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Study of growth parameter on different genotype of *Jatropha curcas* in clustering pattern to improve yield and oil contant

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Abstract
Jatropha curcas is a multipurpose plant with many attributes and considerable potential. It is a tropical plant that can be grown in low to high rainfall areas and can be used to reclaim land, as a hedge and/or as a commercial crop. Thus, growing it could provide employment, improve the environment and enhance the quality of rural life. The experiment was conducted in 2014-2015 at main experiment station of Narendra Deva University of Agriculture and Technology Kumarganj, Ayodhya with different genotypes of Jatropha plant in cluster of 16 geotypes *viz* TNCJC-19, TNCJC-20, TNCJC-25, PDKV-NOV-19, LBJJ-23, CRJ-29, TFRI-07, JJ-2, CALD-14, PANT-JC-P-1, PANT-JC-P-2, TR-4, RJ-92, NDJC-1, MNJ-001, TNCJC-23. The experiment result was that the Plant height, Girth of main shoot, No. of branches, Canopy, No. of fruits per plant, Fruit yield per plant. Fruit yield q/ha, Seed yield per plant, Oil content (%), Oil yield liter/ha was recorded highest in genotype NDJC-1.

Keywords: Jatropha, genotypess, growth, oil, yield

Introduction
Jatropha (*Jatropha curcas* Linn) also known as Physic nut or Ratanjot which belongs to family Euphorbiaceae. It is diploid species with chromosomes number 2n=22 (Heller 1996) [1]. The word Jatropha derived from Greek word *jatros* meaning physician or doctor and *trophe* means nutrition or food indicating wide utilization in ethno-medicine in ancient times. It is believed that plant originated from Mexico and Central America. Jatropha produces seeds with a high oil content (30-35%) that can be transformed into biodiesel fuel that has been used to power Multi-Functional Platforms (MFPs) and water pumps for irrigation (Adhikari and Wegstein 2011) [2]. Jatropha curcas oil can be used directly in older diesel engines or engines running at a constant speed like pumps or generators (Achten, Verchot *et al*. 2008) [3]. Jatropha curcas oil can also be used as substitute for the 'gazoil' mixture used throughout Senegal and rural Mali where it fuels diesel engines that drive water pumps and grain mills. The potential use of Jatropha oil as biodiesel and organic manure (Augustus *et al*. 2002, Pramanik, 2003 and Reddy and Ramesh, 2006) [4, 5]. The biodiesel oil is comparable, cheaper and high quality than diesel fuel, but its density and viscosity are much higher (Namasivayam *et al*., 2007) [6]. It burns with clear smoke free flame. Jatropha oil/bio fuel characteristics: moisture% weight 0.0326, Ramsbottom Carbon Residue 0.22, viscosity (cSt) 34.5, Gross Calorific Value (kJ/g) 46.024, acidity 2.19, density (kg / m^3) 935. Deferent uses Jatropha-**(***Jatropha curcas*) is an anti-feed ant agent (Adebowale *et al*, 2006) [7]. The milky latex of *Jatropha curcas* contains an alkaloid known as 'Jatrophine', which has anti-cancerous properties and also used herbal drug in dental complaints and used in Mesoamerica for the treatment of different dermato- mucosal disease (Girach *et al*, 1995 and Marroquin *et al*, 1997) [8]. The first commercial use of Jatropha were reported from Lisbon, where the oil was imported from Cape Verde and used for soap production and for lamps. The seeds of this species produce oil which acts as a source of energy in the form of bio-diesel (Karmakar *et al* 2006, Punia *et al*, 2006) [9]. The seed of *Jatropha curcas* contain around 30-40% on non edible oil, which has been identified as a source of bio-fuel (Ajeet *et al*,2006) [10].

Materials and Method
The mean performance of 16 genotype and general mean along with range sixteen characters are presented in Table 1.

