

## Analysis for Identification of Distinct and Uniform Extant Jute (*Corchorus olitorius* L. and *C. capsularis* L.) Varieties

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**ABSTRACT** In the present era of Intellectual Property Rights, the distinctiveness, uniformity and stability of a candidate variety are the basis for granting protection of Plant Breeder's Rights. Keeping this in view, 27 jute varieties were characterized for 5 quantitative characters viz. leaf angle, time of 50 per cent flowering, plant height, days to maturity and 1000 seed weight, prescribed in the Draft National DUS Test Guidelines of Jute. On the basis of COYD and COYU analysis of 5 quantitative characteristics, distinctiveness and uniformity of 3 *olitorius* varieties viz. JRO 3690, Chinsurah Green and JRO 36E at CRIJAF, Barrackpore location and 4 varieties TJ 40, Chinsurah Green, Bidhan Rupali and JRO 36E at CSRSJAF, Budbud location could be established whereas 6 *capsularis* varieties (JRC 212, JRC 7447, JRC 321, JRC 4444, UPC 94 and Bidhan Pat 2) at CRIJAF, Barrackpore location and only 1 variety, JRC 321 at CSRSJAF, Budbud location was ascertained.

**Key words:** Jute, *Corchorus olitorius*, *C. capsularis*, distinctiveness, uniformity, extant variety

Characterization of extant jute varieties is required for their protection under Protection of Plant Variety (PPV) legislation, because varietal testing for Distinctiveness, Uniformity and Stability (DUS) is the basis for grant of protection of extant jute varieties under the Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act, 2001 [1]. The Act has the provision to compare the novel candidate variety with the varieties of common knowledge on a set of relevant characteristics prescribed in the Draft National Test Guidelines for DUS testing of jute [2] and commonly accepted for this purpose at the time of filling of application. Extant jute varieties seeking protection need to be registered with Protection of Plant Varieties and Farmers' Rights (PPV&FR) Authority and the registered extant jute varieties will be the varieties of common knowledge/reference varieties.

Though morphological characterization of 27 jute varieties (20 released/notified and 7 varieties of common knowledge) for 3 years using 16 qualitative morphological characteristics was done for application of DUS Testing [3] to establish distinctiveness among the varieties, distinctiveness of only few varieties could be established individually and remaining varieties could be classified into 2 or more groups. The present investigation has therefore, been aimed at establishing distinctiveness and uniformity of extant jute varieties based on combined over year analysis of quantitative traits using DUS Trial Software facilitating registration of distinct extant jute varieties with PPV&FR Authority.

### MATERIALS AND METHODS

A DUS trial of 20 varieties of 2 species of jute (*Corchorus olitorius* and *C. capsularis*) released or

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notified in India and 7 varieties of common knowledge were evaluated for 5 quantitative characters *viz.* leaf angle, time of 50 per cent flowering, plant height, days to maturity and 1000 seed weight. Nucleus or breeder seed was used for the study in the first year and later seed grown from the original seed was used for further study. The experiment was conducted during rainy season of 2003-04, 2004-05 and 2005-06 at 2 designated DUS testing centers for jute in West Bengal *viz.* Central Research Institute for Jute and Allied Fibres (CRIJAF), Barrackpore and Central Seed Research Station for Jute and Allied Fibres (CSRSJAF), Budbud, Burdwan in randomized block design with 3 replications. Each replication consisted of 4 rows of 5m length with 40 x 5 cm spacing.

The observations were recorded on 10 plants in each replication at specified stages of crop growth period when the characters under study had full expression.

UPOV has developed a method known as the Combined Over Years Distinctness (COYD) analysis, which takes into account variations between years. This method requires the size of the differences to be sufficiently consistent over the years and takes into account the variation between years (TG/1/3) [4]. When the uniformity of plants of a variety is to be judged on the basis of quantitative characteristics then the standard deviation (SD) can be used to summarise the spread of the observations. A new variety can then be tested for uniformity by comparing its SD with that of reference varieties. There are several possible ways of assessing uniformity based on the SD. UPOV has provided Combined-Over-Years Uniformity (COYU) criterion using the SD for the determination of uniformity (TGP/10) [5].

Analysis of the DUS trial data was done following COYD for distinctiveness and COYU for uniformity using the DUST Software [6]. Calculation of the COYD criterion involved analysing the variety-by-year table of means for each characteristic to get an estimate of the varieties-by-years variation, which was used to calculate an LSD. The varieties-by-years mean square is used as the estimate of the varieties-

by-years variation, and the resulting LSD is known as the COYD LSD (TGP/9) [7]. A pair of varieties is considered to be distinct if their over-years means differ by at least the COYD LSD in 1 or more characteristics.

Marked differences between years in the range of expression of a characteristic can occur. To take account of this effect it is possible to fit extra terms, 1 for each year, in the analysis of variance. Each term represents the linear regression of the observations for the year against the variety means over all years. The method is known as modified joint regression analysis (MJRA) [8] and is recommended in situations where there is a statistically significant ( $p \leq 1\%$ ) contribution from the regression terms in the analysis of variance. Occasionally, a pair of varieties may be declared distinct on the basis of a t-test which is significant solely due to a very large difference between the varieties in a single year. To monitor such situations a check statistic is calculated, called  $F_3$ , which is the variety-by-years mean square for the particular variety pair expressed as a ratio of the overall variety-by-years mean square. This statistic should be compared with F-distribution tables with 1 and  $g$ , or 2 and  $g$ , degrees of freedom, for tests with 2 or 3 years of data respectively where  $g$  is the degrees of freedom for the variety-by-years mean square. If the calculated  $F_3$  value exceeds the tabulated F value at the 1 per cent level then an explanation for the unusual result should be sought before making a decision on distinctiveness. From the over-year variety means following expressions are also included in the table.

