ASSESSMENT OF NURSERY RAISING TECHNIQUES OF VARIOUS JATROPHA VARIETIES

Ali Sher Chandio[1], Muhammad Siddique Depar[1], Behari Lal Meghwar[1], Muhammad Waseem Kalroo[1], Farman Ali Chandio[2,*] and Attaullah Khan Pathan[1]

[1]Arid Zone Research Institute, (PARC), Umerkot, Pakistan

[2,*]Department of Farm Power and Machinery, Faculty of Agricultural Engineering, SAU, Tandojam, Pakistan.

Corresponding Author: farman_chandio@yahoo.com

ABSTRACT:*The experiment was conducted for consecutive two years (2010 and 2011) in a three replicated randomized complete block design (Factorial) to examine the effect of nursery raising techniques (Polythelene bags, Flat bed, Earthern pots and Iron tray) on the growth, seed yield and oil content of three Jatropha varieties (Thailand, Malaysian and Indian). The results revealed that the seed sown for nursery on flat bed remained an effective sowing technique with maximum seed germination (60.88 %), plant height (56.84 cm) and stem girth (7.9 cm), followed by sowing in polyethylene bags and lowest seed germination and seedling growth was achieved in iron trays. On average for sowing techniques, Thai variety performed better than Malaysian and Indian varieties with highest seed germination (56.78%), seedling height (56.44 cm) and stem girth (7.3 cm). The seed germination and seedling growth was better in 2011 than the year 2010 due to climatic suitability and improved management practices. The interactive effect of variety Thai x flat bed sowing x 2011 remained the effective treatment combination in this experiment. Statistically, the effect of nursery raising techniques and varieties on traits related to seed germination and seedling growth was significant (P<0.05). It was concluded that for successful nursery raising and achieving healthy seedlings in Jatropha, the variety Thai may be sown on flat bed.*

Keywords: Jatropha, varieties, nursery raising techniques, germination, seedling growth

INTRODUCTION

Jatropha *(Jatropha curcas* L.) is a class of approximately 175 succulent plants, shrubs and trees belonging to the family *Euphorbiaceae* [1], along with the various Jatropha species *Jatropha curcas*; *J. glandulifera, J. gossypifolia, J. integerrima, J. multifida, J. nana, J. podagrica* and *J. tanjorensis* are widely cultivated [2]. It was originated in the Caribbean, and extended as a valuable hedge plant to Africa and Asia by Portuguese traders [3]. Jatropha received significant attention of the researchers as a potential basis of non-edible vegetable oil. Jatropha has diverse benefits as the source of green manure, guard gardens from grazing animals by hedges, avoiding soil erosion, retrieve land and prevents shifting of sand dunes in scorched areas [4]. The plants are drought-resistant and recognized as potential biofuel crop [5], also improves rural economy by generating huge manpower through diverse stages of its cultivation [6]. It is drought and pests resistant, produces seeds containing up to 40% oil which after refining can be turned into Jatropha biodiesel [7, 8].

Successful container-developed plants in green house or nursery depend largely on the chemical and physical properties of growing media which is used. A perfect potting medium must be free from weeds and diseases, it should be well drained and have efficieny to preserve sufficient water. So selection of appropriate medium is decisive for the successful production of plants [9]. Jatropha is propagated generally by seeds; therefore healthy seeds are selected for sowing in the raised nursery beds. Bahadur *et. al.* [10] suggested that before sowing it should be ensured that seed is viable and only certified seed may be obtained because they produce healthy seedlings which endure in natural environmental stresses. Before sowing, seeds are soaked in cow dung solution for 12 hours and kept under the wet gunny bags for 12 hours [11]. Under controlled conditions, the soil media containing canal sand is most effective for higher seed germinability and improved agronomic performance of Jatropha. Current study is aimed to examine the impact of nursery raising techniques on the germination and seedling growth of jatropha varieties under laboratory conditions.

MATERIALS AND METHODS

Jatropha plant in Pakistan is at initial stage; thus it is essential to assess its cultivation on commercial scale, the general production practices right from the nursery raising techniques, till harvest. According to Wani, *et. al.* [12] jatropha plants can be grown by two methods i.e. bare root (nursery bed) and container (polythene bag).

In our study for nursery raising techniques the material such as iron trays, earthen pots and polythelene bags (22.5x15 cm) were filled by canal sand. Pre-soaked (24 hours) seed (one in each bag) was sown at 2.5 cm depth. In flat beds, the canal sand was filled at a depth of 22 cm and pre-soaked seeds were sown at 2.5 cm deep followed by 15 cm distance between seedlings. The experimental design employed in this study was Randomized complete block design (RCBD) Factorial.

