus and 0.5-1% potassium (CRIDA, 2009). Two seeds were sown in each polybag and for each size 100 polybags were used with three different media. The group of 100 polybags of each size filled with each type of media was divided into 5 groups, each group was considered as a replicate which was containing 20 polybags. Eighteen combinations were thus formed with five replications in completely randomised block design in controlled conditions in nursery.

Measurement of growth variables: The data on seed germination was recorded from 7th day of germination up to 21 days by daily counting the emerged seedlings (Noor Mohamed *et al.,* 2018). The data on ten seedlings per replication were used to record the other growth parameters like root collar diameter (cm), plant height (cm), number of branches, root length (cm), root and shoot weight in 5 months old seedlings from the centre most portions of polybags to avoid edge effects. The root collar diameter was taken with the help of digital vernier caliper, shoot and root length with measuring scale. Five randomly selected seedlings from each replication were uprooted and roots were cleaned by washing them in water and their lengths were measured at the collar. Root and shoot of these seedlings were separated and their fresh weight was measured using a top pan electronic balance. Then, the seedlings were kept in paper bags and were dried in an oven separately at 65°C for 48 hours to calculate the dry weight.

Statistical analyses: All data were statistically analyzed by ANOVA for 2×2 factorial CRD using the SPSS software package (SPSS v.22 (SPSS, Armonk NY). To separate treatment means within each measured parameter, Duncan's multiple range test was performed at P = 0.05. Pearson's correlation coefficient and regression analysis was used to measure the strength of the association between the two variables.

Results and Discussion

Germination of seedlings: The rate of germination in all the treatments was generally high ranging from 79 to 96.5 percent (data not shown). Significant differences in germination percentage were observed among different potting media ($P<0.05$), while non-significant differences in germination were observed in different sizes of polybag and interaction between media and polybag sizes in both the years. *P. cineraria* germinated very well ranging between 80 to 90% with sulphuric acid treatment prior to sowing in control (M1 (sand: FYM media). Vilela and Ravetta (2001) had also reported that in most of the *Prosopis* species germination rates were generally high but needed proper scarification treatment and controlled conditions for storage. The *Prosopis cinerara* had very hard seed coat and germination percentage in untreated seeds was very low whereas, after treatment the germination percentage enhanced (Sacheti and Al-Areimi, 2000).

Shoot parameters: Seedlings showed significant difference for height and root collar diameter among different potting media and polybag sizes ($P<0.01$) in both the years. The analysis was done to evaluate the consistency of results of both the years and it was observed that except root collar diameter all the shoot and root parameters differed non-significantly for their performance over the years (data not shown). The maximum height of seedlings was in media M3 (sand: VC: clayey soil) and polybag size P6 ranging between 42.31 cm and 59.23 cm over the mean of media. Similar improved effect of using big containers on seedling height was also outlined by Dumroese *et al*. (2011) and Mugloo *et al*. (2015). The height of plants was significantly higher by 30.18% and 15.82% in media M3 (sand: vermi compost: clayey soil) when compared with media M1 (sand: FYM) and media M2 (sand: FYM: clayey soil), respectively (Table 1). The mixture containing soil: sand: VC (2:1:1 ratio) recorded the maximum shoot length and stem girth in *Bixa orellana* (Navamaniraj *et al*., 2008). Similar results were also reported in *Pinus gerardiana* (Kumar *et al*., 2016) and bamboo (Raja *et al*., 2012). As shown in Figure 1(a) and 1(b) the significant difference of seedling height were recorded between media and polybag sizes. The data showed that the height of seedlings was maximum in bigger size polybags in all the media used but it was maximum when media M3 (sand: VC: clayey soil) was used along with polybag sizes P5 (65.8 cm) and P6 (64.6 cm). However, it was statistically at par with the media M2 (sand: FYM: clayey soil) and polybag size P5 (59.0 cm) and P6 (61.2 cm) in year 2014, whereas in the year 2015 the maximum height of seedlings was in polybag size P6 and media M3 (sand: VC: clayey soil) (68.6 cm) which was statistically superior to all other treatments. There was not much difference observed in height of seedlings in both the years for all the treatments. Similarly root collar diameter was 32.10 percent higher in media M3 (sand: VC: clayey soil) over media M1 (sand: FYM) and 23.30 per cent higher over media M2 (sand: FYM: clayey soil). Enhanced stem girth in papaya seedlings containing VC was also stated by Bhardwaj (2014). Similar results of enhanced collar diameter in media containing vermicompost were monitored by Kumar *et al*. (2016). The root collar diameter of the seedlings increased as the size of the polybags increased and followed the pattern as P6 (0.40 cm)>P5 (0.37 cm)>P4 (0.31 cm) >P3 (0.30 cm)>P2 (0.26 cm)>P1 (0.24 cm) (Table 1). The positive effect of container size on root collar diameter of seedlings was also observed by Dumroese *et al*. (2011) and Mugloo *et al*. (2015). The seedlings grow better in larger pots due to more space availability, early development of long tap root which are the mandatory conditions for transplantation success in arid or semi-arid conditions (Abera *et al*., 2018). Alike height, there was significant interaction among the media and polybag sizes for root collar diameter also. In both the years, almost similar trend was observed; maximum root collar diameter was when seedlings raised in media M3 (sand: VC: clayey soil) with polybag sizes P5 (0.47 cm) and P6 (0.48 cm). Though in media M1 (sand: FYM) and media M2 (sand: FYM: clayey soil) also the root collar diameter was on higher side when seedlings were grown in bigger polybag sizes but it was statistically lower than the media M3 (sand: VC: clayey soil) [Fig 1(c)-1(d)].