YEAR MS: the mean square term for years

VARIETY MS: the mean square term for varieties

VAR. YEAR MS: the mean square for varieties-by-years interaction

F1 RATIO: ratio of VARIETY MS to VAR.YEAR MS

VAR.REP MS: average of the variety-by-replicate mean squares from each year

F2 RATIO: ratio of VAR.YEAR MS to VAR.REP MS

BETWEEN SE: standard error of variety means over trials on a plot basis

WITHIN SE: the standard error of variety means within a trial on a plot basis

DF: the degree of freedom for varieties-by-years

MJRA SLOPE: the slope of the regression of a single year's variety means on the means over the 3 years

REGR F VALUE: the mean square due to MJRA regression as a ratio of the mean square about regression

REGR PROB: the statistical significance of the REGR F VALUE

TEST: indicates whether MJRA adjustment was applied (REG) or not (COY).

The calculation technique for uniformity involved ranking the reference and candidate varieties by the mean value of 3 characteristics viz. leaf angle, plant height and 1000 seed weight (the data on time to 50 per cent flowering and days to maturity was not available on individual plants which is required for the determination of COYU analysis). Each variety's SD was taken and the mean SD of the most similar varieties was subtracted. This procedure gave, for each variety, a measure of its uniformity expressed relative to that of comparable varieties. The results for each year were combined in a variety-by-years table of adjusted SDs and analysis of variance was applied. The mean adjusted SD for the candidate was compared with the mean for the reference varieties using a standard t-test. COYU, in effect, compared the uniformity of a candidate variety with that of the reference varieties most similar in relation to the characteristic being assessed. The main advantages of COYU were that all varieties could be compared on the same basis and that information from several years of testing might be combined into a single criterion.

An analysis was performed for 2 years and 3 years separately. For the distinctiveness, only those varieties were considered in the third year which were not distinct in the 2 years analysis. However for the uniformity, all the varieties

present in the 2 years analysis have also been included in the 3 years analysis.

## RESULTS AND DISCUSSION

Variety means over 2 years distinctiveness for 5 quantitative traits of *olitorius* varieties at CSRSJAF, Budbud location revealed that leaf angle of the 16 varieties ranged from 59.8° to 70.6° (Table 1). The variety TJ 40 exhibited highest leaf angle (70.6°) followed by variety JRO 36 E (69.6°). Minimum number of days to 50 per cent flowering was recorded for the variety Chinsurah Green (101.7 days) followed by the variety Sudan Green (113.5 days). Among 16 *olitorius* varieties maximum plant height was observed in variety Bidhan Rupali (441.0 cm) followed by TJ 40 (438.0 cm). Minimum days to maturity was recorded for the variety Sudan Green followed by Tanganyika 1 indicating that these 2 varieties were early with regard to maturity as compared to other *olitorius* varieties. Variety Chinsurah Green recorded highest 1000 seed weight (2.18g) indicating higher seed yield than the other varieties. As there was no significant regression, F value at  $P \leq 1\%$ , COY was adopted for all the 5 descriptors (Table 1).

COYD analysis for 2 years distinctiveness for *olitorius* varieties at CSRSJAF, Budbud location exhibited that 5 varieties viz. TJ 40, Chinsurah Green, Sudan Green, Bidhan Rupali and JRO 36E were distinct from all *olitorius* varieties (Table 2), while remaining eleven varieties were non-distinct from 1 or more varieties. The non-distinct varieties therefore, needed 3 years for further distinctiveness analysis.

Three years distinctiveness analysis for *olitorius* varieties at Budbud showed that 3 more varieties viz. JRO 632, JRO 128 and Tanganyika 1 were distinct from other *olitorius* varieties (Table 2). Therefore, a total of 8 *olitorius* varieties were distinct from other *olitorius* varieties at CSRSJAF, Budbud location after 3 years of distinctiveness analysis.

Uniformity analysis for 2 years and 3 years of *olitorius* varieties at CSRSJAF, Budbud location showed that 5 varieties viz. JRO 3690, TJ 40, Sudan Green, Bidhan Rupali and JRO 36E were

Table 1. Variety means over 2/3 years distinctiveness for five quantitative traits of *C. olitorius* at CSRSJAF, Budbud