Nursery Observations

Following observations were recorded: Seed germination (%), Day to emergence, Day taken by appearance of leave 3, 6 and 7 on plants (L3, L6 and L7), Leaves seedling^{-1}, Leaf area seedlings^{-1} (cm^2), Seedling height (cm) and Stem girth (cm). The germination (%) was calculated using following formulla.

$$\text{Seed germination (\%)} = \frac{\text{No of germinated seeds x100}}{\text{No seeds sown}}$$

and Leaf area seedlings^{-1} (cm^2) was calculated as = Leaf length x Leaf width x CF (0.75).

The data thus collected were statistically analysed using analysis of variance and DMRT as suggested by Gomez and Gomez [13].

RESULTS AND DISCUSSION

1.1. Effect of varieties on various traits of Jatropha

The data (Table-1) indicates significant (p<0.05) difference in all agronomic and physiological parameters studied. Kumar

Table 1, Effect of varieties on various agronomic and physiological traits of Jatropha

Traits	S.E.	LSD 0.05	Varieties		
			Thai	Malaysian	Indian
Seed germination (%)	0.0376	0.1071	56.78 a	49.09 b	40.71 c
Days to emergence	0.0483	0.1375	9.2 c	11.69 b	13.80 a
Days to L3	0.0524	0.1493	9.8 c	11.87 b	13.89 a
Days to L6	0.0661	0.1883	26.30 c	31.29 b	36.47 a
Days to L7	0.0683	0.1945	31.42 c	37.29 b	44.15 a
Leaves plant^{-1}	0.0322	0.0918	25.86 a	20.43 b	15.63 c
Leaf area (cm^2)	0.0309	0.0881	48.40 a	43.20 b	38.18 c
Plant height (cm)	0.0347	0.0989	56.44 a	47.35 b	39.88 c
Stem girth (cm)	0.0204	0.0581	7.3 a	5.9 b	4.5 c

and Singh [14] also observed significant differences in seed as well as in vegetative traits in *Jatropha curcas*. The results revealed that variety Thai have better performance over Malaysian and Indian varieties for seed germination (56.78%), leaves plant-1 (25.86), leaf area (48.40 cm^2), plant height (56.44 cm) and stem girth (7.376 cm); minimum days to emergence (9.2) days to appearance of L3 (9.8), L6 (26.30) and L7 (31.42) respectively. Kumar and Singh [14] also showed that accession J_{17} have maximum seed length, seed width, surface area and germination percentage. Malaysian variety ranked 2nd with 49.0% seed germination, 20.43 leaves plant^{-1}, 43.20 cm^2 leaf area, 47.35 cm plant height 5.9 cm stem girth, 11.69 days to emergence, 11.87 days to L3, 31.29 L6 and 37.29 L7. where Indian variety showed lower 40.71% seed germination, 15.63 leaves plant^{-1}, 38.18 cm^2 leaf area, 39.88 cm plant height 4.522 cm stem girth, 13.80 days to emergence, 13.89 days to appearance L3 36.47, L6 and 44.15 L7, respectively. So results revealed that the variety Thai showed better performance than rest of the varieties for studied traits. Chengxin *et al.* [15] stated that Jatropha variety "JO S2" has higher seed production, early flowering, better branching, more fruits per bunch and better uniformity of plants. Tripathi *et al.* [16] evaluated 72 different clonal accessions for 13 characters and observed significient difference between them. Mahapatra and Panda [6] also studied 20 different accessions and observed significient difference among different traits like growth, flowering, fruiting, seed length, seed width, single seed weight, test weight and oil content.

1.2. Effect of nursery raising techniques on various traits of Jatropha

The data (Table-2) exhibits that all the studied traits were significantly (P<0.05) affected by the nursery raising techniques. The highest seed germination (60.88%), leaves plant^{-1} (28.12), leaf area (52.19cm^2), plant height (56.84 cm), stem girth (7.9 cm), lowest days to emrgence (8.961), days to L3 (9.722), L6 (24.47) and L7 (30.50) was observed in jatropha planted on flat bed followed by polyethylene bags with (22.79) leaves plant^{-1}, (46.26 cm^2) leaf area, (50.62 cm) plant height and (6.3 cm) stem girth. But according to the Henning [17] pre-cultivation of *Jatropha* seedlings in poly-ethylene bags is more suitable to speed up the plantation by at least 3 months. Where Abugre and Boateng [18] showed significant variation in seed weight, maximum germination percentage and seedling growth of *Jatropha curcas*.

