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Effect of Temperatures and Germination Media on Seed Germination of *Jatropha Curcas* Linn.

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ABSTRACT
The effect of different temperatures and different germination media in J. curcas seeds was studied in the present work. The influence of 8 constant temperatures viz. 20°C, 22°C, 25°C, 27°C, 30°C, 32°C, 35°C and 37°C, 4 alternate temperatures viz. 37/27°C, 35/25°C, 32/22°C and 30/20°C and 6 germination media viz. vermiculite, coco-peat, perlite, normal soil, sand and filter paper were used for the observation. The optimum temperature for the germination of J. curcas seeds was recorded "30°C" and suitable germination media was recorded "Vermiculite" for the reason that the highest germination percentage 84.44 recorded at 30°C whereas in Vermiculite has recorded 85.
Key worlds: *J. curcas, seed germination, different temperatures and different germination media.*

INTRODUCTION

The temperature and light are the most important environmental factors that promote the seed germination in the soil when water is available. For most of the plants, if the light and water are available, the temperature of the soil determines the fraction of the germinated seeds and the rate of the germination [1]. The germination of the seeds is a complex process where several reactions and individual factors are involved, every process affected by the temperature [5]. The temperature affects the germination and the state of dormancy of the seeds and the seasonal changes of the dormancy state of the seeds of some species is directly related to the seasonal temperature changes [15]. Some species can present the seeds with the light requirement for the germination at one temperature and in another, the light insensitivity [17].

Seed germination is affected by the ecological conditions prevailing in the habitat; it depends on several environmental conditions such as light, temperature, moisture germination media. It is well known that seed of certain species have different temperature responses according to variety and provenances and also reasonable to believe that these responses are adaptive success or failure of a population in a particular environment depends on the way of its germination responses fit in to the ecological conditions of the habitat. Thus in most of the seeds, the rate of germination are strongly governed by temperature [14].

Germination takes place over a definite range of temperature and this range varies from species to species. *J. curcas* is found world wide and therefore it is likely to have wide range of temperature adaptability for its seed germination. Thus it was considered in the present investigation, of interest to investigate the response of its seed to the varying levels of temperatures and germination media. Various germination media are used for germinating to seeds. For good result the medium must be sufficiently firm and dense to hold the seeds in place during germination. It must retain enough moisture so that watering does not have to be too frequent. Hence the study on germination at different temperature and media was carried out to find out the best thermal regime and suitable germination media to maximize seed germination.

MATERIAL AND METHODS

The seeds of *J. curcas* were studied for their germinability under different temperatures regimes for which bulk lot from all sources was used. For this purpose, 8 constant and 4 alternating temperature levels were used. The regimes included of constant temperatures 20°C, 22°C, 25°C, 27°C, 30°C, 32°C, 35°C and 37°C and alternating temperatures 37/27°C, 35/25°C, 32/22°C and 30/20°C. Under alternating temperature regimes 16 hours light with higher temperature and 8 hours dark with low temperature conditions was given to the seeds. Under constant temperature regimes also, seed were given a 16 hr high and 8 hr dark period. The seeds were divided into 36 lots for entire study of germinability at different temperature regimes. Seeds were kept in plastic boxes, half embedded in vermiculite as described above. The vermiculite was regularly moistened with distilled water. Each temperature regimes had three replicates with 40 seeds in each replicate. The plastic boxes were placed in seed germinators fixed at designated temperature stated above. For alternating temperature the boxes were shifted between the germinators fixed at desired temperatures maintaining the light and dark condition for 16 and 8 hours respectively as mentioned above. Seeds were observed daily for seed germination (radicle emergence).

Germination study at different germination media:

Germination study of *J. curcas* in different germination media were conducted at 30°C constant temperature. The sterilized different germination media viz. vermiculite, coco-peat, perlite, normal soil, sand and filter paper were used for the observation. Daily observations were made on radicle emergence.

