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Correlation studies in seed traits, moisture and oil content and effect of hormones on flowering of *Jatropha curcas* L.

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Abstract. *Jatropha curcas* L. is an oil-bearing species with multiple uses and considerable potential as a bioenergy crop. The present investigation has been undertaken to assess the variability in seed traits, moisture percentage and oil content of 25 accessions of *J. curcas* collected from different agroclimatic zones of North-East India. There were significant differences ($P < 0.05$) in seed size, 100 seed weight and oil content among the accessions. The maximum seed weight was recorded in J22 collected from Baramura, Tripura and the minimum in J13 collected from Roing, Arunachal Pradesh. Oil variability ranged from 25% (J20, collected from Mokochung, Nagaland) to 36% (J18, collected from Mamit, Mizoram). The moisture percentage in the sun dried seeds varied from 6.06% (J5, collected from Lambding, Assam) to 11.32% (J6, collected from Lakhimpur, Assam). When the oil percentage of seeds is correlated with the sun dried seed moisture percentage and 100 seed weight, it has been found that the oil yield is negatively correlated with the seed moisture. On the other hand the seed weight has strong positive correlation with the oil yield. The effect of hormones on growth and yield potentiality of *J. curcas* was also studied. The hormonal solutions of indole-3-acetic acid (IAA), indole-3-butyric acid (IBA) and 1-naphthalene acetic acid (NAA) in 150, 200, 250 and 500 ppm concentrations were used for the treatments while water was used as control. Data on flowering was recorded before and after treatment of hormones. The male: female ratio was very less (minimum 2:0 in case of J9, and maximum 15:2 in case of J11) in each branch but after hormonal treatment, the number of female flowers were found more in all the accessions. IBA showed the maximum number of female flowers followed by IAA and NAA. Maximum number of female flowers was recorded in each branch of J2 followed by J1 when treated with 250 ppm of IBA.

Keywords: Jatropha, Moisture percentage, Oil percentage, Hormone, Flowering, Seed.

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Introduction

The world reserve of primary energy and raw materials are limited and according to an estimate, the reserves will last for 218 years for coal, 41 years for oil and 63 years for natural gas (Kessel, 2000; Goldemberg et al., 2001; Gilbert and Perl, 2005). The present energy scenario has stimulated active research interest in non-petroleum renewable and non-polluting fuels. *Jatropha curcas* L. also known as physic nut belongs to the family Euphorbiaceae has been identified as a potential biodiesel crop because of the presence of 40-50% oil (Gubitz et al.,

1999). It is a native of Mexico and Central American Region (Heller, 1996). In India it is introduced by the Portuguese in 16th Century (Burkill, 1996). *J. curcas* is a multipurpose species with many attributes and considerable potential. The oil from the seed is the most valuable end product. Except being an oil yielding plant it is a rich source of herbal drugs also. In nature wide range of variability exists for various qualitative and quantitative characters of *J. curcas*. The availability of variability for a given crop is the basic prerequisite in improvement programme and correlations between different characters provide a realistic basis for deciding upon a suitable selection criteria (Singh, 1990). So far as *J. curcas* is concerned, little work has been done on germplasm collection and evaluation of oil content of seeds. Jatropha species are essentially cross-pollinated, which results in a high degree of variation (Saikia et al., 2009) and offers the breeder ample scope to understand screening and selection of seed source for desired traits. Genetic variation in seed morphology and oil content of *J. curcas* have contributed great potential in its improvement programmes, particularly the selection of genotypes having more oil content and yield (Kaushik et al., 2007).

In the present study 25 different accessions of *J. curcas* collected from seven North-Eastern states of India were screened and evaluated. The objective of the study was to understand the pattern of variation existing in different population of *J. curcas* in respect of seed morphology and the effect of hormonal treatments on flowering of *J curcas*, as little attention was paid on the post flowering manipulation of the crop. Such an investigation may help in early evaluation of criteria for selection of some prominent traits both in the laboratory and nursery conditions, which may be related to subsequent performance in the field. Also it is expected that such type of exploratory study will bear significant impact on selection of economically important species and their adaptability and genetic improvement.