The nursery raised in earthen pots ranked 3rd with (18.24) leaves plant^{-1}, (40.16 cm^2) leaf area, (44.38) cm plant height and (5.393) cm stem girth; while nursery raised in iron tray remained least effective with lowest (13.40) leaves plant^{-1}, (34.45 cm^2) leaf area, (39.73 cm) plant height and (4.1cm) stem girth with maximum days to emergence (14.24), days to appearance L3 (13.64), L6 (38.22) and L7 (44.22). So the results conclude that flat bed system was most effective technique for raising jatropha nursery, followed by raising nursery in polyethylene bags and earthen pots. Geply *et. al.* [19] reported about same results that river sand in bed raised system for nursery has the highest value and is effective technique that produced high quality seedlings,. But according to Severino *et. al.* [20] the most vigorous root system was observed in the plants that originate from direct seeding, without any transplanting.

1.3. Interactive effect of varieties x nursery raising techniques on various traits of Jatropha

For interactive effect of varieties × nursery raising techniques on the studied characters of jatropha the data (Table-3) indicated statistically significant (P<0.05) difference among traits. Under flat bed nursery raising technique, the jatropha varieties Thai, Malaysian and Indian produced highest seed germination (69.10, 61.37and 52.17%), leaves plant^{-1} (33.67, 28.02 and 22.68), leaf area (57.45, 52.31 and 46.80cm^2), plant height (65.57, 55.85 and 49.12 cm) and stem girth (9.4, 8.2 and 6.2 cm), minimum days to emergence (6.7, 8.9 and 11.23), days to appearance of L3 (7.6, 10.0 and 11.57), L6 (19.58, 24.40 and 29.42) and L7 (24.00, 29.50 and 38.00) respectively, followed by polyethylene bag nursery raising technique, the varieties Thai, Malaysian and Indian produced seed germination (61.28, 53.43 and 44.47%), days to emergence (8.400, 11.25 and 13.30), days to appearance of L3 (9.183, 11.60 and 13.66), L6 (23.88, 29.52 and 35.05) and L7 (29.67, 36.32and 43.42), leaves plant^{-1} (28.38, 22.50 and 17.50), leaf area (51.59, 46.25 and 40.93cm^2), plant height (59.43, 49.62 and 42.80 cm) and stem girth (7.9, 6.2and 4.8 cm), respectively. Nursery raised under earthen pots and iron tray techniques showed relatively weaker performance when compared with flat bed and polyethylene bags. For treatment interaction variety Thai and flat bed nursery raising techniques proved to be most effective combination. Whereas Sarhan *et. al.* [21] reported that seedlings in polyethylene bags has been shown to accelerate the installation of a plantation under controlled conditions, the soil media containing canal sand is most effective for higher seed germinability and improved agronomic performance of Jatropha. Moreover, Kalhoro [22] has also

Table 2, Effect of nursery raising techniques on various agronomic and physiological traits of Jatropha

Traits	S.E	LSD 0.05	Nursery raising techniques			
			Polyethylene bags	Flat bed	Earthen pots	Iron tray
Germination (%)	0.0434	0.1237	53.06 b	60.88 a	44.55 c	36.95 d
Days to emergence	0.0557	0.1588	10.98 c	8.9 d	12.17 b	14.24 a
Days to L3	0.0605	0.1724	11.48 c	9.7 d	12.60 b	13.64 a
Days to L6	0.0763	0.2174	29.48 c	24.47 d	33.25 b	38.22 a
Days to L7	0.0788	0.2245	36.47 c	30.50 d	39.28 b	44.22 a
Leaves plant^{-1}	0.0372	0.1061	22.79 b	28.12 a	18.24 c	13.40 d
Leaf area (cm^2)	0.0357	0.1018	46.26 b	52.19 a	40.16 c	34.45 d
Plant height (cm)	0.04014	0.1143	50.62 b	56.84 a	44.38 c	39.73 d
Stem girth (cm)	0.02357	0.0671	6.3 b	7.9 a	5.3 c	4.1 d

Table 3, Interactive Effect of varieties x nursery raising techniques on various agronomic and physiological traits of Jatropha

