RESEARCH ARTICLE

SABRAO Journal
of Breeding and Genetics
48 (4) 391-401, 2016

GENETIC ANALYSIS OF MORPHOLOGICAL AND PHYSIOLOGICAL TRAITS IN INDIAN MUSTARD (*Brassica juncea* L.)

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SUMMARY

Eighty advanced progenies along with four check varieties of Indian mustard (*Brassica juncea* L. Czern and Coss) were evaluated in an augmented block design with five blocks during *rabi* 2014-15. Analysis of variance indicated significant variability among progenies for most of the characters studied except primary branches per plant. Estimate of high GCV and PCV (>30%) were observed for seed yield per plant, harvest index and water use efficiency. Hence, direct selection of these traits will prove effective. The estimates of moderate heritability were (>50%) for all the characters studied. The genetic advance ranged from 88.0% (water use efficiency) to 6.1% (low oil content). The genetic advance expressed as percentage of mean was high (>30%) for secondary branches per plant (66.2%), siliquae per plant (48.8%), seed yield per plant (57.2%), dry weight (42.3%), relative water content (36.0%), water use efficiency (88.0%). The seed yield per plant had positive and significant correlation with plant height (0.38**), primary branches per plant (0.48**), fruiting zone length (0.54**), siliquae per plant (0.58**), main shoot length (0.37**) and siliquae on main shoot (0.28**). However, with flowering time, maturity, secondary branches per plant, siliqua length positive but non-significant association was observed.

Key words: *Brassica*, Genetic variability, genetic advance, heritability, genotypic correlation, grain yield

Key findings: Morphological and physiological characters confer the potentiality of particular genotype and association with yield is necessary for suitable genotype selection.

Manuscript received: November 13, 2015; Decision on manuscript: August 13, 2016; Manuscript accepted: October 8, 2016.

Communicating Editor: Bertrand Collard

INTRODUCTION

The genus *Brassica* is an important member of the family Brassicaceae. Oilseed Brassicas, commonly known as rapeseed and mustard occupy an important position in rainfed agriculture of India. They are grown as a pure or a mixed crop culture during *rabi* and often grown under rainfed condition with low inputs. Central Asia-Himalayas is a primary center of diversity for this species with migration to China, India and Caucasus (Hemingway, 1976). It is highly polymorphic and includes both leafy and oileferous varieties. In India, *Brassica juncea* is a predominant species which accounts for nearly 85% hectare of the oilseed Brassica

(Supriya*et al.*, 2014) and is mostly grown on light textured soils using water conserved from monsoon rains, it inevitably suffers from drought stress during its reproductive stage, when stored water becomes depleted (Kumar and Singh 1998). This calls for the development of highly water use efficient genotypes. The crop is largely self-pollinated with limited outcrossing ranging up to 10-18% of the seed set (Banga, 2008). Being native to India, it possesses vast genetic variability for seed and drought tolerance characteristics.

The genetic variability is the basic requirement for making progress in crop breeding. Hence, there is an ample scope for improving this important crop. It is of great importance and helps in categorising the various varieties into diverse groups and evaluate their genetic relatedness and evolutionary relationships with wild relatives which has significant impact for the improvement of crop plants (Chandra *et al*., 2013). Further, it may lead to detect changes in allele frequencies in genotypes or populations and to explore new alleles at loci of interest. The extent of variability existing in a crop is of great importance, since greater the genetic diversity, wider the scope for selection. The correlation coefficient is a measure of the degree of association between two traits worked at the same time (Steel and Torrie, 1984). Based upon genotypic and phenotypic correlations, the breeder would be able to decide the breeding method to be used to exploit the desirable and break the undesirable associations.

The identification of drought tolerant genotypes and also transfer of physiological traits responsible for drought tolerance in high yielding and agronomically superior cultivars is prerequisite. The information on the nature and magnitude of variability for different morpho-physiological traits is necessary to judge the potentiality of particular genotype. Furthermore, the information on the association of different morpho-physiological traits with each other and with seed yield is necessary for formulation of suitable selection criteria.