Materials and methods

In this research 25 accessions of *J. curcas* were collected from different parts of North-East India (Table 1). The experiment is laid out in a Randomized Block Design (RBD) with three replications in the experimental fields of CSIR - North East Institute of Science & Technology, Jorhat, Assam with a spacing of 2.5 m x 2.5 m. Fully matured capsules are collected from the 2-3 years old plants. The seeds are manually separated from the capsules and shade dried for 30 days till the seeds become completely dry. Three samples were drawn from each seed lot and 100 random undamaged seeds (total 300 seeds) were measured for their length, breath and thickness.

To determine the moisture content of shade dried seeds, three samples each again containing 100 seeds from each accession has been randomly selected and kept in Hot Air Oven at a constant temperature of 70 °C for overnight until the seed weight becomes constant. The oil content of the seeds was estimated by soxhlet method using three replicates for each accession.

To determine the effect of hormones on flowering, hormonal solutions of indole-3-acetic acid (IAA), indole-3-butyric acid (IBA) and 1-naphthalene acetic acid (NAA), in different concentrations, i.e. 150, 200, 250 and 500 ppm were used for the treatment while water was used as control. Flowering data was recorded before and after hormonal treatment and studied the effect of hormones. Statistical analysis was done according to the standard procedure (Panse and Shukhatme, 1967).

Results and discussion

Significant differences ($P < 0.05$) occurred among the accessions for seed size (Table 2). Maximum seed length has been observed in J18 (19.10 mm) followed by J22 (18.75 mm) and lowest in J8 (16.15 mm). The low ranking accessions varied significantly from the rest of the

Table 1. Passport data of the accessions collected.

Sl. No.	Code	Place of Collection and State	Latitude	Longitude	Annual rainfall (mm)	Temperature (°C)	
						Minimum	Maximum
1	J1	Jorhat, Assam	26° 73" N	94° 01" E	2.052	10.8	31.9
2	J2	Bongaigaon, Assam	26° 55" N	90° 58" E	1.614	12.9	31.7
3	J3	Golaghat, Assam	26° 45" N	97° 30" E	2.072	10.8	31.9
4	J4	Tezpur, Assam	26° 60"N	92° 78" E	1.563	11.0	31.2
5	J5	Lambding, Assam	25° 86" N	92° 59" E	1.854	9.8	31.0
6	J6	Lakhimpur, Assam	27° 65" N	96° 25" E	2.635	8.0	31.5
7	J7	Nagaon, Assam	26° 21" N	92° 41" E	1.745	10.0	35.0
8	J8	Sibsagar, Assam	26° 15" N	95° 25" E	2.142	15.0	28.0
9	J9	Goalpara, Assam	25° 54" N	91° 05" E	2.424	7.0	33.0
10	J10	Nalbari, Assam	26° 25" N	91° 26" E	1.500	10.0	36.0
11	J11	Dergaon, Assam	26° 41" N	93° 58" E	2.050	10.0	35.0
12	J12	Naharlagun, Arunachal Pradesh	24° 44" N	93° 65" E	2.688	8.0	32.0
13	J13	Roing, Arunachal Pradesh	28° 05" N	95° 89" E	2.800	5.0	29.0
14	J14	Lamphelpat, Manipur	24° 44" N	93° 65" E	2.027	8.0	34.0
15	J15	Senapati, Manipur	24° 20" N	93° 42" E	2.593	3.0	32.0
16	J16	Ccpur, Manipur	24° 00" N	93° 15" E	2.745	0.0	41.0
17	J17	Kolasib, Mizoram	23° 44" N	92° 47" E	2.800	11.0	30.0
18	J18	Mamit, Mizoram	23° 44" N	92° 48" E	3.000	12.0	30.0
19	J19	Mon, Nagaland	26° 78" N	94° 77" E	1.644	13.3	24.8
20	J20	Mokokchung, Nagaland	26° 44" N	94° 65" E	2.330	9.0	25.0
21	J21	Kamalasagar, Tripura	23° 82" N	91° 65" E	2.800	12.5	33.0
22	J22	Baramura, Tripura	23° 63" N	91° 25" E	2.700	10.1	34.3
23	J23	Watrigithim, Meghalaya	25° 98" N	90° 68" E	3.350	10.0	37.0
24	J24	Tura, Meghalaya	25° 31" N	90° 13" E	2.600	7.0	30.0
25	J25	Borapani, Meghalaya	25° 39" N	91° 54" E	2.138	0.0	28.0