Seed germination percentage was calculated using the following formula [10]:

Germination % =Number of germinated seeds / Total number of seeds × 100

Germination associate parameters were calculated by using following formulas:

a. Speed of germination

Speed of germination was calculated by the following formula given by [6].

Speed of germination= $n_1/d_1+n_2/d_2+n_3/d_3$+----------

Where, n = number of germinated seeds, d= number of days.

b. Mean germination Time (MGT)

Mean germination time was calculated by the formula given by [7]

MGT = $n_1 \times d_1 + n_2 \times d_2 + n_3 \times d_3$ + --------/ Total number of days

Where, n= number of germinated seed

d = number of days

c. Mean daily germination (MDG)

Mean daily germination can be calculated by the following formula given by [6]

MDG = Total number of germinated seeds/ Total number of days

d. Peak Value (PV)

Peak value was calculated by the following formula given by [6].

PV = Highest seed germinated/ Number of days

e. Germination Value (GV)

Germination value was calculated by the following formula given by [6].

GV = PV X MDG

Moisture content :

For the moisture content the seeds were dried in an electric oven at 103^0C for 17 hours. Moisture content of seeds was determined by the following formula given by [8].

Moisture percentage = Fresh weight – Dry weight/ Fresh weight X 100

RESULTS

Percent germination in *J. curcas* seeds under twelve constant and four alternating temperature conditions has been presented in table 1. Maximum percentage of germination (84.44±3.85) was recorded at 30°C constant temperature followed by 77.50±2.50% at 35°C and 35–25°C temperatures. Germination percentage further declined to 65% at 37°C, 32°C and 37–27°C temperature. There was almost a sequential decrease in percent germination with further decrease in temperature and germination almost failed to take place at 22°C and lower temperature. However, alternation of 20°C, 22°C and 25°C with 10°C higher temperature resulted in significant increase in germination percentage.

The germination percentage at different temperatures was significantly different at P<0.001 level of significance. Similar to percent seed germination considerable variations were also recorded in different parameters of germination under different temperature conditions. Speed of germination was recorded highest at 35°C (8.40±0.44) and lowest at 22°C (0.11±0.10). Similarly the mean daily germination was recorded maximum (5.51±0.62) at 35°C and minimum (0.11±0.10) at 22°C. Differences in both mean daily germination and speed of germination, in different temperatures were statistically highly significant at P<0.001 significance level. Mean germination time in seed at different temperatures varied from the minimum 3.74±0.12 at 35°C to the maximum 9.33±1.15 at 20°C and the differences across the temperatures were statistically highly significant at 0.01% level. Germination value was recorded maximum at 37°C (28.40±5.80) and minimum at 20 and 22°C (0.02±0.02) temperature and the differences in germination value were statistically highly significant at P<0.001 significance level. Thus the results indicate that highest germination percentage was recorded at 30°C while the speed of germination and mean daily germination were recorded highest at 35°C. Present study revealed that the optimum temperature of 30–35°C favored seed germination in *J. curcas*.

Table.1- Germination percentage in *J. curcas* under different temperatures

Temp. (°C)	Germination percentage	Speed of germination	Mean germination time	Peak value	Germination value	Mean daily germination
37	65.80±2.89	7.21±0.98	3.77±0.42	4.94±1.92	28.40±5.80	5.43±1.30
35	77.50±2.50	8.40±0.44	3.74±0.12	4.58±1.23	24.93±5.01	5.51±0.62
32	65.00±4.33	5.56±0.42	4.69±0.45	5.06±0.12	22.37±3.93	4.41±0.75
30	84.44±3.85	6.65±0.06	4.05±0.36	3.61±0.17	13.07±1.19	3.61±0.17
27	35.00±2.50	2.62±0.37	5.53±0.61	1.94±0.41	3.74±2.19	2.04±0.44
25	27.50±6.61	1.40±0.25	6.67±1.57	0.67±0.32	0.65±0.31	1.18±0.23
22	2.50±2.50	0.11±0.10	5.66±5.13	0.11±0.10	0.02±0.02	0.11±0.10
20	3.33±1.44	0.15±0.09	9.33±1.15	0.15±0.09	0.02±0.02	0.15±0.09
37-27	65.00±5.00	7.21±0.90	3.79±0.23	4.33±1.20	20.39±7.42	4.64±0.84
35-25	77.50±0.00	7.76±0.37	4.12±0.23	4.50±0.00	23.89±5.66	5.31±1.26
32-22	62.50±2.50	4.85±0.37	4.85±0.29	3.06±1.10	10.67±4.11	3.47±0.22
30-20	50.00±0.00	2.67±0.54	7.52±0.46	0.70±0.14	1.40±0.28	2.00±0.00
P value	<0.001	<0.001	<0.001	<0.01	<0.001	<0.001
LSD at 5%	5.70	0.83	1.11	2.84	1.39	1.15