Shoot fresh weight and shoot dry weight were significantly different for media and polybag sizes, whereas there were non-significant differences observed with media and polybag interaction for both the parameters. The shoot fresh weight and shoot dry weight increased as the media composition changed from M1 (sand: FYM) to M3 (sand: VC: clayey soil). The media containing VC displayed the higher shoot fresh weight in papaya seedlings as well (Bhardwaj, 2014). Shoot fresh weight ranged between 2.68 to 3.07 g and shoot dry weight between 1.32 and 1.50 g. The shoot fresh (average 2.9 g seedling^{-1}) and dry weight (average 1.41 g seedling^{-1}) increased with increased size of polybags over the mean of media (Table 1). The higher dry weight of shoots with increase in volume of polybag was also observed by Abugre and Oti-Boateng (2011) and Mugloo *et al*. (2015).

Table 1. Mean effects of media and polybags size on growth parameters of *Prosopis cineraria* seedlings

Treatment	Height (cm)			Root collar diameter (cm)			Root length (cm)			Shoot fresh weight (g)		
Media (M)	**2014**	**2015**	**Mean**	**2014**	**2015**	**Mean**	**2014**	**2015**	**Mean**	**2014**	**2015**	**Mean**
M1	42.20^{c}	42.06^{c}	42.13	0.28^{b}	0.28^{b}	0.28	42.50^{c}	43.25^{c}	42.88	2.71^{b}	2.66^{c}	2.66^{c}
M2	48.50^{b}	46.20^{b}	47.35	0.28^{b}	0.30^{b}	0.29	47.33^{b}	46.50^{b}	46.92	2.95^{a}	2.88^{b}	2.88^{b}
M3	54.53^{a}	55.16^{a}	54.85	0.36^{a}	0.37^{a}	0.37	54.25^{a}	52.08^{a}	53.17	3.01^{a}	3.14^{a}	3.14^{a}
Polybags (P)												
P1	42.88^{b}	41.73^{c}	42.31	0.24^{d}	0.23^{c}	0.24	41.83^{cd}	40.50^{de}	41.16	1.68^{e}	1.62^{a}	1.62^{a}
P2	42.48^{b}	41.53^{c}	42.01	0.24^{cd}	0.28^{bc}	0.26	39.16^{d}	37.50^{e}	38.33	2.23^{d}	2.22^{b}	2.22^{b}
P3	42.73^{b}	42.88^{c}	42.81	0.29^{bc}	0.30^{b}	0.30	44.00^{bc}	44.66^{c}	44.33	2.88^{c}	2.83^{c}	2.83^{c}
P4	45.13^{b}	44.80^{c}	44.97	0.29^{b}	0.32^{b}	0.31	47.00^{b}	44.50^{bc}	45.75	3.17^{bc}	3.17^{bc}	3.17^{bc}
P5	59.73^{a}	55.80^{b}	57.77	0.36^{a}	0.38^{a}	0.37	55.83^{a}	56.16^{b}	56.00	3.37^{b}	3.51^{b}	3.51^{b}
P6	58.33^{a}	60.13^{a}	59.23	0.39^{a}	0.40^{a}	0.40	60.33^{a}	60.33^{a}	60.33	4.02^{a}	4.02^{a}	4.02^{a}
Significance												
M	***	***	-	***	***	-	***	***	-	**	***	***
P	***	***	-	***	***	-	***	***	-	***	***	***
M x P	*	***	-	***	***	-	*	**	-	NS	NS	NS