Table 2. Seed size, moisture and oil content variability table.

Sl. No.	Accession Code	Seed Length (mm) Mean±s.d.	Seed Breadth (mm) Mean±s.d.	Seed Thickness (mm) Mean±s.d.	Moisture % Mean±s.d.	100 seed weight (g) Mean±s.d.	Oil % Mean±s.d.
1	J1	17.75±1.30	11.00±1.00	8.65±1.26	8.19±0.13	61.00±1.05	34.00±1.00
2	J2	17.00±1.05	11.10±0.79	8.05±0.51	7.69±2.66	45.85±0.26	30.00±1.32
3	J3	17.55±0.33	10.95±0.18	8.90±0.36	6.25±0.39	48.00±1.32	28.00±0.00
4	J4	17.55±0.55	11.10±0.96	8.85±0.10	7.14±0.14	56.00±1.32	31.00±1.00
5	J5	18.30±0.34	10.70±0.26	8.90±0.13	6.06±0.13	66.00±2.29	35.00±0.50
6	J6	18.30±0.26	10.45±0.43	8.10±0.53	11.32±0.03	53.00±3.97	28.00±0.50
7	J7	17.60±0.36	11.30±0.26	8.50±0.23	7.58±0.46	59.30±1.13	30.00±1.00
8	J8	16.15±1.43	11.25±0.66	8.70±0.33	7.27±0.12	55.00±2.64	27.00±1.00
9	J9	17.92±1.28	11.25±0.25	8.57±0.05	7.90±0.13	63.00±3.05	30.02±1.03
10	J10	17.55±0.51	11.00±0.25	8.72±0.20	9.67±0.29	62.00±2.78	31.00±1.00
11	J11	17.40±0.53	10.60±0.36	8.55±0.43	6.89±0.13	58.00±3.50	28.33±1.15
12	J12	18.60±0.22	10.45±0.23	8.40±0.53	7.60±0.61	46.33±2.97	33.50±0.50
13	J13	18.20±0.20	11.00±0.86	8.00±0.50	6.78±0.19	40.43±2.20	29.00±1.73
14	J14	18.10±0.26	11.20±0.44	8.90±0.15	8.06±0.36	62.00±1.82	31.60±1.44
15	J15	18.20±0.09	11.05±0.51	8.90±0.41	6.89±0.33	58.00±1.00	30.00±1.00
16	J16	18.35±0.65	11.05±0.91	8.70±2.06	8.95±0.42	67.00±2.60	33.50±0.50
17	J17	17.92±0.15	11.25±0.25	8.57±0.16	7.90±0.10	63.00±3.77	35.00±0.86
18	J18	19.10±1.74	10.80±0.18	8.72±0.25	8.30±0.34	68.50±2.78	36.00±1.32
19	J19	18.42±0.53	10.47±0.79	8.42±0.52	11.11±0.97	45.00±2.78	26.00±1.00
20	J20	17.80±0.46	11.70±0.70	8.60±0.96	7.69±0.54	52.00±3.04	25.00±0.50
21	J21	17.50±0.50	10.00± 0.66	8.10±0.79	8.62±0.55	46.99±1.72	29.00±1.00
22	J22	18.75±0.43	10.42±0.62	8.40±0.54	8.69±0.97	69.00±3.12	33.00±0.50
23	J23	18.20±0.18	10.50±0.28	8.60±0.36	7.46±0.14	65.14±2.73	35.00±1.00
24	J24	18.05±0.18	10.95±0.40	8.30±0.26	8.47±0.75	59.00±1.32	30.00±2.64
25	J25	17.30±0.26	11.10±0.34	8.87±0.12	8.82±0.28	68.00±2.64	31.00±1.00
SEM		0.57	0.46	0.52	0.56	2.04	0.90
CV (%)		0.03	0.03	0.03	0.16	0.14	0.10
CD (at 5%)		1.12	NS	NS	1.10	4.00	1.76