1. Plant height (cm): Plant height ranged from 315.69 cm (JJ-2) to 337.76 cm (NDJC-1), with

general mean of 324.75 cm. Six genotypes namely, TNCJC-19 (337.75 cm), TNCJC-20 (333.69 cm), TNCJC-25 (329.99 cm), PANT-JC-P-2 (228.09 cm), NDJC-1 (337.76 cm) and TNCJC-23 (332.74 cm) were significantly in long plant stature than the general mean.

2. Girth of main shoot (cm): The general mean of girth of main shoots was 40.20 cm, whereas, it ranged from 35.03cm (RJ-92) to 46.68cm (TNCJC-19). Four genotypes namely, TNCJC-19 (46.68), TNCJC-20 (45.47), TNCJC-25 (43.16 cm) and NDJC-1 (46.20 cm) were significant in girth of main shoot.

3. Number of branches at harvesting time The number of branches at harvesting time varied from 26.80 (RJ-92) to 48.40 (TNCJC-19). Out of sixteen studied genotypes, six genotypes were significantly for these traits; the best six genotypes in order of merit were TNCJC-19 (48.40), TNCJC-20 (47.40), NDJC-1 (46.80), and MNJ-001 (45.20).

4. Canopy (cm): The general mean of canopy was 241.53cm, whereas, it ranged from 218.15cm (JJ-2) to 276.31 cm (TNCJC-19). Out of sixteen studied genotypes three genotypes were showed significant for this trait. Four best genotypes in order of merit and TNCJC-19 (276.31cm), TNCJC-20 (274.61cm), NDJC-1 (276.02 cm) and TNCJC-23 (271.07cm).

5. Number of fruits per plant: Number of fruits per plant varied from 223.60 (JJ-2) to 262.40 TNCJC-19 with general mean 246.75. The genotypes *viz.*, TNCJC-19 (262.40) and TNCJC-20 (258.00) and NDJC-1 (255.60) were significantly superior for number of fruits per plant.

6. Fruit yield per plant (kg): The fruit yield per plant ranged from 0.44 (RJ-92) to maximum 0.61(TNCJC-19) with 0.51kg general mean. The four genotypes viz., TNCJC-19, TNCJC-20, TNCJC-25, PANT-JC-P-2 and NDJC-1 in which TNCJC-19 was statistically at par with TNCJC-20, TNCJC-25 was statistically significantly at par with NDJC-1.

7. Fruit yield quintal /ha: Fruit yield quintal par hectare ranged from 2.44(RJ-92) to 3.40(TNCJC-19) with general mean 2.86. Out of sixteen genotypes, four genotypes *viz.*, TNCJC-19(3.40), TNCJC-20(3.15), TNCJC-25(3.03), PANT-JC-P-2(2.94) and NDJC-1(2.92) showed more fruit yield q/ha significantly than the general mean.

8. Seed yield per plant (kg): Maximum seed yield per plant was recorded in TNCJC-20 (045), while it was minimum in RJ-92 (0.32). The population need for seed yield per plant was 0.40 kg. Out of sixteen genotype, two genotypes namely TNCJC-19(0.44), TNCJC-20(0.45), NDJC-1 (0.44) and PANT-JC-P-2(0.42) were statistically superior to the general mean.

9. Seed yield quintal /ha: The maximum seed yield quintal per ha was recorded in TNCJC-19 (3.70q/ha) whereas, it was minimum in case of LBJJ-23 (2.53q/ha) and the average yield was 3.09 q/ha. Four genotypes viz., TNCJC-19 (3.70q/ha), TNCJC-20(3.42q/ha), PANT-JC-P-1(3.37q/ha) and NDJC-1(3.52q/ha) showed significantly higher seed yield quintal per ha than the general mean.