Treatment	Shoot dry weight (g)			Root fresh weight (g)			Root dry weight (g)			Root shoot ratio		
Media (M)	**2014**	**2015**	**Mean**	**2014**	**2015**	**Mean**	**2014**	**2015**	**Mean**	**2014**	**2015**	**Mean**
M1	1.32^{b}	1.33^{c}	1.32	3.02^{b}	3.04^{b}	3.03	1.45^{b}	1.50^{b}	1.48	1.22	1.25	1.24
M2	1.42^{ab}	1.42^{ab}	1.42	3.44^{a}	3.54^{a}	3.49	1.72^{a}	1.70^{a}	1.71	1.25	1.23	1.24
M3	1.49^{a}	1.50^{a}	1.49	3.44^{a}	3.35^{a}	3.40	1.68^{ab}	1.62^{ab}	1.65	1.16	1.10	1.13
Polybags (P)												
P1	0.83^{c}	0.80^{e}	0.81	2.49^{c}	2.32^{d}	2.41	1.28^{b}	1.18^{d}	1.23	1.57^{a}	1.51^{a}	1.54
P2	1.10^{d}	1.08^{d}	1.09	3.05^{bc}	3.02^{c}	3.04	1.53^{ab}	1.38^{cd}	1.46	1.42^{b}	1.32^{ab}	1.37
P3	1.35^{c}	1.33^{cd}	1.34	3.25^{b}	3.22^{bc}	3.24	1.64^{ab}	1.52^{c}	1.58	1.22^{bc}	1.14^{b}	1.18
P4	1.57^{b}	1.58^{bc}	1.57	3.40^{b}	3.49^{bc}	3.45	1.57^{ab}	1.62^{bc}	1.60	1.02^{c}	1.03^{b}	1.03
P5	1.70^{b}	1.70^{b}	1.7	3.62^{ab}	3.74^{ab}	3.68	1.74^{ab}	1.80^{b}	1.77	1.03^{c}	1.07^{b}	1.05
P6	1.94^{a}	2.00^{a}	1.97	4.01^{ab}	4.07^{a}	4.04	1.93^{a}	2.15^{a}	2.04	1.00^{c}	1.07^{b}	1.04
Significance												
M	**	*	-	**	**	-	*	*	-	NS	NS	-
P	**	***	-	***	***	-	*	***	-	***	**	-
M x P	NS	NS	-	NS	NS	-	NS	NS	-	NS	*	-

NS: Non-significant; *P < 0.05; **P < 0.01; ***P < 0.001; Different letters indicate significant differences according to the Duncan's multi-range test (P ≤ 0.05)