MATERIALS AND METHODS

Experimental sites, plant materials, experimental design and year of experiment

Eighty advanced progenies of Indian mustard (F_6) derived from different crosses were evaluated in an augmented block design at ICAR- Directorate of Rapeseed-Mustard Research (77 27^o E, 27 12^o N, 178.37 m above sea level), Sewar, Bharatpur (Rajasthan) during *rabi* 2014-15. The material was divided into five blocks, each block consisted 16 progenies and 4 check varieties namely RB-50, RH-819, RGN-48, RGN-229 which were common to each block. In each block, progenies and check varieties were sown in three row plots of five meter length, spaced 30 cm apart with plant to plant distance of 10 cm.

Observations and evaluation

Observations were recorded for different morpho-physiological characters on 10 randomly selected plants. Plants were randomly selected from each plot to record the data on plant height, primary branches per plant, secondary branches per plant, fruiting zone length, main shoot length, siliquae per plant, siliquae number, siliquae length, seeds per siliqua, seed yield per plant, 1000-seed weight, oil content, dry weight, relative water content (RWC) and water use efficiency (WUE). Measurement for flowering time and maturity was done on row basis. RWC was estimated by using following formula:

$$\mathrm{RWC} = \frac{Fresh\ weight - Dry\ weight}{Turgid\ weight - Dry\ weight} \times 100$$

The WUE was estimated by the following formula:

$$\mathrm{WUE} = \frac{Seed\ yield\ \left(\frac{kg}{ha}\right)}{Water\ use\ (mm) or\ Evapo\ transpiration\ (ET)}$$

It gives the amount of economic yield obtained per unit of water use.

Statistical analysis

The mean data were subjected to analysis of variance as per standard procedure using Windostat software version 8.5. Genetic parameters were calculated as per standard procedure (Burton, 1952, Johnson *et al.*, 1955). Phenotypic and genotypic correlations were calculated as per method suggested by Al-Jibouri *et al.* (1958).

RESULTS AND DISCUSSION

Analysis of variance

In this study, an analysis of variance revealed (Table 1a and b) that the check varieties differed significantly for flowering time, maturity, plant height, primary branches per plant, secondary branches per plant, siliquae on main shoot, siliquae length, 1000-seed weight and dry weight. While differences for fruiting zone length, main shoot length, siliquae per plant, seeds per siliquae, seed yield, oil content, relative water content, and water use efficiency were found to be non-significant. Mean squares due to progenies were found to be significant for all characters except primary branches per plant. This indicates that material under study has adequate variability for most of the traits which may be exploited for further selection of improved genotypes. This also suggests that the material has adequate variability for these characters and response to selection may be expected in future breeding programme for seed yield.

Genetic parameters

Estimates of mean and range for all the characters exhibited wide range of variation (Table 2). Genotypic and phenotypic coefficients of variation (GCV and PCV) were moderate (11-30%) for fruiting zone length, siliquae per plant, main shoot length, siliquae on main shoot, siliquae length, 1000-seed weight, dry weight. Higher estimate of GCV and PCV (>30%) were observed for secondary branches per plant, seed yield per plant and water use efficiency. Whereas, low estimates (<10%) were obtained for rest of the characters *viz*; flowering time, maturity, plant height, seeds per siliqua, oil content and relative water content. Heritability estimates were high (>50%) for all the characters under study. The genetic advance expressed as percentage of mean was high (>30%) for secondary branches per plant, siliquae per plant, seed yield per plant, dry weight, relative water content, water use efficiency. Moderate (11-30%) genetic advance expressed as percentage of the mean was observed for flowering time, plant height, fruiting zone length, main shoot length, siliquae on main shoot, siliqua length, seeds per siliqua, 1000-seed weight while low genetic advance was recorded for maturity and oil content.