Variety	Leaf angle		Time of 50% flowering		Plant height (cm)		Days to maturity		1000 seed weight (g)	
	2 yrs	3 yrs	2 yrs	3 yrs	2 yrs	3 yrs	2 yrs	3 yrs	2 yrs	3 yrs
1. JRO 632	61.2	62.7	137.7	139.4	329.6	325.7	146.5	147.1	2.09	2.09
2. JRO 3690	63.6	64.5	138.5	140.2	326.8	326.1	148.0	148.9	1.85	1.85
3. KOM 62	69.1	69.3	134.2	137.1	340.9	328.6	145.2	146.2	1.93	1.93
4. TJ 40	70.6	72.0	129.7	132.1	438.0	439.9	141.5	141.4	1.82	1.83
5. JRO 66	65.9	66.3	136.0	138.8	391.0	360.5	143.8	146.7	1.92	1.91
6. JRO 524	59.8	61.4	143.2	145.8	325.0	323.7	155.7	156.4	1.85	1.85
7. JRO 7835	62.9	62.8	152.0	150.0	357.3	352.0	166.5	164.0	1.86	1.86
8. JRO 878	64.1	64.9	144.2	145.3	359.2	353.1	156.5	156.8	1.85	1.85
9. JRO 8432	63.5	63.6	139.8	141.1	361.3	354.7	148.3	150.0	1.84	1.84
10. JRO 128	63.7	63.6	141.3	141.3	361.9	352.7	150.2	150.4	2.07	2.06
11. JRO 620	66.0	66.5	124.5	126.9	316.9	318.4	135.5	139.3	1.88	1.88
12. Chinsurah Green	67.7	68.0	101.7	109.7	228.0	239.5	131.0	135.4	2.18	2.19
13. Sudan Green	67.4	67.7	113.5	117.7	267.4	268.1	124.0	126.1	2.14	2.13
14. Tanganyika 1	63.3	64.6	115.0	120.3	279.4	279.5	128.2	132.8	1.91	1.91
15. Bidhan Rupali	64.4	64.8	139.7	140.7	441.3	440.4	149.0	151.7	1.87	1.87
16. JRO 36E	69.6	69.5	155.2	154.1	414.4	415.2	165.2	164.8	1.79	1.79
YEAR MS	75.3	89.7	176.0	755.4	4924.9	4519.1	60.2	330.5	0.00	0.00
VARIETY MS	55.8	75.3	221.0	1300.0	20620.2	28150.6	876.1	1017.8	0.09	0.13
VAR. YEAR MS	67.7	37.2	204.8	101.7	1980.0	1714.3	99.1	82.1	0.00	0.00
F1 RATIO	0.8	2.0	6.0	12.8	10.4	16.4	8.8	12.4	205.17	291.69
VAR. REP MS	0.6	0.4	0.8	0.9	22.5	19.4	1.5	1.4	0.00	0.00
F2 RATIO	122.0	96.4	255.2	112.5	87.9	88.6	67.5	60.7	2.20	2.52
BETWEEN SE	3.4	2.0	5.8	3.4	18.2	13.8	4.1	3.0	0.01	0.01
WITHIN SE	0.3	0.2	0.4	0.3	1.9	1.5	0.5	0.4	0.01	0.00
MJRA SLOPE (Yr 1)	1.6	1.7	0.7	0.9	0.9	1.0	0.9	1.0	0.97	0.98
MJRA SLOPE (Yr 2)	-0.2	0.1	1.3	1.5	1.1	1.1	1.1	1.3	1.03	1.05
MJRA SLOPE (Yr 3)	NA	0.7	NA	0.6	NA	0.9	NA	0.7	NA	0.98
REGR F VAL	8.5	3.3	7.5	11.1	0.9	0.7	1.9	5.2	4.47	2.50
REGR PROB	1.2	5.4	1.6	0.0	36.4	52.2	19.6	1.2	5.29	9.99
Test	COY	COY	COY	MJR	COY	COY	COY	COY	COY	COY

Table 2. Summary for COYD criterion for distinctiveness for *C. olitorius* at CSRSJAF, Budbud location at 1.0% level using MJRA when regression significant at 1 per cent level

## A. 2 years distinctiveness

Candidate varieties	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1 JRO 632	-	D	D	D	D	D	D	D	D	ND	D	D	D	D	D	D
2 JRO 3690	D	-	D	D	D	ND	D	ND	ND	D	ND	D	D	D	D	D
3 KOM 62	D	D	-	D	ND	D	D	D	D	D	D	D	D	D	D	D
4 TJ 40	D	D	D	-	D	D	D	D	D	D	D	D	D	D	D	D
5 JRO 66	D	D	ND	D	-	D	D	D	D	D	D	D	D	D	D	D
6 JRO 524	D	ND	D	D	D	-	ND	ND	ND	D	D	D	D	D	D	D
7 JRO 7835	D	D	D	D	D	ND	-	ND	D	D	D	D	D	D	D	D
8 JRO 878	D	ND	D	D	D	ND	ND	-	ND	D	D	D	D	D	D	D
9 JRO 8432	D	ND	D	D	D	ND	D	ND	-	D	D	D	D	D	D	D
10 JRO 128	ND	D	D	D	D	D	D	D	D	-	D	D	D	D	D	D
11 JRO 620	D	ND	D	D	D	D	D	D	D	D	-	D	D	ND	D	D
12 Chinsurah Green	D	D	D	D	D	D	D	D	D	D	D	-	D	D	D	D
13 Sudan Green	D	D	D	D	D	D	D	D	D	D	D	D	-	D	D	D
14 Tanganyika 1	D	D	D	D	D	D	D	D	D	D	ND	D	D	-	D	D
15 Bidhan Rupali	D	D	D	D	D	D	D	D	D	D	D	D	D	D	-	D
16 JRO 36E	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	-
No of ND varieties	1	4	1	0	1	4	2	4	3	1	2	0	0	1	0	0
Overall distinctiveness	ND	ND	ND	D	ND	ND	ND	ND	ND	ND	ND	D	D	ND	D	D
Candidate varieties	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

## B. 3 years distinctiveness\*

Overall distinctiveness D ND ND ND ND ND ND ND D ND D

Candidate varieties 1 2 3 5 6 7 8 9 10 11 14

\*In 3 years analysis only those varieties which are not distinct in 2 years have been considered

uniform for the traits leaf angle, plant height and 1000 seed weight (Table 3).

Therefore, it can be concluded that 4 varieties, TJ 40, Chinsurah Green, Bidhan Rupaii and JRO 36E, were distinct and uniform at CSRSJAF, Budbud location based on 2 and 3 years analysis.