Root parameters: Significant differences were observed among the different media, polybag sizes and interaction between media and polybag sizes for root length of the seedlings. There was root coiling observed in the polybags but that does not affect the overall quality of seedlings. The average length of roots was significantly higher by 24% and 13.32% in media M3 (sand: VC: clayey soil) when compared to media M1 (sand: FYM) and M2 (sand: FYM: clayey soil) (average 47.67 cm), respectively. The length of roots when averaged over media ranged between 38.33 cm and 60.33 cm with minimum root length in polybag size P2 and maximum in P6 (Table 1). The root length similar to height and root collar diameter of plants showed better response in bigger polybag sizes when seedlings were raised in media M3 (sand: VC: clayey soil). However, seedlings raised in media × polybag interaction M2P6 (sand: FYM: clayey soil) and M3P6 (sand: VC: clayey soil) were significantly at par with each other in both the years. Seedlings raised in media M1 (sand: FYM) had comparatively low root length growth than media M2 (sand: FYM: clayey soil) and M3 (sand: VC: clayey soil) for all the polybag sizes [Fig 1(e)-1(f)]. On contrary to above mentioned parameters where media M3 (sand: VC: clayey soil) was performing better to other medias, the root fresh and dry weights were15.81 per cent and 2.64 per cent higher in media M2 (sand: FYM: clayey soil) when compared to media M1 (sand: FYM) and M3 (sand: VC: clayey soil) but the performance

of seedlings in media M2 (sand: FYM: clayey soil) was statistically at par with those of seedlings in media M3 (sand: VC: clayey soil). The root length, root fresh and dry weight also showed better response in media containing sand: soil: VC in 2:1:1 ratio. Dry matter production in *B. orellana* was increased to maximum in the potting mixture containing soil: sand: VC in the ratio of 2:1:1 (Navamaniraj *et al*., 2008). Highest root fresh weight was recorded in the media containing VC in papaya seedlings (Bhardwaj, 2014). While over the mean of media for different polybag sizes root fresh weight and dry weight followed the pattern P1<P2<P3<P4<P5<P6 with root fresh weight ranging between 2.41 and 4.04 g and root dry weight ranging between 1.23 and 2.04 g, respectively (Table 1). Root shoot ratio was non-significant for different media, and media and polybag sizes interaction. However, significant differences were observed among different polybag sizes ranging between 1.03 (P4) and 1.54 (P1) (Table 1). Abugre and Oti-Boateng (2011) showed that with large size polybags the root length as well as root biomass influenced significantly. Similar results of better root growth were ascribed to use of large volume containers (Mugloo *et al.,* 2015). The interaction between media composition and polybag sizes was found to be non-significant.

The more striking response of VC over compost mixed media was probably due to higher nutrient contents in VC, besides its richness in some plant growth regulating materials and humic acids resulted by increased microbial activities (Arancon *et al*., 2004; Kumar *et al*., 2014). Therefore, the selection of media used to grow and establish quality planting material plays a vital role.

The bigger size polybags used in the study significantly influenced the growth of *Prosopis cineraria* seedlings. The height, root collar diameter, root length, shoot fresh and dry weight and root fresh and dry weight was enhanced by the use of bigger size polybags parallel to the smaller sizes of polybags used. Also, regression analysis revealed that when the size of bags was small the values of the various parameters was increasing at moderate rate but as the polythene size increased from P4 to P5 and P6 there was sudden increase in most of the growth variables studied. Similarly Abugre and Oti-Boateng (2011) reported the tap root length in *Jatropha curcas* increased as the polybag size increased from small to large. This might be attributed to the bigger space of container where plant had the advantage to develop its roots deeper and extract more nutrients, water etc. Likewise Malik and Shamet (2009) found all these seedlings growth parameters in *Pinus gerardiana* performed better when grown in larger polybag size of 23 × 10 cm. They also reported enhanced fibrous root development in bigger polybag size. Increasing container volume from 50 to 656 ml yielded koa seedlings with 200% more height and stem diameter growth (Dumroese *et al*., 2011).