Traits	LSD 0.05	Varieties x nursery raising techniques											
		Thai				Malaysian				Indian			
		Poly ethylene bags	Flat bed	Earthen pots	Iron tray	Poly ethylene bags	Flat bed	Earthen pots	Iron tray	Poly ethylene bags	Flat bed	Earthen pots	Iron tray
1	0.214	61.28 b	69.10 a	52.37 d	44.37 f	53.43 c	61.37 b	44.60 e	36.95 g	44.47 ef	52.17 d	36.68 h	29.53 i
2	0.275	8.4 h	6.700 i	10.00 f	12.00 d	11.25 e	8.9 g	12.25 d	14.30 b	13.30 c	11.23 e	14.25 b	16.43 a
3	0.298	9.1 h	7.6 i	10.67 f	11.85 e	11.60 e	10.00 g	12.43 d	13.43 c	13.66 c	11.57 e	14.70 b	15.63 a
4	0.376	23.88 i	19.58 j	28.17 g	33.58 d	29.52 f	24.40 h	33.17 e	38.07 b	35.05 c	29.42 f	38.42 b	43.00 a
5	0.388	29.67 i	24.00 j	34.08 h	37.92 f	36.32 g	29.50 i	38.67 e	44.67 c	43.42 d	38.00 f	45.08 b	50.08 a
6	0.183	28.38 b	33.67 a	23.45 d	17.95 f	22.50 e	28.02 c	17.85 f	13.35 h	17.50 g	22.68 e	13.42 h	8.900 i
7	0.176	51.59 c	57.45 a	45.27 f	39.32 i	46.25 e	52.31 b	40.13 h	34.12 k	40.93 g	46.80 d	35.08 j	29.92 l
8	0.197	59.43 b	65.57 a	53.40 d	47.37 g	49.62 e	55.85 c	43.38 h	40.57 j	42.80 i	49.12 f	36.37 k	31.25 l
9	0.116	7.9 c	9.4 a	6.8 d	5.2 f	6.2 e	8.2 b	5.3 f	4.1 h	4.8 g	6.2 e	4.0 h	3.0 i

1. Germination (%), 2. Days to emergence. 3. Days to L3. 4. Days to L6. 5. Days to L7 6. Leaves plant^{-1} 7. Leaf area (cm^2), 8. Plant height (cm), 9. Stem girth (cm)

reported that raised bed technique of seedling development proved to be highly effective than the Polyethylene bags or earthen pots.

1.4. Interactive effect of varieties x years on various traits of Jatropha

For interactive effect of jatropha varieties × years the results (Table-4) indicated that the varieties showed significantly ($P<0.05$) varied response in relation to their agronomic and physiological traits during the two years of study. Variety Thai × year 2011 resulted in highest values for seed germination (62.00%), leaves plant^{-1} (28.75), leaf area (52.41 cm^2), plant height (60.51 cm) and stem girth (8.0 cm), lowest days to emergence (8.4), days to appearance of L3 (8.1), L6 (22.48) and L7 (27.50). Variety Malaysian × year 2011 ranked 2nd and the interaction of variety Thai × year 2010 ranked 3rd , where the interactive effect of variety Malaysian × year 2010 ranked 4th for same studied traits. The interactions of variety Indian × 2010 and 2011 resulted in lower values for all the agronomical and physiological traits. It was concluded that interactive effect of Thai variety × 2011 proved to be a combination of significance for the various agronomic and physiological traits of Jatropha as compared to rest of the treatment combinations. Chengxin *et al.* [15] demonstrated Jatropha variety JO S_2, on two sites India, which produced up to 2.95 ton/ha of dry seeds in the first year and up to 4.25 ton/ha of dry seeds in the second year, much better than the local variety control. According to the Zaman *et. al.* [23] maximum economic yield of jatropha starts from fifth year which is about 6.2 tons ha^{-1} for average of first four years and 12.5 t ons ha^{-1} fifth year, as it is planted on marginal land using marginal water the yield cannot exceed from 4 and 6 tons ha^{-1}. Kumar [24] also reported that seed production ranges from about 2 tons per hectare per year to over 12.5t/ha/year, after five years of growth.