Variety means over both 2 and 3 years distinctiveness analysis of *olitorius* varieties for the traits studied at CRIJAF, Barrackpore location (Table 4) recorded highest leaf angle for the

variety JRO 36 E, maximum plant height for the variety JRO 66, and maximum weight of 1000 seeds for the variety Chinsurah Green. On the other hand 2 years analysis exhibited minimum number of days to 50 per cent of flowering and days to maturity for JRO 632 and JRO 620, respectively, while the reverse condition was noted in 3 years analysis. As there was no significant regression F value at  $P \leq 1\%$ , COY was adopted for all the 5 descriptors.

Table 3. 2/3 years uniformity at CSRSJAF, Budbud

Variety	Leaf angle		Plant height (cm)		1000 seed weight (g)							
	2Yr	3Yr	2Yr	3Yr	2Yr	3 Yr						
<i>C. olitorius</i>												
1. JRO 632	95	97	89	91	112	1	108	1				
2. JRO 3690	100	100	102	98	101		106					
3. KOM 62	102	101	90	1	92	1	112		113			
4. TJ 40	99	100	109		109		106		110			
5. JRO 66	109	1	103	1	102		106	1	77	80		
6. JRO 524	111	1	109	1	94		101	1	97	99		
7. JRO 7835	96		96		111	1	112	1	82	82		
8. JRO 878	95		95		109	1	113	2	89	92		
9. JRO 8432	90		90		116	1	115	1	109	100		
10. JRO 128	96		100	1	108	1	103	1	164	2	153	*3
11. JRO 620	99		101		97	1	89	1	114	1	108	1
12. Chinsurah Green	121	1	114	1	100	1	108	2	86		82	
13. Sudan Green	95		96		92		91		80		89	
14. Tanganyika 1	109	1	110	1	110	1	101	1	79		84	
15. Bidhan Rupali	89		93		97		97		95		98	
16. JRO 36E	94		95		71		73		96		95	
<i>C. capsularis</i>												
17. JRC212	96		95		100	1	102	2	95	1	99	1
18. JRC 7447	97		98		104		96		123	2	119	2
19. JRC 321	105		109	1	90		86		108		109	
20. Padma	108		100		99		107	1	103		96	
21. JRC 4444	97		97		104	1	106	1	103		95	
22. UPC94	104		105	1	108	1	107	1	105		104	
23. JRC 698	105		107	1	101		103		103		100	
24. Bidhan Pat 1	94		96		97		91		88		108	1
25. Bidhan Pat 2	96		98		112	1	100	1	100		94	
26. Bidhan Pat 3	101		98		99		104	1	85		91	
27. D 154	97	1	97	1	88		97	1	86	1	84	1

\* - SD exceeds over-years criterion after 3 years with probability 0.0100

: - SD not yet acceptable after 2 years with probability 0.0500

1,2,3 - the number of occasions the within-years SD exceeds the UPOV criterion

Table 4. Variety means over 2/3 years distinctiveness for five quantitative traits of *C. olitorius* at CRIJAF, Barrackpore

Variety	Leaf angle		Time of 50% flowering		Plant height (cm)		Days to maturity		1000 seed weight (g)	
	2 yrs	3 yrs	2 yrs	3 yrs	2 yrs	3 yrs	2 yrs	3 yrs	2 yrs	3 yrs
1 JRO 632	65.8	66.9	110.0	110.3	318.9	337.2	129.0	128.0	2.09	2.09
2 JRO 3690	67.1	68.6	121.0	121.7	329.3	342.8	139.0	139.3	1.86	1.86
3 KOM 62	70.1	68.5	130.0	126.0	331.9	345.3	143.5	139.6	1.92	1.92
4 TJ 40	68.4	71.4	131.0	131.7	438.6	436.5	146.5	146.7	1.81	1.83
5 JRO 66	61.1	64.6	136.3	136.4	443.6	439.1	146.8	147.4	1.93	1.92
6 JRO 524	63.7	68.6	147.0	143.8	372.5	382.3	158.0	155.3	1.85	1.86
7 JRO 7835	60.0	59.8	158.0	158.0	411.2	412.6	169.5	169.4	1.85	1.86
8 JRO 878	70.0	69.8	141.5	142.4	391.9	405.6	156.5	156.7	1.85	1.85
9 JRO 8432	66.0	64.8	149.7	149.7	381.3	387.5	160.2	161.0	1.84	1.87
10 JRO 128	62.7	67.1	160.0	160.3	378.5	384.9	170.5	171.2	2.05	2.02
11 JRO 620	69.4	69.2	110.7	116.7	318.4	343.9	125.5	131.1	1.90	1.92
12 Chinsurah Green	68.4	68.4	111.8	111.9	270.5	306.1	129.3	129.6	2.18	2.16
13 Sudan Green	71.3	71.1	113.0	102.1	271.5	309.0	129.7	130.1	2.13	2.12
14 Tanganyika 1	72.5	73.3	113.2	113.1	284.5	319.0	131.0	131.1	1.92	1.92
15 Bidhan Rupali	68.2	69.8	154.8	155.2	440.3	437.8	167.8	168.2	1.89	1.90
16 JRO 36E	74.6	74.3	156.5	156.2	409.1	411.0	167.0	167.0	1.78	1.81
YEAR MS	473.0	397.7	12.8	51.4	428.9	24747.2	1.8	3.0	0.00	0.00
VARIETY MS	100.0	111.2	2139.7	3391.1	21300.3	18961.5	1595.4	2307.2	0.09	0.11
VAR. YEAR MS	88.5	79.1	41.8	127.8	1459.4	2672.9	36.8	52.6	0.00	0.00
F1 Ratio	1.1	1.4	51.2	26.5	14.6	7.1	43.4	43.8	164.01	59.77
Var. Rep MS	0.3	1.6	1.4	43.0	200.5	160.6	1.6	1.5	0.00	0.00
F2 Ratio	348.5	49.4	31.0	3.0	7.3	16.6	22.4	34.9	1.46	1.71
Between SE	3.8	3.0	2.6	3.8	15.6	17.2	2.5	2.4	0.01	0.01
Within SE	0.2	0.4	0.5	2.2	5.8	4.2	0.5	0.4	0.01	0.01
MJRA slope (Yr 1)	0.3	0.6	1.0	1.0	0.9	1.2	1.0	1.0	0.98	1.08
MJRA slope (Yr 2)	1.4	1.5	1.0	1.0	1.1	1.4	1.0	1.0	1.02	1.13
MJRA slope (Yr 3)	NA	0.6	NA	1.1	NA	0.4	NA	1.0	NA	0.79
REGR F VAL	1.9	0.2	0.2	0.8	1.3	8.9	0.1	0.1	1.22	9.51
REGR PROB	19.3	78.7	66.4	47.7	27.7	0.1	83.5	92.3	28.74	0.07
Test	COY	COY	COY	COY	COY	MJR	COY	COY	COY	MJR