Correlation and regression analysis: The phenotypic correlation matrix of different growth parameters of seedlings was also estimated (Table 2). The data exhibited maximum positive correlation between shoot fresh weight and shoot dry weight (r=0.98) followed by height and root length of seedlings (r=0.95) and root fresh weight and root dry weight (r=0.92) by taking the average of both the years. The strong positive significant (P>0.05) relation (r>0.80) between height of seedlings and root collar diameter, height and shoot fresh and dry weight, height and root fresh and dry weight, root collar diameter and root length, root collar diameter and shoot fresh and dry weight, root collar diameter and root fresh and dry weight, root length and shoot fresh and dry weight, root length and root fresh and dry weight was observed. The minimum correlation of r = -0.005 was observed between root length and number of branches. Both media composition and polybag size significantly affected seedling height, root collar diameter, root length, shoot and root biomass. In addition to this seedlings grew larger with increased size of polybags. The regression analysis was also carried out between seedling parameters and different polybag sizes to know the trend of seedling growth as the polybag size increased. The height, root collar diameter, root length, shoot dry weight and root shoot ratio of seedlings was best fit to the polynomial curve in relation to increased polybag size. [Fig 2(a); 2(b); 2(c); 2(e); 2(h)]. Whereas shoot fresh weight, root fresh and dry weight were best fit into power curve [Fig 2(d), 2(f)-2(g)]. The regression analysis between the polybag size and seedling growth parameters displayed a strong relationship (R^2> 0.80). The height of seedlings was slightly increased as the size of polybags increased from P1 to P4 but the sudden increase in height was observed in the polybag size P5 and P6. However, there was periodic increase in the root collar diameter of seedlings as the size of polybag increased from P1 to P6. Root length of the seedlings was slightly less in polybag size P2 as compared to polybag P1 but after that there was a steady increase as the size of polybags increased. Shoot fresh weight and dry weight showed an increasing trend every time when

the size of polybag was increased. Similarly root fresh and dry weight enhanced as the size of the polybags got bigger. In contrary to all parameters, root shoot ratio showed the reverse trend and was maximum in polybag size P1 and decreased steadily up to polybag size P4 and after that the root shoot ratio was almost stable with increase in polybag size. Therefore, the interaction among the media and polybag size i.e. bigger polybag sizes P5 and P6 along with different media mixtures significantly influenced the growth parameters. Similar results were reported by Malik and Shamet (2009) in *P. gerardiana,* where they have found that container type and growing media put out notable impact on the growth parameters of seedlings. Similar interaction effect between container type and potting medium was reported by Mugloo *et al*. (2015) in *Picea smithiana*. Arvind *et al*. (2015) found interaction effect between media and container (soil + cocopeat + FYM (1:1:1) + earthen pots) for fresh and dry weight of papaya seedlings. However, in our study no interaction effect between media and polybag was found for root shoot ratio and fresh and dry weight of seedlings.