SEM = standard error of means, CV (%) = coefficient of variation, CD (at 5%) = critical difference at 5%, NS = not significant.

Table 3. Simple correlation matrix.

	Seed length	Seed breadth	Seed thickness	Moisture	100 seed weight	Oil %
Seed length	1.000					
Seed breadth	-0.357	1.000				
Seed thickness	-0.048	0.381	1.000			
Moisture %	0.231	-0.301	-0.328	1.000		
100 seed weight	0.225	0.142	0.566	0.017	1.000	
Oil %	0.465	-0.160	0.263	-0.165	0.633	1.000

Table 4. Flowering data (male:female).

Sl. No.	Code	Control	IAA (ppm)				IBA (ppm)				NAA (ppm)			
			150	200	250	500	150	200	250	500	150	200	250	500
1	J1	7:1	15:2	17:2	24:2	24:1	16:2	18:2	25:3	15:2	22:2	25:2.5	22:2	24:1
2	J2	8:1	23:2.5	25:2.5	24:2	24:1	18:2	24:3	22:8	20:2	20:2.5	21:2	22:3	26:1
3	J3	8:1	20:2	28:3	28:3	27:1	16:2	18:2	20:2.5	18:1	16:1	19:1.5	20:1.5	23:1
4	J4	6:1	18:2	22:2	20:2	22:1	21:2	23:2	26:2.5	22:2	15:1	18:1	22:2.5	25:1
5	J5	8:0	18:2	24:2	22:2	22:1	20:2	23:2	23:2.5	18:2	21:1.5	20:1.5	17:2	27:1
6	J6	9:1	15:2	18:2	18:2	20:1	18:2	21:2.5	21:2.5	18:2	12:1	12:1	12:1.5	20:1
7	J7	6:1	16:2	21:1.5	23:2	23:1	16:2	18:2	21:2.5	22:2.5	20:2	22:2	22:2	26:1
8	J8	5:0	18:1	20:1.5	20:1	20:1	20:1.5	22:2	26:2.5	22:2	15:1	15:1	14:1	20:1
9	J9	2:0	15:1	17:1	18:1.5	18:1	15:1.5	18:2	18:2	15:1.5	8:1	9:1	11:1	18:1
10	J10	10:1	17:1	18:1	20:1.5	20:1	20:1.5	22:2	25:2.5	22:2.5	7:1	10:1	12:2	21:1
11	J11	15:2	16:2	15:2	15:2	18:2	15:2	15:2	24:2	18:2	16:2	17:2	15:2	24:1
12	J12	12:1	18:2	20:2	20:2	24:3	23:2.5	20:2	24:2	24:3	18:2	25:2.5	20:2	24:1
13	J13	9:1	16:2	18:1	18:1	18:2	20:2	18:1	28:2	18:2	16:2	28:3.0	18:1	27:1
14	J14	10:1	21:2	22:2	22:2	23:2	18:2	22:2	20:2	23:2	21:2	22:2	22:2	22:1
15	J15	9:1	20:2	18:2	18:2	23:2	18:2	18:2	22:2	23:2	20:2	24:2	18:2	22:1
16	J16	11:1	18:2	18:2	18:2	21:2.5	15:2	18:2	18:2	21:2.5	18:2	18:2	18:2	20:1
17	J17	8:1	16:2	22:2.5	22:2.5	18:2	16:2	22:2.5	23:2	18:2	16:2	21:1.5	22:2.5	23:1
18	J18	5:1	20:1.5	22:2	22:2	22:2	18:1	22:2	20:1	22:2	20:1.5	20:1.5	22:2	20:1
19	J19	6:1	15:1.5	15:1.5	15:1.5	18:2	15:1	15:1.5	18:1.5	18:2	15:1.5	17:1	15:1.5	18:1
20	J20	8:2	20:1.5	22:2.5	22:2.5	22:2	17:1	22:2.5	20:1.5	22:2	20:1.5	18:1	22:2.5	20:1
21	J21	8:1	16:2	15:2	15:2	18:2	15:2	15:2	24:2	18:2	16:2	17:2	15:2	24:1
22	J22	8:0	18:2	20:2	20:2	24:3	23:2.5	20:2	24:2	24:3	18:2	25:2.5	20:2	24:1
23	J23	7:1	16:2	18:1	18:1	18:2	20:2	18:1	28:2	18:2	16:2	28:3	18:1	27:1
24	J24	6:1	21:2	22:2	22:2	23:2	18:2	22:2	20:2	23:2	21:2	22:2	22:2	22:1
25	J25	7:1	20:2	18:2	18:2	23:2	18:2	18:2	22:2	23:2	20:2	24:2	18:2	22:1