1.5. Interactive effect of nursery raising techniques × years on various traits of Jatropha

The data (Table-5) showed that the interactive effect of nursery raising techniques × years (during 2010 and 2011) on various agronomic and physiological traits of jatropha was statistically significant ($P<0.05$). The flat bed sowing during 2011 resulted in highest seed germination (65.99%), leaves plant^{-1} (31.11), leaf area (56.35 cm^2), plant height (60.81 cm) and stem girth (8.7 cm), lowest days to emergence (8.9), days to L3 (8.167), L6 (21.33) and L7 (26.67). The sowing in polyethylene bags during 2011 ranked 2nd, where the sowing of jatropha for nursery in flat bed during 2010 ranked 3rd for studied traits. However, earthen pots and iron tray nursery raising techniques showed relatively poor performance in both the years. It was concluded that interaction of flat bed nursery raising technique was found to be most effective technique, followed by polyethylene bags techniques during both the years of study. According to Peer [25] Raised beds usually give the highest germination rate of Jatropha seeds. Where Gurgel *et. al.* [26] observed variation in the growth of

Table 4, Interactive effect of varieties x years on various agronomic and physiological traits of Jatropha

Traits	S.E	LSD 0.05	Varieties x year					
			2010			2011		
			Thai	Malaysian	Indian	Thai	Malaysian	Indian
Germination (%)	0.0532	0.1515	51.56 c	44.84 d	36.83 f	62.00 a	53.33 b	44.60 e
Days to emergnce	0.0683	0.1945	10.12 e	12.57 c	14.77 a	8.433 f	10.81 d	12.83 b
Days to L3	0.0741	0.2111	11.52 d	13.43 b	15.49 a	8.125 f	10.30 e	12.29 c
Days to L6	0.0935	0.2663	30.13 d	34.38 b	38.98 a	22.48 f	28.20 e	33.96 c
Days to L7	0.0966	0.2750	35.33 d	41.17 b	48.00 a	27.50 f	33.41 e	40.29 c
Leaves plant^{-1}	0.0456	0.1299	22.98 c	17.74 e	13.05 f	28.75 a	23.12 b	18.20 d
Leaf area (cm^2)	0.0437	0.1246	44.40 c	39.27 e	34.27 f	52.41 a	47.14 b	42.10 d
Plant height (cm)	0.0491	0.1399	52.38 b	43.30 e	35.84 f	60.51 a	51.41 c	43.92 d
Stem girth (cm)	0.0288	0.0821	6.7 b	5.2 c	4.0 e	8.0 a	6.6 b	3.0 d

Table 5, Interactive effect of nursery raising techniques x years on various agronomic and physiological traits of Jatropha

Traits	S.E.	LSD 0.05%	Nursery raising techniques x year							
			2010				2011			
			Polyeth-ylene bags	Flat bed	Earthem pots	Iron tray	Polyeth-ylene bags	Flat bed	Earthen pots	Iron tray
Germination (%)	0.0614	0.1750	48.09 e	55.77 c	40.61 f	33.17 g	58.03 b	65.99 a	48.49 d	40.73 f
Days to emergence	0.0757	0.1788	10.98 c	8.9 d	12.17 b	14.24 a	10.99 c	8.9 d	12.27 b	14.28 a
Days to L3	0.0856	0.2438	13.33 c	11.28 e	14.09 b	15.23 a	9.6 f	8.1 g	11.11 e	12.04 d
Days to L6	0.1080	0.3075	32.89 d	27.60 f	36.17 b	41.33 a	26.08 g	21.33 h	30.33 e	35.10 c
Days to L7	0.1116	0.3176	40.22 c	34.33 e	43.33 b	48.11 a	32.71 f	26.67 g	35.22 d	40.33 c
Leaves plant^{-1}	0.0527	0.1500	19.70 e	25.13 c	15.58 f	11.28 g	25.89 b	31.11 a	20.90 d	15.52 f
Leaf area (cm^2)	0.0505	0.1439	42.15 e	48.02 c	36.41 g	30.67 h	50.37 b	56.35 a	43.91 d	38.23 f
Plant height (cm)	0.05676	0.1616	46.30 e	52.88 c	40.47 g	35.71 h	54.93 b	60.81 a	48.30 d	43.74 f
Stem girth (cm)	0.0333	0.0948	5.6 e	7.2 b	4.8 f	3.5 h	7.0 c	8.7 a	5.9 d	4.5 g

period, and reached at final height of 2.60 m, where accession the accessions between August 2009 and July 2010. Accession CNPAE-102 showed higher growth throughout the CNPAE-169 showed lower growth. CNPAE-259 showed an intermediate growth behavior.