At CRIJAF, Barrackpore location 2 years distinctiveness analysis for *olitorius* varieties revealed that 6 varieties viz. JRO 3690, KOM 62, JRO 66, JRO 128, Chinsurah Green and JRO 36E were quite distinct from all other *olitorius* varieties (Table 5). The remaining ten varieties were non-distinct from 1 or more *olitorius* varieties. These ten non-distinct varieties at CRIJAF, Barrackpore location were further analysed for 3 years distinctiveness test.

Three years distinctiveness test of *olitorius* varieties at CRIJAF, Barrackpore location showed that no variety was distinct at this location (Table 5). Therefore, no additional distinctiveness could be achieved from 3 years distinctiveness analysis.

At CRIJAF, Barrackpore location 2 years uniformity analysis of *olitorius* varieties exhibited that 7 varieties viz. JRO 632, JRO 3690, JRO 524, JRO 878, Chinsurah Green, Tanganyika 1 and JRO 36E were uniform for all the characters (Table 6). On the other hand, 3 years uniformity analysis revealed that 4 varieties (JRO 524, Chinsurah Green, Tanganyika 1 and JRO 36 E) were uniform. These 4 varieties were also exhibited their uniformity in 2 years uniformity analysis. Therefore, there was no extra benefit for conducting 3 years uniformity analysis.

Distinctiveness and uniformity analysis for *olitorius* varieties at CRIJAF, Barrackpore location revealed that 3 varieties viz. JRO 3690, Chinsurah Green and JRO 36 E were distinct and uniform.

Variety means over both 2 and 3 years distinctiveness analysis of *capsularis* varieties at CSRSJAF, Budbud location showed that variety JRC 321 recorded least number of days to 50 per cent flowering and days to maturity as compared to other varieties (Table 7). In both cases highest plant height was recorded for the variety JRC 321, while highest value for 1000 seed weight was recorded for the variety UPC 94. Interestingly, in 2 years analysis variety JRC 321 recorded highest leaf angle, whereas it was variety D-154 in 3 years analysis. As there was no significant regression F value at  $P \leq 1$  per cent, COY was adopted for all the 5 descriptors.

Two years distinctiveness analysis for *capsularis* varieties at CSRSJAF, Budbud location revealed that only variety UPC 94 was distinct from the other *capsularis* varieties (Table 8).

Three years distinctiveness analysis of *capsularis* varieties at CSRSJAF, Budbud location revealed that only 1 variety, JRC 321, was distinct from all *capsularis* varieties (Table 8). But the remaining varieties were non-distinct from other varieties. Therefore, only 2 varieties were distinct from other *capsularis* varieties after 3 years distinctiveness analysis.

Two years uniformity analysis of *capsularis* varieties at, CSRSJAF, Budbud location showed that 5 varieties viz. JRC 321, Padma, JRC 698, Bidhan Pat 1 and Bidhan Pat 3 were uniform for the traits leaf angle, plant height and 1000-seed weight (Table 3). But not a single variety appeared uniform in 3 years uniformity analysis at this location.

Therefore, the distinctiveness and uniformity study for *capsularis* varieties at Budbud location showed that only variety JRC 321 was distinct and uniform.

Variety means over 2 years distinctiveness analysis of *capsularis* varieties at CRIJAF, Barrackpore location showed that variety JRC 321 exhibited minimum number of days to 50 per cent flowering and days to maturity, while highest leaf angle, plant height and 1000 seed weight was observed in varieties JRC 7447, JRC 4444 and UPC 94 respectively (Table 9). MJRA was used for leaf angle as significant regression F value at  $P \leq 1\%$  was observed.

At CRIJAF, Barrackpore location 2 years distinctiveness analysis for *capsularis* varieties revealed that all varieties were distinct (Table 10). Therefore, 3 years analysis for distinctiveness of *capsularis* was not required.

At CRIJAF, Barrackpore location 2 years uniformity analysis for *capsularis* varieties showed 6 varieties viz. JRC 212, JRC 7447, JRC 321, JRC 4444, UPC 94 and Bidhan Pat 2 were uniform for all the traits (Table 6). Three years uniformity analysis revealed that 4 varieties viz. JRC 212, JRC 321, UPC 94 and Bidhan Pat 2 were uniform.