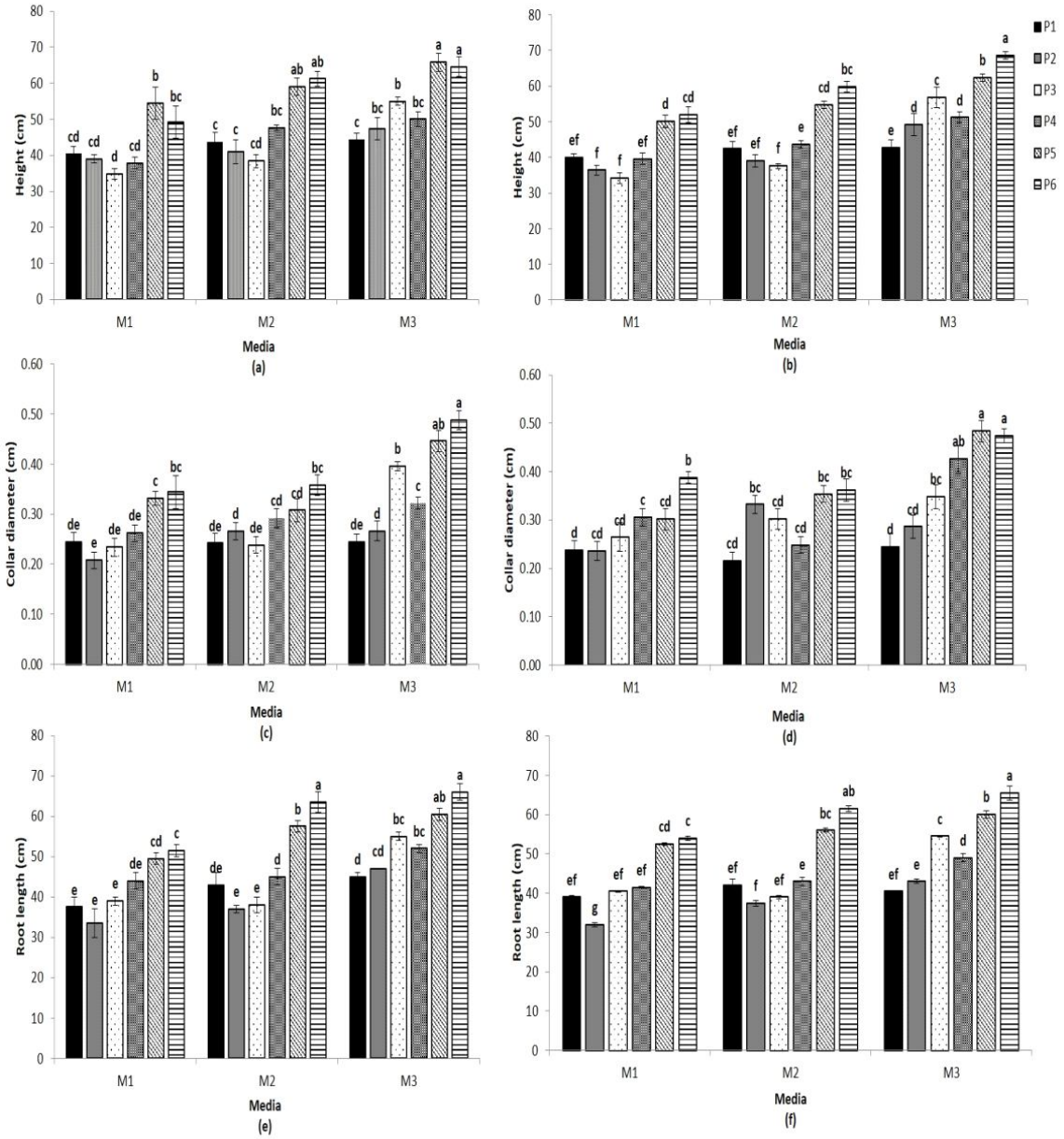

Fig 1. Interaction effect of polybag size and potting mixture (a)Height (2014), (b) Height (2015), (c) Root collar diameter (2014), (d) Root collar diameter (2015), (e) Root length (2014) and (f) Root length (2015) of seedlings