1.6. Interactive effect of varieties × nursery raising techniques × years on varios traits of Jatopha

The interactive effect of varieties × nursery raising techniques × years on Jatropha was examined and the data (Table-6) showed statistically significant ($P<0.05$) level between them. During the year 2010, the nursery raised under flat bed technique of varieties Thai, Malaysian and Indian resulted in highest seed germination (63.87, 57.03, 46.40%), leaves plant^{-1} (30.70, 25.27, 19.43), leaf area (53.43, 48.20, 42.43 cm^2), plant height (61.57, 51.93, 45.13 cm) and stem girth (8.733, 5.440, 5.683 cm), minimum days to seedling emergence (6.80, 8.00, 11.84), days to L3 (9.20, 11.50, 13.13), L6 (23.33, 27.47, 32.00), and L7 (27.83, 33.17, 42.00), respectively. The nursery raised in polyethylene bag technique varieties Thai, Malaysian and Indian ranked 2nd during the year 2010. During 2011, the nursery raised under flat bed technique varieties Thai, Malaysian and Indian resulted in highest seed germination (74.33, 65.70, 57.93%), leaves plant^{-1} (36.63, 30.77, 25.93), leaf area (61.47, 56.41, 51.17 cm^2), plant height (69.57, 59.77, 53.10 cm) and stem girth (10.20, 9.1, 6.7 cm), minimum days to seedling emergence (6.10, 7.801, 11.80), days to L3 (6.00, 8.500, 10.00), L6 (15.83, 21.33, 26.83) and L7 (20.17, 25.83, 34.00), respectively. and same year 2011, the nursery raised under polyethylene bag technique the varieties Thai, Malaysian and Indian ranked 2nd for studied traits. Whereas during the years (2010 and 2011), earthen pots and iron tray nursery raising techniques showed weaker performance than other techniques. However, during 2011, the agronomic and physiological performance of jatropha varieties was superior as compared to the year 2010. That might be due to favourable weather conditions during nursery growing time. According to Saadaoui *et. al.* [27] Seed production occurred in three periods: summer, autumn and winter. In summer, the highest value was of 256 g (J1), and the lowest of 63 g (J7). In winter, the highest values were 140 g (J8) and the lowest ones of 64 g (J4). Plants from Paranà (J2) had higher seed yield (467 g) where plants from Mozambique (J7) have lowest yield (158 g). Yield increased along the years of culture.

Table 6, Interactive effect of varieties x nursery raising techniques x years on various agronomic and physiological traits of Jatro

Year	Varieties	Nursery raising techniques	Plant traits								
			Seed germination(%)	Days to emergence	Days to L3	Days to L6	Days to L7	Leaves plant^{-1}	Leaf area (cm^2)	Plant height (cm)	Stem girth (cm)
2010	Thai	Polyethylene bags	55.00 i	9.2 j	11.37 gh	27.87 k	33.50 lm	25.33 g	47.54 i	55.37 f	7.3 e
		Flat bed	63.87 d	6.8 m	9.200 j	23.33 o	27.83 p	30.70 c	53.43 d	61.57 c	8.7 c
		Earthen pots	47.30 l	10.2 h	12.17 f	32.33 i	38.17 j	20.50 h	41.13 n	49.37 k	6.2 h
		Iron tray	40.07 o	12.00 e	13.37 e	37.00 e	41.83 g	15.37 k	35.50 r	43.20 o	4.6 l
	Malaysian	Polyethylene bags	48.53 j	11.67 g	13.30 e	32.87 h	40.33 i	19.40 i	42.33 m	45.13 m	5.4 j
		Flat bed	57.03 h	8.00 k	11.50 g	27.47 k	33.17 m	25.27 g	48.20 h	51.93 i	7.3 e
		Earthen pots	40.53 n	12.0 e	13.87 d	36.33 f	42.83 f	15.07 l	36.47 q	39.43 q	4.8 k
		Iron tray	33.27 r	14.50 b	15.07 c	40.83 b	48.33 c	11.23 n	30.07 u	36.70 s	3.5 n
	Indian	Polyethylene bags	40.73 n	13.5 c	15.32 c	37.93 d	46.83 d	14.37 m	36.57 q	38.40 r	4.2 m
		Flat bed	46.40 m	11.84 f	13.13 e	32.00 i	42.00 g	19.43 i	42.43 m	45.13 m	5.6 i
		Earthen pots	34.00 q	14.35 b	16.23 b	39.83 c	49.00 b	11.17 n	31.63 t	32.60 u	3.5 n
		Iron tray	26.17 t	16.50 a	17.27 a	46.17 a	54.17 a	7.233 p	26.43 v	27.23 v	2.5 o
2011	Thai	Polythylene bags	67.57 b	9.00 j	7.0	19.90 q	25.83 q	31.43 b	55.63 c	63.50 b	8.5 d
		Flat bed	74.33 a	6.10 n	6.0 m	15.83 r	20.17 r	36.63 a	61.47 a	69.57 a	10.20 a
		Earthen pots	57.43 g	9.85 i	9.1 j	24.00 n	30.00 o	26.40 d	49.40 g	57.43 e	7.4 e
		Iron tray	48.67 j	11.75 g	10.33 i	30.17 j	34.00 kl	20.53 h	43.13 l	51.53 j	5.8 i
	Malaysian	Polythylene bags	58.33 e	11.30 g	9.9 i	26.17 m	32.30 n	25.60 f	50.17 f	54.10 g	7.0 f
		Flat bed	65.70 c	7.80 l	8.5 k	21.33 p	25.83 q	30.77 c	56.41 b	59.77 d	9.1 b
		Earthen pots	48.67 j	11.50 g	11.00 h	30.00 j	34.50 k	20.63 h	43.80 k	47.33 l	5.7 i
		Iron tray	40.63 n	13.30 c	11.80 fg	35.30 g	41.00 h	15.47 jk	38.17 p	44.43 n	4.6 l
	Indian	Polythylene bags	48.20 k	12.80 d	12.00 f	32.17 i	40.00 i	20.63 h	45.30 j	47.20 l	5.3 j
		Flat bed	57.93 f	11.10 g	10.00 i	26.83 l	34.00 kl	25.93 e	51.17 e	53.10 h	6.7 g
		Earthen pots	39.37 p	11.80 f	13.17 e	37.00 e	41.17 h	15.67 j	38.53 o	40.13 p	4.4 l
		Iron tray	32.90 s	13.75 c	14.00 d	39.83 c	46.00 e	10.57 o	33.40 s	35.27 t	3.5 n
SE			0.1065	0.0930	0.1483	0.1871	0.1932	0.0913	0.0875	0.0983	0.0577
LSD 0.05			0.4031	0.2655	0.4222	0.5326	0.5500	0.2599	0.2493	0.2799	0.1644