Phenotypic variance was generally higher than genotypic variances indicating role of environmental factors on character expression. The variances of various characters were compared on the basis of coefficient of variation. It was observed that secondary branches per plant followed by water use efficiency, seed yield per plant showed higher estimates of genotypic as well as phenotypic coefficient of variation as compared to other characters. This indicated that simple selection may be advantageous for seed yield as compared to the other traits. Earlier Patel *et al.* (2006), Mittal *et al.* (2007), Lodhi *et al.* (2014) and Akabari *et al.* (2015) made similar reports. The genotypic and phenotypic coefficient of variation was very low for oil content. This report is consistent with earlier report of Kumar and Singh (2013). Since, in augmented design only the error variance of check varieties could be subtracted from the variance of genotypes, a portion of it may be confounded with the genotypic variance used for calculating the heritability therefore, caution should be exercised in interpreting the estimates of heritability value as it represent only the upper limit of heritability. The estimates of heritability in this investigation were moderately high (>50%) for all the characters studied. Similar reports were also made by Mehmood *et al.* (2003), Shweta *et al.* (2013), Tihara *et al.* (2014). The genetic advance was highest for secondary branches per plant, water use efficiency, seed yield, and siliquae.

Table 1a. Mean squares and variances for morpho-physiological traits in Indian mustard.

Source of variation	df	Flowering time	Maturity	Plant height (cm)	Primary branches/ plant	Secondary branches/ plant	Fruiting zone length (cm)	Main shoot length (cm)	Siliquae per Plant	Siliquae on main shoot
Block (b-1)	4	9.2	5.3	367.6**	0.3	2.3*	120.1*	24.4	33887.0**	76.0**
Treatment [(c+g)-1]	83	39.1**	60.7**	307.6**	0.7*	2.9**	92.0*	82.9*	1656.3*	41.8*
Check (c-1)	3	515.3**	21.6**	277.0**	0.3*	2.9*	42.3	28.3	1269.5	16.2*
Progenies (g-1)	79	19.0**	52.2**	262.2**	0.5	3.0**	94.9*	78.7**	1664.8*	47.3*
Check V/s progenies	1	200.2**	846.8**	430.5**	16.4**	1.2*	13.2*	474.1**	2528.5	100.2*
Error (b-1)(c-1)	12	7.0	3.2	54.7	0.3	0.6	36.7	20.4	20.4	13.9
Genotypic Variance(Vg)		11.9	49.0	207.6	0.2	2.4	58.2	58.3	1644.4	33.4
Phenotypic Variance (Vp)		18.9	52.2	262.2	0.5	3.0	78.7	78.7	1664.8	47.3
ErrorVariance (Ve)		7.0	3.1	54.7	0.3	0.6	36.7	20.4	20.4	13.9

Table 1b. Mean squares and variances for morpho-physiological traits in Indian mustard.

Source of variation	df	Seeds per siliqua	Siliquae length (cm)	Seed yield (g)	1000 Seed wt. (g)	Oil content (%)	Dry weight (g)	Relative water content (%)	Water use efficiency (kg/ha/mm)
Block(b-1)	4	3.0**	0.1	10.2	0.8**	0.5**	0.50**	187.8**	300.1**
Treatment [(c+g)-1]	83	1.5**	0.7**	19.1**	1.1**	1.6**	0.04**	21.4**	126.8**
Check(c-1)	3	1.1	5.5**	6.6	1.6**	0.1	0.02*	10.8	21.3
Progenies (g-1)	79	1.5**	0.4**	19.6**	0.7**	1.7**	0.04*	21.7**	129.3**
Check V/s progenies	1	0.1	7.8**	19.5	29.5**	3.2**	0.01**	38.6**	246.4**
Error (b-1)(c-1)	12	0.3	0.1	5.6	0.1	0.1	0.01	6.7	17.6
Genotypic Variance (Vg)		1.2	0.4	14.0	0.7	1.6	0.03	14.8	111.7
Phenotypic Variance (Vp)		1.5	0.4	19.6	0.7	1.7	0.04	21.6	129.3
ErrorVariance (Ve)		0.3	0.1	5.6	0.1	0.1	0.01	6.7	17.6

Table 2. Overall mean value of progenies, their range, genotypic and phenotypic coefficients of variation, heritability in broad sense and genetic advance as percentage of mean for morpho-physiological traits in Indian mustard.