Germination study in different germination media:

The data on percent seed germination in *J. curcas* under different germination media along with germination associated parameters are given in Table 2. As evident in the table maximum percentage of germination was recorded in vermiculite (85.00±9.01%) whereas minimum was recorded in filter paper (55.00±6.61). Germination in sand was also close to vermiculite with 82% that was followed by perlite, coco-peat and garden soil ranging from 71% to 76%. On the basis of ANOVA germination percentage was significantly different in different media at P<0.01 significance level (Table 2). Speed of germination was recorded maximum (8.54±0.52) in sand and minimum in filter paper (3.55±0.33). Mean germination time was observed maximum in filter paper (6.58±0.26) and minimum was recorded in sand (3.97±0.05). Although mean daily germination was recorded maximum in vermiculite (3.40±0.36) it was close to sand with MGT 3.30±0.26 and minimum was in filter paper (2.20±0.26). Differences in mean daily germination in different media was significant at P<0.01 significance level on the basis of ANOVA (Table 2). Peak value was observed maximum in sand (6.58±0.63) and minimum in filter paper (1.06±0.12). Similarly the germination value was recorded maximum in sand (21.80±3.42) and minimum in filter paper (2.36±0.55).

Based on the analysis of variance of data the differences in all the parameters of germination among the different media used for seed germination were found highly significant at 0.01% level.
The overall results indicate that germination percentage was recorded maximum in vermiculite germination media whereas speed of germination, peak value and germination value were recorded maximum in sand. The study indicates that the preferable germination media for *J. curcas* are vermiculite and sand.

Table.2- Germination percentage of *J. curcas* seeds in different germination media and its associated parameters.

Germination media	Germination %	Speed of germination	Mean germination time	Mean daily germination	Peak value	Germination value
Vermiculite	85.00±9.01	6.81±0.36	5.26±0.48	3.40±0.36	3.73±0.42	12.79±2.82
Coco-peat	74.16±3.82	7.39±0.66	4.17±0.40	2.96±0.15	5.75±0.25	17.07±1.45
Perlite	76.66±7.64	7.39±0.58	4.25±0.22	3.06±0.31	5.25±0.66	16.23±3.70
Normal soil	71.66±2.89	6.63±0.49	4.50±0.37	2.86±0.12	5.08±0.88	14.56±2.47
Sand	82.50±6.61	8.54±0.52	3.97±0.05	3.30±0.26	6.58±0.63	21.80±3.42
Filter paper	55.00±6.61	3.55±0.33	6.58±0.26	2.20±0.26	1.06±0.12	2.36±0.55
P value	< 0.01	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001
LSD at 5% level	11.55	0.90	0.58	0.46	0.99	7.23

Table.3- Correlation matrix between temperature regime, germination percentage and associated parameters

	Temperature regimes	Germination %	SG	MDG	MGT
Temperature regimes	1				
Germination %	0.881**	1			
SG	0.944**	0.957**	1		
MDG	0.959**	0.890**	0.934**	1	
MGT	-0.612**	-0.546**	-0.577**	-0.560**	1