CONCLUSIONS

1. Flat bed nursery raising technique was more effective with maximum seed germination (60.88 %), plant height (56.84 cm) and stem girth (7.9 cm) than sowing in polyethylene bags, earthen pots and iron trays.
2. Variety Thai x flat bed sowing remained the effective treatment combination in this experiment.

RECOMMENDATIONS

- For successful nursery raising and achieving healthy seedlings, the variety Thai may preferably be cultivated that suits better to the prevailing environmental conditions as compared to Malaysian and Indian varieties.
- Flat bed nursery raising system may be adopted which is easy, cheaper and feasible as compared to other techniques.
- For achieving healthy seedlings, the nursery may be raised from black ripened seed, rather to use yellow (fully matured) and half yellow half green seed.

REFERENCES

[1] Fairless, D., 2007. Biofuel: the little shrub that could - maybe. Nature, 449: 652-655.

[2] Das, B. and B. Venkataiah, 2000. A minor coumarino-lignoid from *Jatropha gossypifolia*, Biochem Syst and Ecol, 29 : 213-214.

[3] Oseni, O.A. and A.A. Akindahunsi. 2011. Some Phytochemical Properties and Effect of Fermentation on the Seed of *Jatropha curcas* L..*American Journal of Food Technology, 6: 158-165.*

[4] Islam, A. K. M. A., Z. Yaakob and N. Anuar.2011. Jatropha: A multipurpose plant with considerable potential for the tropics. Scientific Research and Essays, 6(13): 2597-2605

[5] Openshaw, K. 2000. A review of *Jatropha curcas*: an oil plant of unfulfilled promise. Biomass and Bioenergy, 19 (1): 1-15.

[6] Mahapatra, S. and P.K. Panda. 2011. Effects of Fertilizer Application on Growth and Yield of Jatropha curcas L. in an Aeric Tropaquept of Eastern India. *Not. Sci. Biol.*, 3(1):95-100.

[7] Ofor, M. O. and N. I. Martin. 2011. The search for alternative energy sources: jatropha and moringa seeds for biofuel production. Journal of Agriculture and Social Research, 11(2): 87-94

[8] Lakshmanan, P., S. Mohan and R. Jeyarajan. 1990. Cultivation of Biodiesel plant "Jatropha"*Madras Agric. J*., 77, 1–4.

[9] James, A. R. and R. E. Michael. 2009. Growing media for container production in green house or nursery. Agriculture and Natural Resources. http://www.uaex.edu.