Characters	Mean	Range	Genotypic coefficient of variation (GCV)	Phenotypic coefficient of variation (PCV)	Heritability in broad sense (%)	Genetic advance as percentage of mean
Flowering time	51.0	42.6-61.7	6.8	8.5	62.8	10.9
Maturity	141.0	116.1-153.8	4.9	5.1	93.9	9.8
Plant height (cm)	164.4	124.8– 230.5	8.8	9.8	79.2	16.0
Primary branches/plant	4.4	3.1 – 6.2	*	*	*	*
Secondary branches /plant	4.3	0.9-9.3	36.1	40.3	80.3	66.2
Fruiting zone length (cm)	72.4	54.6-98.0	9.3	12.6	55.1	14.2
Main shoot length (cm)	65.09	41.0 – 85.6	11.8	13.7	74.0	20.8
Siliquae per plant	168.6	92.8 – 276.5	24.1	20.2	98.8	48.8
Siliquae on main shoot	41.1	20.3 – 61.6	14.1	16.7	70.6	24.1
Siliquae length (cm)	4.5	2.5-7.4	13.2	14.1	87.8	25.3
Seeds per siliqua	13.2	10.4 – 16.1	8.2	9.3	78.0	14.9
Seed yield/plant (g)	11.3	0.9-24.6	33.1	39.2	71.6	57.2
1000- seed weight (g)	5.7	3.7 – 7.7	14.3	15.1	90.5	27.9
Oil content (%)	40.4	30.3 – 42.0	3.1	3.2	92.9	6.1
Dry weight (g)	0.7	0.1 – 1.4	23.7	27.4	75.0	42.3
Relative water content (kg/ha/mm)	86.3	74.6-104.4	4.5	5.4	68.8	35.9
Water use efficiency (%)	22.9	1.3-65.4	46.1	49.6	86.4	87.9

* Mean sum squares due to progeny were non-significant.

The high genetic advance (>50%) for these traits was also reported by Shalini *et al.* (2000), Tihara *et al.* (2014) and Akabari *et al.* (2015). Moderate genetic advance expressed as percent of mean (21-50%) was observed for siliquae per plant followed by dry weight, relative water content, 1000-seed weight, siliquae length and siliquae on main shoot. Similar results of moderate genetic advance expressed as percent of mean has been reported by Shalini *et al.* (2000), Kumar and Singh (2013) for siliquae per plant, Srivastav and Singh (2007) for siliquae on main shoot. Low estimates (<20%) of expected genetic advance was observed for oil content, maturity, flowering time, fruiting zone length, seeds per siliqua and plant height. High heritability along with high genetic advance was found for secondary branches per plant, water use efficiency and seed yield per plant. Similar results of high heritability and high genetic advance for seed yield per plant were earlier reported by Das *et al.* (2001), Patel *et al.* (2006) and Srivastava and Singh (2007). This suggests that selection would be more effective in this material for these characters in comparison to others.

Character association

In general the phenotypic correlation coefficients were similar to or slightly higher than genotypic correlation coefficients. A similar pattern was earlier reported by Kumar *et al.* (1999) and Kardam and Singh (2005) in Indian mustard (Table 3). Seed yield per plant showed positive and significant correlation with plant height, primary branches per plant, fruiting zone length, siliquae per plant, main shoot length and siliquae on main shoot. These results are in accordance with the earlier reports of Mahla *et al.* (2003), Lohia *et al.* (2013), Kumar and Singh (2013), Lodhi *et al.* (2014) and Akabari *et al.* (2015).

Siliquae per plant showed positive and significant correlation with main shoot length, siliquae on main shoot, seeds per siliqua, dry weight and relative water content. This report is in agreement to earlier reports made by Patel *et al.* (2000), Singh and Mishra (2002) and Kumar and Singh (2013). Main shoot length had positive and significant association with siliquae on main shoot, dry weight and water use efficiency. This result is in conformity with the earlier reports of Lodhi *et al.* (2014). Siliquae on main shoot was found to be positively and significantly correlated with water use efficiency. Siliquae length had positive and significant correlation with seeds per siliqua and dry weight. Similar reports were earlier obtained by Gupta and Thakur (2002) and Singh (2004). Seeds per siliqua exhibited positive and significant correlation with oil content and dry weight. Relative water content had positive and significant association with secondary branches per plant, siliquae per plant and seed yield per plant. Water use efficiency was found to be significantly correlated with flowering time, plant height, fruiting zone length, main shoot length, siliqua on main shoot and seed yield per plant. Significant association of water use efficiency with seed yield per plant was also reported by Shahidumar (2006) and Singh *et al.* (2009). Among the 80 progenies, 15 were ranked based on seed yield performance as listed in Table 4 (a and b). Out of them, best genotypes are BPR-1616-31, BPR-1694-13, BPR-1684-42, BPR-1676-26, BPR-1686-31, BPR-1566-9, BPR-1679-50, BPR-1684-42, BPR-1360-34 and BPR-1679-48.