10. Seed husk (g/plant): The general mean of seed husk g/plant was 116.13g, whereas, it ranged from 104.00g (PDKV-NOV-19) to 130.00g (TNCJC-19). Five genotypes showed significantly higher seed husk g/plant than the general mean, four best genotypes in order of merit were TNCJC-19 (130.00g), TNCJC-25 (128.00g), RJ-92 (124.00g) and MNJ-001(122.00g).

11. Seed husk ratio: The general mean of seed husk ratio was 35.23g, whereas, it ranged from 31.25g (RJ-92) to 39.66g (NDJC-1). Four genotypes showed significantly higher seed husk ratio than the general mean, three best genotypes in order of merit were NDJC-1 (39.66g), PDKV-NOV-19(39.05g) and TFRI-07 (38.93g).

12. 100 seed weight (g): The general mean of 100 seed weight was 60.41g, whereas, it ranged from 55.08g (PDKV-NOV-19) to 67.77g (JJ-2). Six genotypes showed significantly higher 100 seed weight (g) than the general mean, four best genotypes in order of merit were JJ-2 (67.77g), LBJJ-23 (64.83) CALD-14 (65.06g) and NDJC-1 (65.00g).

13. Oil content (%): The oil content varied from 26.95 (LBJJ-23) to 35.71 (NDJC-1) with the general mean of 31.33 per cent. The eight genotypes, viz., NDJC-1 (35.71%), TNCJC-25 (33.89%), TR-4(33.83), TNCJC-20 (33.56%), MNJ-001 (33.54%), TNCJC-23 (33.33%), PDKV-NOV-19 (32.81%) and RJ-92 (32.59%), showed significantly higher oil content% then the general mean.

14. Oil yield per ha: The general mean of oil yield liter per hectare was 69.88, where as oil yield liter par hectare varied from 54.43(JJ-2) to 87.64(NDJC-1). The six genotype *viz.*, TNCJC-19(83.82), TNCJC-20(84.24), TNCJC-25(79.51), PDKV-NOV-19(73.30), NDJC-1(87.64) and TNCJC-23(82.97) showed significantly higher oil yield liter per hectare then the general mean.

15. Polar diameter of fruit: Polar diameter of fruit varied from 6.53 (PDKV-NOV-19) to 7.51 (RJ-92) and the general mean was 7.10 cm. Out of sixteen genotype, two genotype *viz.*, RJ-92 (7.51cm) and TNCJC-23 (7.42cm) showed significant to the general mean fallowed by JJ-2 (7.30CM) and Pant-JCP-2 (7.20cm).

16. Equatorial diameter of fruit: The general mean of equatorial diameter of fruit was 6.81, where as the ranged of this characters was recorded from 6.54cm (TNC-JC-20) to 7.06cm (RJ-92). Out of sixteen genotype, five genotypes *viz.*, RJ-92 (7.06cm), CALD-14 (7.04cm), PANT-JC-P-1 (7.01cm), PANT-JC-P-2 (6.95 cm) and TNCJC-25 (6.92 cm) showed significantly higher equatorial diameter of fruit than the general mean.

Table 1: List of genotypes used under experiment and their origin

S. No.	Name of germplasm	Developing centers
1.	TNCJC-19	T.N.U.A.T.- Coimbatore
2.	TNCJC-20	T.N.U.A.T.- Coimbatore
3.	TNCJC-25	T.N.U.A.T. – Coimbatore
4.	PDKV-NOV-19	P.D.K.V.- Akola
5.	LBJJ-23	B.A.U.- Ranchi
6.	CRJ-29	C.R.I.D.A.- Hyderabad
7.	TFRI-07	T.F.R.I.- Jabalpur
8.	JJ-2	J.N.K.V.V- Jabalpur
9.	CALD-14	C.S.F.E.R.- Allahabad
10.	PANT-JC-P-1	G.B.P.U.A.T. – Pantnagar
11.	PANT-JC-P-2	G.B.P.U.A.T. –Pantnagar
12.	TR-4	I.C.A.R. N.E.H. – Tripura
13.	RJ-92	M.P.K.V. – Rahori
14.	NDJC-1	N.D.U.A.T. – Faizabad
15.	MNJ-001	I.C.A.R. NEH –Manipur
16.	TNCJC-23	T.N.UAT- Coimbatore