[10] Bahadur,T., S. Govardhan, and E. Chamundeswari. 1997. Comparative LM & SEM studies of pollen in two varieties of *Jatropha gossypiifolia* L. (Euphorbiaceae). Journal of Palynology, 33 (1/2): 123-127.

[11] Zaidman BZ, Ghanim M, Vaknin Y (2010). Effect of seed weight on seed vigour and early seedling growth of *Jatropha curcas*, a biodiesel plant. Seed Sci Technol 38:757-766.

[12] Wani, S. P., M. Osman, E. D. Silva and T. K. Sreedevi. 2006. Improved livelihoods and environmental protection through biodiesel plantations in Asia. Asian Biotechnology and development review. 8(2): 11-29.

[13] Gomez, K.A. and Gomez, A.A. "Statistics of Agricultural Research" (**2nd ed**.) *John wiley and sons, New York*. 1984.

[14] Kumar, S. and S. Singh. 2014. Variability assessment of seed traits in Jatropha curcas L. for improvement of oil yield. International Journal of Genetics and Molecular Biology. 6(1): 8-15.

[15] Chengxin, Y., C. Reddy, K. Varghese, T. N. H. Bui, S. Zhang, M. Kallath, B. Kunjachen, S. Ramachandran and Y. Hong. 2014. A New *Jatropha curcas* Variety (JO S2) with Improved Seed Productivity. Sustainability. 6: 4355-4368

[16] Tripathi, A., D. K. Mishra and J. K. Shukla.2015.Genetic diversity and trait association between growth, yield and seed component of jatropha curcas (L.) source collection from Indian sub-continent. J. pl. breed. and crop sci.7(5):143-156

[17] Henning, R. (2000). *The Jatropha Booklet*. A Guide to the Jatropha System and its Dissemination in Zambia. GTZ-ASIP Support Project Southern Province. Bagani GbR. *Jatropha* Plant in Zambia.

[18] Abugre, S. and C.O. Boateng . 2011 .Seed source variation and polybag size on early growth of jatropha curcas. ARPN Journal of Agricultural and Biological Science, 6 (4): 39-45

[19] Geply, O.A., R.A. Baiyewu, I.A. Adegoke, O.O. Ayodele and I.T. Ademola. 2011. Effect of Different Pot Sizes and Growth Media on the Agronomic Performance of *Jatropha curcas.* Pakistan Journal of Nutrition, 10 (10): 952-954.

[20] Severino, L.S., R.L.S. Lima, A.A.M. Lucena, M.A.O. Freire, L.R.G. Sampaio, R.P. Veras, K.A.A.L. Medeiros, V. Sofiatti and N.H.C. Arriel. 2011. Propagation by stem cuttings and root system structure of Jatropha curcas. Biomass and Bioenergy, 35:3160-3166.

[21] Sarhan, A.Z., T.M.A., Daliab, A.M.A.M. El-Dayem and M.I. Bahnasy. 2010. Study of water and fertilization requirements of Jatropha curcas, L. under sewage water irrigation conditions. Bulletin of Faculty of Agriculture, Cairo University, 61 (2) : 173-181.

[22] Kalhoro, M.A. 2011. Effect of different soil growth media on the germinability of Jatropha (*Jatropha curcas* L.) varieties. Thesis submitted to Sindh Agriculture University Tandojam.

[23] Zaman, S. B., S. Majeed and S. Ahmad.2010. Retrospect and prospects of edible oil and bio-diesel in Pakistan - A review. Pak. J. Agric. Res. 23 (3-4):177-192

[24] Kumar, A. 2009. Growth and productivity of Jatropha curcas under semi arid conditions. Science 2.0, www.science20.com/humboldt_fellow_and_science/blog/growth_and productivity *Jatropha curcas* under_semi_arid_conditions_

[25] Peer, A.V. 2010. Growing Jatropha including propagation methods for Jatropha curcas: Annex 2, Supported by the Global Sustainable Biomass Fund of NL Agency

[26] Gurgel, F.D.L., B.G. Laviola, D.M.D. Silva, A.K. Kobayashi, T. B. Rosado. 2011. Phenology and biometry of physic nut in the Brazilian savannah. Ciencia e Agrotecnologia. 35 (6): 1122-1131.

[27] Saadaoui, E., J. J. Martín, R. Bouazizi, C. B. Romdhane, M. Grira, S. Abdelkabir, M. L. Khouja and E. Cervantes.2015. Phenotypic variability and seed yield of *jatropha curcas* l. Introduced to Tunisia. Acta Botanica Mexicana 110: 119-134