CONCLUSION

Evaluation of 80 advanced progenies of Indian mustard for morpho-physiological characters indicated presence of adequate variability for most of the traits. All the significant characters had high heritability and some had low to moderate genetic advance. It may lead to the conclusion that the material may be faithfully utilized for improvement of these characters. Further, in these characters plant height, primary branches per plant, fruiting zone length, main shoot length, siliquae per plant and siliquae on main shoot showed significant and positive correlation with seed yield per plant. The best progenies may further be tested in multi-location trials and can be used in hybridization programs as parents to develop high yielding varieties.

Table 3. Correlaton coefficient on the basis of adjusted values between different characters of Indian mustard.

Characters		FT	M	PH	PB	SB	FZL	S/P	MSL	SMS	SL	SPS	SY/PLT	T.wt.	OC	DW	RWC	WUE
FT	rg	1.00																
	rp	1.00																
M	rg	0.08	1.00															
	rp	0.23*	1.00															
PH	rg	0.32	-0.06	1.00														
	rp	0.37**	0.10	1.00														
PB	rg	0.26	0.20	-0.03	1.00													
	rp	0.24*	0.26*	0.25*	1.00													
SB	rg	-0.16	0.09	-0.08	0.31	1.00												
	rp	0.05	0.12	0.01	0.62**	1.00												
FZL	rg	0.20	0.07	0.56	0.08	0.21	1.00											
	rp	0.36**	0.13	0.62**	0.46**	0.24*	1.00											
S/P	rg	0.23	-0.05	0.48	0.39	0.44	0.43	1.00										
	rp	0.29**	0.26	0.48**	0.63**	0.65**	0.56**	1.00										
MSL	rg	0.28	-0.03	0.45	-0.02	-0.14	0.62	0.28	1.00									
	rp	0.42**	0.07	0.54**	0.18	-0.03	0.72**	0.33**	1.00									
SMS	rg	0.19	0.01	0.46	-0.01	0.04	0.58	0.54	0.62	1.00								
	rp	0.37**	0.17	0.58**	0.22*	-0.03	0.62**	0.51**	0.66*	1.00								
SL	rg	-0.09	-0.01	-0.21	0.26*	0.16	0.03	0.01	-0.08	-0.26*	1.00							
	rp	0.02	-0.09	-0.13	0.16	0.26**	-0.05	0.05	-0.09	-0.32**	1.00							
SPS	rg	-0.12	-0.07	0.19	-0.02	0.28	0.25	0.23	0.04	0.10	0.18	1.00						
	rp	0.09	-0.02	0.40**	0.33**	0.28**	0.37**	0.36**	0.18	0.12	0.26*	1.00						
SY/Pt.	rg	0.15	0.24	0.18	0.41	0.38	0.47	0.34	0.28	0.18	0.25	0.14	1.00					
	rp	0.17	0.17	0.38**	0.48**	0.48	0.54**	0.58**	0.37**	0.28*	0.18	0.391	1.00					
T.wt.	rg	-0.34	-0.03	-0.47	0.15	-0.02	-0.39	-0.37	-0.26	-0.44	0.18	0.02	0.0	1.00				
	rp	-0.19	-0.086	-0.15	-0.08	-0.14	-0.12	-0.23*	-0.24*	-0.249*	-0.11	-0.19	-0.11	1.00				
OC	rg	-0.04	-0.06	0.07	0.04	0.08	0.13	0.01	0.04	0.01	-0.01	0.15	0.19	0.18	1.00			
	rp	0.04	0.07	0.11	0.161	0.18	0.20	0.18	0.14	0.12	0.00	0.26*	0.18	-0.04	1.00			
DW	rg	0.25	0.12	-0.09	0.36	-0.01	-0.09	-0.09	-0.05	-0.35	0.28	-0.12	0.07	0.02	0.14	1.00		
	rp	0.17	0.11	0.26*	0.46**	0.33**	0.29**	0.38**	0.26*	0.15	0.35**	0.39**	0.29**	-0.26*	0.18	1.00		
RWC	rg	0.08	0.01	0.19	-0.16	-0.11	0.15	0.02	0.08	0.26	-0.16	0.12	-0.17	0.02	-0.19	0.15	1.00	
	rp	0.02	0.29**	0.16	0.13	0.16	0.24*	0.29**	0.14	0.28	-0.07	0.18	0.24*	-0.15	0.13	0.16	1.00	
WUE	rg	0.28	-0.04	0.31	-0.07	-0.14	0.23	0.09	0.35	0.20	-0.17	-0.04	0.43	0.06	-0.10	0.01	0.09	1.00
	rp	0.29**	0.02	0.25*	0.14	0.03	0.35**	0.18	0.39**	0.38**	0.10	0.05	0.29**	-0.06	0.02	0.17	0.15	1.00