Table 2: Mean performance of sixteen genotypes of Jatropha

S. No.	Characters	Plant height (cm)	Girth of main shoot (cm)	No. of branches at harvesting time	Canopy (cm)	No. of fruits per plant	Fruit yield per plant (kg)	Fruit yield q/ha	Seed yield per plant (kg)	Seed yield q/ha	Seed husk (g/plant)	Seed husk ratio	100 seed weight (g)	Oil content (%)	Oil yield liter / ha	Polar diameter of fruit (cm)	Equatorial diameter (cm)
1	TNCJC-19	337.75*	46.68*	48.40*	276.31*	262.40*	0.61*	3.40*	0.44*	3.70*	130.00*	37.17*	58.70	31.30	83.82*	7.15*	6.64
2	TNCJC-20	333.96*	45.47*	47.40*	274.61*	258.00*	0.57*	3.15*	0.45*	3.42*	114.00	38.49*	57.94	33.56*	84.24*	7.05	6.54
3	TNCJC-25	329.99*	43.16*	42.00*	235.00	254.80*	0.55*	3.03*	0.42*	3.20*	128.00*	33.19	60.04	33.89*	79.51*	6.99	6.92*
4	PDKV-NOV-19	320.43	40.58	37.40	225.02	244.80	0.51	2.81	0.40	2.96	104.00	39.05*	55.08	32.81*	73.30*	6.53	6.74
5	LBJJ-23	317.03	38.01	32.60	230.38	238.00	0.48	2.65	0.36	2.53	116.00	31.77	64.83*	29.19	58.78	6.92	6.73
6	CRJ-29	321.43	38.72	37.00	227.11	242.00	0.50	2.76	0.39	2.98	108.00	36.34	60.06	26.95	58.10	6.73	6.70
7	TFRI-07	318.77	36.93	34.80	220.36	243.40	0.52*	2.90	0.41	3.20	106.00	38.93*	62.24*	30.66	70.04	7.17*	6.61
8	JJ-2	315.69	35.05	32.00	218.15	234.80	0.47	2.60	0.35	2.89	118.00	34.50	67.77*	28.03	54.43	7.30*	6.94
9	CALD-14	318.64	37.15	34.80	221.95	244.00	0.49	2.74	0.38	3.19	116.00	32.80	65.06*	29.99	62.98	7.14	7.04*
10	PANT-JC-P-1	325.49	39.91	39.60	235.70	245.60	0.52	2.91*	0.40	3.37*	116.00	35.00	60.55	28.90	63.79	6.83	7.01*
11	PANT-JC-P-2	328.09*	40.11	39.20	250.19*	248.40	0.53*	2.94*	0.42*	3.41*	106.00	36.97	58.15	27.14	63.88	7.20*	6.95*
12	TR-4	322.71	38.90	39.40	235.41	243.80	0.47	2.62	0.35	2.69	120.00*	31.56	57.71	33.83*	66.11	7.02	6.63
13	RJ-92	310.95	35.03	26.80	226.51	223.60	0.44	2.44	0.32	2.54	124.00*	31.25	55.22	32.59	57.22	7.51*	7.06*
14	NDJC-1	337.76*	46.20*	46.80*	276.02*	255.60*	0.55*	3.05*	0.44*	3.52*	112.00	39.66*	65.00*	35.71*	87.64*	7.40*	6.75
15	MNJ-001	324.61	40.05	45.20*	240.70	248.00	0.51	2.81	0.38	2.56	122.00*	32.49	61.41*	33.54*	71.27	7.23*	6.86
16	TNCJC-23	332.74*	41.59*	42.60*	271.07*	251.80*	0.53*	2.92*	0.41	3.37*	118.00	34.57	56.79	33.33*	82.97*	7.42*	6.82
	Mean	324.75	40.22	39.13	241.53	246.75	0.51	2.86	0.40	3.09	116.13	35.23	60.41	31.33	69.88	7.10	6.81
	C.V.	0.38	1.06	5.04	0.70	0.64	2.25	2.26	2.69	2.24	7.23	9.87	1.26	0.80	4.22	0.75	0.36
	SEm±	0.55	0.19	0.88	0.76	0.71	0.01	0.03	0.00	0.03	3.75	1.56	0.34	0.11	1.32	0.02	0.01
	C.D. 5%	1.57	0.54	2.49	2.15	2.01	0.01	0.08	0.01	0.09	10.62	4.40	0.96	0.32	3.73	0.07	0.03