IAA = Indole-3-acetic acid; IBA = Indole-3-butyric acid; NAA = 1-Naphthalene acetic acid.

accessions. Seed breadth varies from 10.00 mm to 11.70 mm with maximum in J20 and minimum in J21. On the other hand seed thickness varies from 8.00 mm in J13 to 8.90 mm in J3, J5, J14 and J15. Though the seeds were dried under similar condition they showed significant variation in their moisture content. Highest moisture percentage (Table 2) is found in J6 with 11.32% which is closely followed by J19 with 11.11% and lowest in J5 with 6.06%. The accessions also showed significant variability for 100 seed weight and oil content (Table 2). For 100 seed weight the top ranking accession is J22 (69.00 g) followed by J18 (68.50 g). The top ranking accessions differed significantly from the rest. There is also significant variability in oil content that varies from 25% in J20 to 36% in J18.

The magnitude of simple correlation coefficient among the six characters has been presented (Table 3). The seed length is positively correlated with the oil percentage and the sun dried seed moisture shows negative correlation with the oil percentage. The 100 seed weight shows strong positive correlation with the oil content of the seeds. Variation is the phenomenon where individuals of a population differ from each other. The extent of variation in seed weight and oil content in the whole seed and kernel is large as compared to other traits.

The male and the female flowers of *J. curcas* show unique characteristics. It is observed that in normal (control) condition the number of male flowers, were comparatively more than female flowers (Table 4).

The hormonal treatment with different concentrations showed effective results (Table 4). Amongst different hormones, 250 ppm of IBA was observed as more effective in increasing the number of female flowers compared to other hormones. However, 500 ppm of IAA and NAA showed proportionate increase in male flower. Maximum number of female flower was recorded in each branch of the accession J2 (22:8) followed by the accession J1 (25:3) when treated with 250 ppm of IBA.

The consideration of seed weight in selecting and understanding the geographical variation has been advocated because of the least plasticity in this character (Harper et al., 1970). The study of seed morphological characters of a natural population can be considered as a useful step in the study of the genetic variability. Various ecotypes/provinces/seed sources of *J. curcas* exhibit variation in seed morphological traits (Kumar et al., 2003; Ginwal et al., 2005; and Kaushik et al., 2007). Therefore this kind of study can help to identify the better genotypes of *J. curcas* having better yield and oil content and the best genotypes selected will improve energy plantations in the wastelands. However, changes in the physiological functions due to hormonal treatment and their metabolic effect need further detail study. It is expected that such type of exploratory study will bear significant impact on selection of economically important species, their adaptability and genetic improvement.

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Conflict of interest statement

Authors declare that they have no conflict of interests.

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