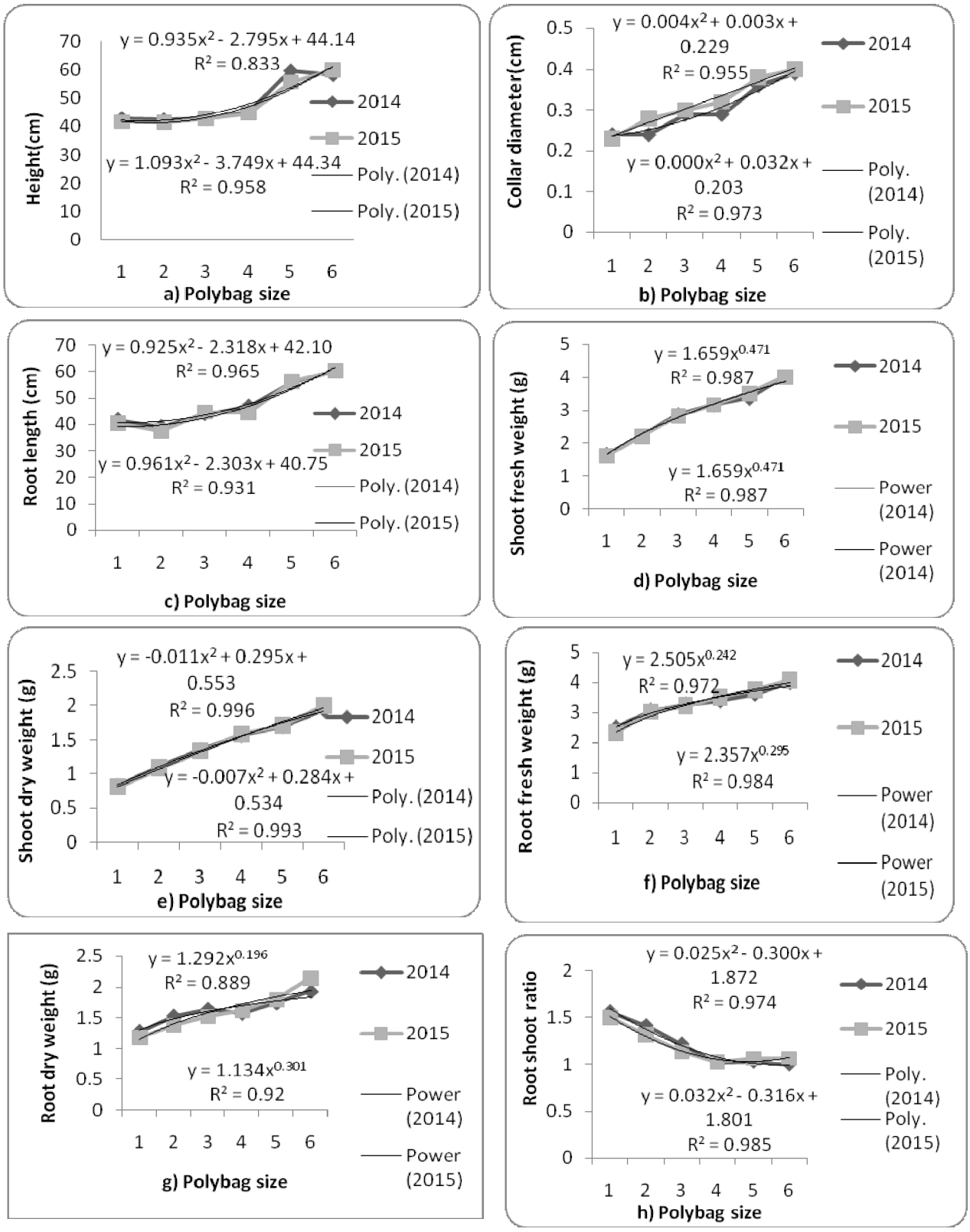

Fig 2. Regression analysis between polybag size (a) Height (b) Root collar diameter (c) Root length (d) Shoot fresh weight (e) Shoot dry weight (f) Root fresh weight (g) Root dry weight (h) Root shoot ratio

Table 2. Correlation matrix of different seedling parameters in 2014 (lower diagonal) and 2015 (upper diagonal)

Parameters	Height	Root collar diameter	Number of branches	Root length	Shoot fresh weight	Shoot dry weight	Root fresh weight	Root dry weight	Root: shoot ratio
Height		0.81**	0.43	0.95**	0.76**	0.73**	0.70**	0.77**	-0.37
Root collar diameter	0.89**		0.39	0.80**	0.85**	0.77**	0.75**	0.67**	-0.54*
Number of branches	-0.42	-0.25		0.27	0.03	-0.06	-0.05	-0.04	-0.006
Root length	0.94**	0.89**	-0.34		0.84**	0.83**	0.75**	0.83**	-0.47
Shoot fresh weight	0.66**	0.75**	-0.03	0.77**		0.98**	0.90**	0.86**	-0.73**
Shoot dry weight	0.71**	0.79**	-0.09	0.79**	0.98**		0.87**	0.86**	-0.75**
Root fresh weight	0.74**	0.73**	-0.24	0.80**	0.89**	0.89**		0.92**	-0.47*
Root dry weight	0.72**	0.72**	-0.24	0.77**	0.82**	0.79**	0.92**		-0.35
Root : Shoot ratio	-0.47*	-0.58*	-0.003	-0.59*	-0.86**	-0.90**	-0.67**	-0.50*	

NS: Non-significant; *P < 0.05; **P < 0.01

Conclusion

With reference to findings of our work it was inferred that the use of media containing sand + clay soil + vermicompost in larger polybag size of 20 × 15 cm and 25 ×15 cm provided more favourable root environment which consequences in enhanced growth and vigour of *Prosopis cineraria* seedlings. These seedlings growing in nursery were also preferred to be bought by farmers from CAZRI nursery. Future research needs to be carried out to evaluate the field level performance of best performing seedlings in nursery.

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