Table 5. Summary for COYD criterion for distinctiveness of *C. olitorius* at CRIJAF, Barrackpore at 1.0% level using MJRA when regression significant at 1 per cent level

## A. 2 years distinctiveness

Candidate varieties	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1 JRO 632	-	D	D	D	D	D	D	D	D	D	D	D	ND	D	D	D
2 JRO 3690	D	-	D	D	D	D	D	D	D	D	D	D	D	D	D	D
3 KOM 62	D	D	-	D	D	D	D	D	D	D	D	D	D	D	D	D
4 TJ 40	D	D	D	-	D	D	D	ND	D	D	D	D	D	D	D	D
5 JRO 66	D	D	D	D	-	D	D	D	D	D	D	D	D	D	D	D
6 JRO 524	D	D	D	D	D	-	D	ND	ND	D	D	D	D	D	D	D
7 JRO 7835	D	D	D	D	D	D	-	D	ND	D	D	D	D	D	ND	D
8 JRO 878	D	D	D	ND	D	ND	D	-	ND	D	D	D	D	D	D	D
9 JRO 8432	D	D	D	D	D	ND	ND	ND	-	D	D	D	D	D	D	D
10 JRO 128	D	D	D	D	D	D	D	D	D	-	D	D	D	D	D	D
11 JRO 620	D	D	D	D	D	D	D	D	D	D	-	D	D	ND	D	D
12 Chinsurah Green	D	D	D	D	D	D	D	D	D	D	D	-	D	D	D	D
13 Sudan Green	ND	D	D	D	D	D	D	D	D	D	D	D	-	D	D	D
14 Tanganyika 1	D	D	D	D	D	D	D	D	D	D	ND	D	D	-	D	D
15 Bidhan Rupali	D	D	D	D	D	D	ND	D	D	D	D	D	D	D	D	-
16 JRO 36E	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	-
No of ND varieties	1	0	0	1	0	2	2	3	3	0	1	0	1	1	1	0
Overall distinctiveness	ND	D	D	ND	D	ND	ND	ND	ND	D	ND	D	ND	ND	ND	D

## B. 3 years distinctiveness\*

Overall distinctiveness	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Candidate varieties	1	4	6	7	8	9	11	13	14	15						

\*In 3 years analysis only those varieties which are not distinct in 2 years have been considered

But these varieties were common in 2 years uniformity analysis. Therefore, there was no extra benefit for conducting 3 years analysis.

At CRIJAF, Barrackpore location the analysis for distinctiveness and uniformity of *capsularis* varieties revealed that 6 varieties viz. JRC 212, JRC 7447, JRC 321, JRC 4444, UPC 94 and Bidhan Pat 2 were distinct and uniform.

On the basis of 16 qualitative morphological

characteristics Kumar *et al.* [3] could establish distinctiveness of 5 *olitorius* varieties viz. Bidhan Rupali, JRO 878, Chinsurah Green, JRO 66, JRO 7835 and JRO 36E and 2 *capsularis* varieties viz. Padma and D 154; and the remaining varieties could be classified into 2 or more groups. In the present study on the basis of 2 years DUS trial analysis of 5 quantitative characters using DUST software distinctiveness was shown by 5 *olitorius* varieties (TJ 40,

Table 6. 2/3 years uniformity at CRIJAF, Barrackpore

Variety	Leaf angle		Plant height (cm)			1000 seed weight (g)			
	2Yr	3Yr	2Yr	3Yr	2Yr	3 Yr			
<i>C. olitorius</i>									
1. JRO 632	92	91	92	108	1	91	100	1	
2. JRO 3690	95	99	1 102	100		99	96		
3. KOM 62	96	100	91	101	1	120	1 112	1	
4. TJ 40	101	102	104	1 102	1	111	106		
5. JRO 66	97	101	1 114	2 108	2	105	1 99	1	
6. JRO 524	98	99	101	92		95	94		
7. JRO 7835	95	95	125	:2 126	3	95	102		
8. JRO 878	100	97	92	97	1	94	95		
9. JRO 8432	102	1 101	1 100	1 115	2	105	116	1	
10. JRO 128	106	102	109	1 95	1	111	115	1	
11. JRO 620	108	1 106	1 111	102		125	1 96	1	
12. Chinsurah Green	96	95	98	95		98	97		
13. Sudan Green	108	1 107	1 101	101		91	93		
14. Tanganyika 1	96	99	98	92		78	83		
15. Bidhan Rupali	110	:1 106	1 87	92		94	92		
16. JRO 36E	101	103	74	74		87	96		
<i>C. capsularis</i>									
17. JRC 212	96	97	97	97		105	106		
18. JRC 7447	99	106	1 99	94		119	100		
19. JRC 321	104	106	95	96		95	105		
20. Padma	95	94	108	1 105	1	82	88		
21. JRC 4444	104	103	84	94	1	88	98		
22. UPC 94	105	104	80	83		98	93		
23. JRC 698	89	90	116	1 113	2	91	107		
24. Bidhan Pat 1	99	98	124	2 110	2	109	99		
25. Bidhan Pat 2	101	97	89	88		115	111		
26. Bidhan Pat 3	97	1 101	1 92	103	1	109	98		
27. D 154	111	1 104	1 116	1 116	1	89	95	1	

Symbols : - SD not yet acceptable after 2 years with probability 0.0500

1,2,3 - the number of occasions the within-years SD exceeds the UPOV criterion

Table 7. Variety means over 2/3 years distinctiveness for five quantitative traits of *C. capsularis* at CSRSJAF, Budbud