*=P<0.05, **= P<0.01 level of significance, SG= speed of germination, MDG= mean daily germination, MGT= mean germination time

DISCUSSION

Temperature plays an important role in controlling the growth and development of plants and the effect of temperature on seed germination is quite complex because it affects each stage of germination process in a different way and is not independent of other factors [12]. The critical temperature level for seed germination is different for each species or cultivar [16]. [11] reported that tropical plants show optimum germination between 15°C to 30°C, temperate plants between 8°C to 25°C and alpine plants between 5°C to 30°C. Although the seeds of *J. curcas* germinated over a wide range of temperature ranging from 25 to 37°C, the germinability of seeds under different temperatures indicated 30–35°C as optimum temperature for the germination of its seeds. Maximum seed germination was observed 84.44±3.85 at 30°C constant temperature and 77.50±0.00 at 35/25^{0}C alternating temperature respectively. Speed of germination was recorded maximum 8.40±0.44 at 35^{0}C and 7.76±0.37 at 35/25°C compared to other temperature regimes. Germination percent and speed of germination were recorded minimum at 20 and 22°C. Mean germination time was recorded maximum 9.33±1.15 at 20°C whereas minimum 3.74±0.12 at 35°C. Peak value of germination was maximum 5.06±0.12 at 32°C and minimum 0.11±0.10 was recorded at 22°C. Germination value was recorded maximum 28.40±5.80 at 37°C and minimum 0.02±0.02 at 20 and 22°C. Mean daily germination was recorded maximum 5.51±0.62 at 35°C whereas minimum range was recorded

0.11±0.10 and 0.15±0.09 at 20 and 22°C respectively (Table 1). Correlation analysis was done to determine the relationship between seed germination in *J. curcas* and temperature regimes. On the basis of correlation matrix, total percent germination as well as the rate of germination, as evident by the speed of germination/mean daily germination, had a significant positive correlation with temperature (Table 3) indicating that germination in *J. curcas* was favored by higher thermal regime that supports its occurrence in tropical and sub-tropical climatic conditions as well as in open exposed sites. In the region of present study it was found to have its naturalized stands on south facing slopes that are sunny habitats with significantly higher temperatures as compared to north facing slopes. [13]studied the effect of different temperature on seed germination and seedling growth in Ber (*Zizyphus mauritiana* Lam.), a species with habitat preferences similar to *J. curcas*, and reported that with increase in the temperature from 20°C to 30°C the percent germination also increased significantly, being highest 60.8% at 30°C and significantly lower 14.4% at 20°C.

Seed germination under different germination media in laboratory condition

Preference of medium for germination in *J. curcas* was also studied with possible implication on soil characteristics of the seed sources representing naturalized stands of the species. Percent seed germination was recorded maximum (85.00±9.01%) in vermiculite closely followed by sand (82.50±6.61%) whereas minimum (55.00±6.61%) was recorded in filter paper (Table 2). Perlite, coco-peat and the normal garden soil had germination ranging from 71.66±2.89 to 76.66±7.64. These findings indicate that the seeds of *J. curcas* prefer well aerated soil with moderate water holding capacity. Earlier, [9] reported that large seeds also may be germinated on paper but *J. curcas* seeds are also comparatively larger in size but do not germinate properly on the filter paper. [2, 3] also found significantly higher germination in *Terminalia myriocarpa* and *Adhatoda vasica* on top of paper (TP) as compared to sand. However, large seeds also may be germinated on paper [9]. Significantly higher germination has been observed on top of paper (TP) as compared to sand in *Terminanalia myriocarpa* and *Adhatoda vasica* [2, 3] and *Alnus nepalensis* and *A. nitida* [18]. [4] studied the germination behaviour of some leguminous and actinorhizal plants of Himalaya: effect of temperature and medium and observed that in all the species compared to soil + sand mixture seed germination was greater on moistened filter paper. In the present observation vermiculite media is the suitable for germination of *J. curcas* seeds while the filter paper method is poor for seeds germination of *J. curcas.*

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