Table 3: Analysis of variance for sixteen characters in Jatropha

S. No.	Characters	Source of variation		
		Replications	Treatments	Error
	d.f.	4	15	60
1.	Plant height (cm)	1.4676	321.7059**	1.5378
2.	Girth of main shoot (cm)	0.2431	66.2291**	0.8104
3.	Number of branches at harvesting time	9.0313	187.0367**	3.8846
4.	Canopy (cm)	3.0731	2254.6436**	2.8845
5.	Number of fruits per plant	3.5938	325.0533**	2.5138
6.	Fruit yield per plant (kg)	0.0003*	0.0089**	0.0001
7.	Fruit yield q/ha	0.0078*	0.2742**	0.0042
8.	Seed yield per plant (kg)	0.0001	0.0089**	0.0001
9.	Seed yield q/ha	0.0017	0.7028**	0.0048
10.	Seed husk (g/plant)	105.1563	297.2500**	70.4896
11.	Seed husk ratio	24.3398*	42.1058*	12.0944
12.	100 seed weight (g)	1.1433	70.2101**	0.5774
13.	Oil content (%)	0.1137	36.5398**	0.0633
14.	Oil yield liter / ha	5.8251	596.4491**	8.6790

15.	Polar diameter of fruit (cm)	0.0024	0.3410**	0.0028
16.	Equatorial diameter (cm)	0.0006	0.1365**s	0.0006

* Significant at 5 per cent probability level
**Significant at 1 per cent probability level

Results

The mean performances of 16 genotypes for 16 characters are given in Table 2. The highest plant height was obtained in the genotypes TFRI- 07 and constituted the top significant group for plant height along with six genotypes. Among the maximum plant height three most promising genotypes in order of merit were PDKV-NOV-19, TNCJC-23 and RJ-92. The genotype NDJC-1 had maximum value of girth of main shoot and constituted the top significant group for high girth of main shoot, five most promising genotypes in order of merit were NDJC-1, PDKV-NOV-19, TCJC-25, JJ-2 and TR-4.

The highest fruit yield quintal per hectare was observed in the genotypes NDJC-1 and constituted top significant group for fruit yield quintal per hectare along with four genotypes. Among high fruit yielding genotypes two most promising genotypes in order of merit, NDJC-1 and Pant-JCP-2. The genotypes RT-4, JJ-2 and Pant-JCP-2 were significantly superior for 100 seed weight. Maximum oil content was observed in genotype NDJC-1 and consist the top significant group with RJ-92, TNCJC-20, PDKV-NOV-19, TR-4, TNCJC-25, MNJ-001 and TNCJC-23. The genotypes MNJ-001, NDJC-1 and JJ-2 had maximum for oil yield liter per hectare.

Conclusion

The data on sixteen characters were utilized for estimation of genotypic and phenotypic coefficients of variation, heritability in broad sense, genetic advance in per cent of mean, genotypic and phenotypic correlation and path coefficient at genotypic and phenotypic level. The salient results of the study and conclusionThe most promising lines showing highest seed yield with high mean performance for various traits yield contributing characters except few traits was identified as NDJC-1.

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