rg = Genotypic value of adjusted mean, rp= Phenotypic value of unadjusted mean, FT= Flowering time, M= Maturity, PH=Plant height, PB= Primary branches,SB= Secondary branches,FZL= Fruiting zone length, S/P= Siliquae per plant, SMS= Siliquae on main shoot, SL= Siliquae length, SPS= Seed per siliquae, SY/Pt. = Seed yield per plant, T.wt.= 1000-seed weight, OC =Oil content (%), DW= Dry weight, RWC = Relative water content, WUE = Water use efficiency.

Table 4a. Ranking of progenies based on *per se* performance.

No.	Progeny	Seed yieldper plant(g)	Flowering time	Maturity	Plant height (cm)	Primary branches/ plant	Secondary branches /plant	Fruiting zone length (cm)	Main shoot length(cm)	Siliquae per plant	Siliquae on main shoot
1	BPR-1616-31	25.1 (1)	54.7 (2)	148.1 (2)	186.7 (3)	4.3 (13)	6.5 (6)	86.2 (9)	85.6 (1)	200.2 (6)	56.3 (1)
2	BPR-1694-13	24.6 (2)	50.7 (12)	139.4 (12)	142.9 (15)	4.8 (89)	1.9 (14)	59.7 (15)	57.4 (14)	92.9 (15)	27.10(14)
	BPR-1684-42	22.4 (3)	53.7 (5)	142.4 (7)	161.7 (9)	5.4 (3)	3.5 (10)	91.7 (6)	84.8 (2)	204.9 (5)	45.1 (6)
4	BPR-1676-26	21.9 (4)	60.7 (1)	149.1 (1)	168.1 (8)	4.9 (6)	5.5 (8)	93.4 (4)	73.2 (9)	193.6 (8)	44.1 (8)
5	BPR-1686-31	20.8 (5)	48.9 (15)	147.6 (3)	181.7 (6)	5.5 (2)	8.8 (1)	92.2 (5)	71.2 (10)	185.5 (9)	43.3 (9)
6	BPR-1566-9	20.1 (6)	53.7 (6)	145.1 (5)	191.5 (2)	3.8 (14)	2.8 (13)	94.8 (3)	76.0 (5)	155.2 (12)	39.3 (12)
7	BPR-1679-50	18.7 (7)	51.9 (10)	128.9 (14)	186.1 (4)	4.7 (10)	7.3 (2)	90.7 (7)	82.3 (3)	234.6 (3)	49.8 (4)
8	BPR-1684-42	18.6 (8)	53.7 (7)	138.4 (13)	157.3 (13)	5.2 (4)	6.5 (4)	79.7 (11)	75.6 (6)	158.0 (11)	37.9 (13)
9	BPR-1360-34	18.5 (9)	54.7 (3)	141.1 (9)	171.3 (7)	4.9 (7)	3.5 (11)	82.1 (10)	66.4 (12)	175.0 (10)	44.5 (7)
10	BPR-1679-48	18.1 (10)	53.9 (4)	143.8 (6)	184.1 (5)	4.7 (11)	4.9 (9)	86.5 (8)	74.5 (7)	198.6 (7)	50.2 (3)
11	BPR-1480-3	17.1 (11)	53.7 (8)	141.1 (8)	159.1 (12)	3.7 (15)	6.8 (3)	98.0 (1)	70.0 (11)	211.0 (4)	48.3 (5)
12	BPR-1684-8	16.4 (12)	53.7 (9)	128.4 (15)	160.7 (11)	4.6 (12)	1.9 (15)	66.5 (14)	64.2 (13)	145.2 (13)	41.3 (10)
13	BPR-1686-30	16.0 (13)	48.9 (14)	139.8 (10)	154.9 (14)	4.9 (5)	5.92 (7)	77.3 (12)	73.2 (8)	129.4 (14)	20.3 (15)
14	BPR-1686-32	15.6 (14)	49.9 (13)	139.6 (11)	197.3 (1)	5.9 (1)	3.4 (12)	96.4 (2)	77.8 (4)	255.3 (2)	56.3 (2)
15	BPR-133-34	15.5 (15)	50.7 (11)	146.4 (4)	162.5 (10)	4.8 (8)	6.5 (5)	73.5 (13)	52.0 (15)	276.5 (1)	40.3 (11)