Variety	Leaf angle		Time of 50% flowering		Plant height (cm)		Days to maturity		1000 seed weight (g)	
	2 yrs	3 yrs	2 yrs	3 yrs	2 yrs	3 yrs	2 yrs	3 yrs	2 yrs	3 yrs
17 JRC 212	63.7	64.9	117.7	127.1	241.5	213.8	127.8	136.9	3.40	3.41
18 JRC 7447	65.3	67.0	128.0	124.0	304.9	307.7	137.5	134.7	3.39	3.40
19 JRC 321	69.1	67.6	90.7	90.1	306.0	301.2	101.7	100.8	3.71	3.73
20 Padma	66.9	61.0	124.5	118.3	307.4	309.5	134.2	127.9	3.57	3.57
21 JRC 4444	68.2	67.0	132.0	130.7	317.0	327.7	143.0	141.3	3.53	3.48
22 UPC 94	55.3	54.4	96.7	96.4	297.7	301.3	106.7	106.6	3.80	3.80
23 JRC 698	64.7	59.6	116.0	115.7	315.6	326.8	127.7	126.8	3.44	3.44
24 Bidhan Pat 1	66.1	67.2	103.8	103.2	299.0	308.0	116.3	116.9	3.44	3.40
25 Bidhan Pat 2	63.6	65.5	91.7	92.6	258.6	301.0	109.0	109.8	3.54	3.49
26 Bidhan Pat 3	66.0	66.8	109.0	109.6	295.2	304.4	122.0	123.4	3.53	3.53
27 D 154	68.0	68.5	120.8	123.4	243.4	242.3	133.8	135.8	3.41	3.40
Year MS	69.6	77.1	23.1	11.6	35761.0	20589.3	7.3	4.6	0.00	0.01
Variety MS	83.1	171.7	1270.6	1878.7	4708.4	10489.1	1113.8	1653.7	0.10	0.17
Var. year MS	44.2	85.3	552.5	414.7	4295.0	1782.7	460.5	356.7	0.01	0.01
F1 Ratio	1.9	2.0	2.3	4.5	1.1	5.9	2.4	4.6	15.03	18.50
Var. Rep MS	0.6	0.4	0.8	0.9	22.5	19.4	1.5	1.4	0.00	0.00
F2 Ratio	79.8	221.4	688.6	459.0	190.7	92.2	313.6	263.7	34.20	51.88
Between SE	2.7	3.1	9.6	6.8	26.8	14.1	8.8	6.3	0.03	0.03
Within SE	0.3	0.2	0.4	0.3	1.9	1.5	0.5	0.4	0.01	0.00
MJRA slope (Yr 1)	0.5	0.2	0.8	1.0	0.1	0.2	0.8	1.1	0.96	0.90
MJRA slope (Yr 2)	1.4	0.6	1.2	0.9	1.5	1.3	1.2	0.8	1.04	0.95
MJRA slope (Yr 3)	NA	1.8	NA	1.1	NA	1.4	NA	1.1	NA	1.15
REGR F VAL	2.3	5.2	0.8	0.1	4.1	7.5	0.5	0.2	0.20	0.99
REGR PROB	16.2	64.9	40.7	127.1	7.4	213.8	48.1	136.9	66.35	3.41
Test	COY	COY	COY	COY	COY	MJR	COY	COY	COY	COY

Table 8. Summary for COYD criterion at 1.0 per cent level using MJRA when regression significant at 1% level of *C. capsularis* at Budbud

A. 2 years distinctiveness

Candidate varieties	17	18	19	20	21	22	23	24	25	26	27
17 JRC 212	-	ND	D	D	ND	D	ND	ND	ND	ND	ND
18 JRC 7447	ND	-	D	D	ND	D	ND	ND	ND	ND	ND
19 JRC 321	D	D	-	ND	D	D	D	D	D	D	D
20 Padma	D	D	ND	-	ND	D	ND	ND	ND	ND	D
21 JRC 4444	ND	ND	D	ND	-	D	ND	ND	ND	ND	ND
22 UPC 94	D	D	D	D	D	-	D	D	D	D	D
23 JRC 698	ND	ND	D	ND	ND	D	-	ND	ND	ND	ND
24 Bidhan Pat 1	ND	ND	D	ND	ND	D	ND	-	ND	ND	ND
25 Bidhan Pat 2	ND	ND	D	ND	ND	D	ND	ND	-	ND	ND
26 Bidhan Pat 3	ND	ND	D	ND	ND	D	ND	ND	ND	-	ND
27 D 154	ND	ND	D	D	ND	D	ND	ND	ND	-	ND
No. of ND varieties	7	7	1	6	8	0	8	8	8	8	7
Overall distinctiveness	ND	ND	ND	ND	ND	D	ND	ND	ND	ND	ND
Candidate varieties	17	18	19	20	21	22	23	24	25	26	27

B. 3 years distinctiveness\*

Overall distinctiveness	ND	ND	D	ND	ND	ND	ND	ND	ND	ND
Candidate varieties	17	18	19	20	21	23	24	25	26	27

\*In 3 years analysis only those varieties which are not distinct in 2 years have been considered

Chinsurah Green, Sudan Green, Bidhan Rupali and JRO 36E) at CSRSJAF, Budbud location and by 6 *olitorius* varieties (JRO 3690, KOM 62, JRO 66, JRO 128, Chinsurah Green and JRO 36E) at CRIJAF, Barackpore location whereas in 3 years DUS trial analysis distinctiveness was shown by only 3 *olitorius* varieties (JRO 632, JRO 128 and Tanganyika 1) at CSRSJAF, Budbud location but no variety was distinct at CRIJAF, Barrackpore location. The result indicated that 2 years' DUS trial data were sufficient to establish distinctiveness of *olitorius* varieties for quantitative characters.