Table 4b. Ranking of progenies based on *per se* performance.

No.	Progeny	Siliquae length(cm)	Seeds per Siliqua	1000-seed weight(g)	Oil content(%)	Dry weight(g)	Relative Water content (kg/ha/mm)	Water use efficiency(%)
1	BPR-1616-31	4.4 (11)	12.2 (13)	4.9 (13)	39.9 (13)	0.1 (15)	94.9 (5)	65.4 (1)
2	BPR-1694-13	5.4 (4)	11.2 (15)	7.1 (3)	40.9 (3)	0.7 (9)	81.8 (13)	21.1 (11)
3	BPR-1684-42	4.4 (10)	12.5 (11)	8.0 (1)	40.9 (4)	1.3 (1)	83.5 (11)	34.3 (5)
4	BPR-1676-26	4.2 (14)	12.7 (10)	4.7 (15)	39.7 (15)	0.8 (5)	95.1 (4)	58.2 (2)
5	BPR-1686-31	3.9 (15)	14.4 (4)	6.7(5)	40.6 (8)	0.6 (11)	87.6 (9)	18.6 (12)
6	BPR-1566-9	4.8 (7)	12.4 (12)	4.8 (14)	40.3 (11)	1.2 (4)	89.5 (7)	28.2 (7)
7	BPR-1679-50	5.4 (3)	15.5 (2)	6.2 (7)	40.8 (5)	0.8 (6)	88.9 (8)	28.1 (8)
8	BPR-1684-42	4.5 (9)	15.2 (3)	6.6 (6)	40.5 (9)	1.4 (2)	85.3 (10)	24.2 (10)
9	BPR-1360-34	5.1 (5)	13.8 (7)	6.2 (8)	39.9 (14)	0.3 (14)	98.1 (1)	35.9 (4)
10	BPR-1679-48	5.5 (2)	13.8 (8)	4.9 (12)	40.5 (10)	0.7 (8)	89.9 (6)	3.9 (15)
11	BPR-1480-3	4.6 (8)	15.5 (1)	4.9 (11)	40.8 (7)	0.6 (13)	96.1 (2)	47.6 (3)
12	BPR-1684-8	4.2 (13)	11.6 (14)	5.1 (10)	40.3 (11)	0.6 (10)	95.1 (3)	33.9 (6)
13	BPR-1686-30	6.6 (1)	13.9 (6)	7.6 (2)	42.0 (1)	1.2 (3)	79.3 (15)	1.9 (15)
14	BPR-1686-32	4.3 (12)	12.8 (9)	7.0 (4)	40.8 (6)	0.6 (12)	81.7 (14)	26.4 (9)
15	BPR-133-34	5.0 (6)	13.9 (5)	5.5 (9)	41.4 (2)	0.8 (7)	82.5 (12)	10.9 (13)

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