COYU analysis of both 2 years' and 3 years' data of CSRSJAF, Budbud, uniformity was shown by 5 *olitorius* varieties (JRO 3690, TJ 40, Sudan

Green, Bidhan Rupali and JRO 36E). At CRIJAF, Barrackpore location uniformity analysis of 2 years' data revealed that 7 *olitorius* varieties (JRO 632, JRO 3690, JRO 524, JRO 878, Chinsurah Green, Tanganyika 1 and JRO 36E) were uniform whereas in 3 years' data analysis 4 *olitorius* varieties (JRO 524, Chinsurah Green, Tanganyika 1 and JRO 36E) were uniform.

When distinctiveness and uniformity were considered together 3 *olitorius* varieties (JRO 3690, Chinsurah Green and JRO 36E) at CRIJAF, Barackpore location and 4 varieties (TJ 40, Chinsurah Green, Bidhan Rupali and JRO 36E) at CSRSJAF, Budbud location were distinct and uniform.

Table 9. Variety means over two years distinctiveness for five quantitative traits of *C. Capsularis* at CRIJAF, Barrackpore

Variety	Leaf weight (g)	Time of angle	Plant 50% flowering	Days to height (cm)	1000 seed maturity
17 JRC 212	64.6	94.5	226.4	105.7	3.4
18 JRC 7447	70.9	115.8	323.0	128.8	3.4
19 JRC 321	64.8	89.0	316.1	100.0	3.7
20 Padma	65.8	106.0	323.5	116.7	3.6
21 JRC 4444	63.4	128.0	354.3	139.5	3.5
22 UPC 94	63.9	99.2	319.9	108.2	3.8
23 JRC 698	49.8	115.5	340.6	128.2	3.4
24 Bidhan Pat 1	51.5	102.2	322.3	117.2	3.4
25 Bidhan Pat 2	64.9	94.7	319.1	109.7	3.5
26 Bidhan Pat 3	62.6	111.0	322.1	127.5	3.5
27 D 154	55.4	114.3	273.3	131.7	3.5
Year MS	5760.5	33.5	18.4	0.2	0.0
Variety MS	195.6	824.9	7207.7	950.6	0.1
Var. Year MS	160.0	4.9	14.2	7.4	0.0
F1 Ratio	1.2	169.4	506.4	128.3	49.5
Var. Rep MS	0.3	1.4	200.5	1.6	0.0
F2 Ratio	630.3	3.6	0.1	4.5	4.8
Between SE	5.2	0.9	1.5	1.1	0.0
Within SE	0.2	0.5	5.8	0.5	0.0
MJRA slope (Yr 1)	-0.5	1.0	1.0	1.0	1.0
MJRA slope (Yr 2)	1.6	1.0	1.0	1.0	1.0
REGR F VAL	10.8	0.4	4.0	0.2	0.3
REGR PROB	0.9	56.4	7.7	66.6	57.2
Test	MJR	COY	COY	COY	COY

In case of *capsularis* varieties only UPC 94 was distinct using COYD analysis for 2 years data of CSRSJAF, Budbud location and only JRC 321 was distinct for 3 years' data of the same location whereas all *capsularis* varieties were distinct in COYD analysis for 2 years at CRIJAF, Barrackpore location.

COYU analysis of 2 years' data revealed that 5 *capsularis* varieties (JRC 321, Padma, JRC 698, Bidhan Pat 1 and Bidhan Pat 3) were uniform at CSRSJAF, Budbud location and 6 varieties (JRC 212, JRC 7447, JRC 321, JRC 4444, UPC 94 and

Bidhan Pat 2) were uniform at CRIJAF, Barackpore location. But COYU analysis for 3 years data revealed that no variety was uniform at CSRSJAF, Budbud and 4 varieties (JRC 212, JRC 321, UPC 94 and Bidhan Pat 2) were uniform at CRIJAF, Barrackpore location.

When distinctiveness and uniformity were considered together 6 *capsularis* varieties (JRC 212, JRC 7447, JRC 321, JRC 4444, UPC 94 and Bidhan Pat 2) were distinct and uniform at CRIJAF, Barrackpore location and only 1 variety, JRC 321, was distinct and uniform at CSRSJAF, Budbud location.

Table 10. Summary for COYD criterion for two years distinctiveness of *C. capsularis* at CRIJAF, Barrackpore at 1.0 per cent level using MJRA when regression significant at 1 per cent level

A. 2 years distinctiveness

Candidate varieties	17	18	19	20	21	22	23	24	25	26	27
17 JRC 212	-	D	D	D	D	D	D	D	D	D	D
18 JRC 7447	D	-	D	D	D	D	D	D	D	D	D
19 JRC 321	D	D	-	D	D	D	D	D	D	D	D
20 Padma	D	D	D	-	D	D	D	D	D	D	D
21 JRC 4444	D	D	D	D	-	D	D	D	D	D	D
22 UPC 94	D	D	D	D	D	-	D	D	D	D	D
23 JRC 698	D	D	D	D	D	D	-	D	D	D	D
24 Bidhan Pat 1	D	D	D	D	D	D	D	-	D	D	D
25 Bidhan Pat 2	D	D	D	D	D	D	D	D	-	D	D
26 Bidhan Pat 3	D	D	D	D	D	D	D	D	D	-	D
27 D 154	D	D	D	D	D	D	D	D	D	D	-
No. of ND varieties	0	0	0	0	0	0	0	0	0	0	0
Overall distinctiveness	D	D	D	D	D	D	D	D	D	D	D
Candidate varieties	17	18	19	20	21	22	23	24	25	26	27

B. 3 years distinctiveness is not required as all the varieties were distinct based on 2 years analysis

We also conclude that the trials should be conducted for 3 years as there is additional gain for the determination of distinctiveness and uniformity.

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