Plant Germplasm Registration Notice*

The Plant Germplasm Registration Committee of ICAR in its XXXVIth meeting held on February 6th, 2017 at the National Bureau of Plant Genetic Resources, New Delhi approved the registration of following 30 germplasm lines out of 68 proposals considered. The information on registered germplasm is published with the purpose to

disseminate the information to respective breeders for utilization of these genetic stocks in their crop improvement programmes. Upon request, the developer(s)/author(s) is/are obliged to distribute the material for crop improvement programme of National Agricultural Research System.

1. NABIMG-9-Blue; BW/2*/PBW621 (IC0620914; INGR17001), a Wheat (*Triticum aestivum*) Germplasm with Blue Grain (aleurone) Color

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Anthocyanins are normal constituents in colored fruits and vegetables. These can act as antioxidants and help in prevention of cardiovascular diseases (Kris-Etherton *et al*., 2004), diabetes (Patel *et al*., 2013), inflammation, cancer (Arts *et al*., 2005), obesity (Tsuda *et al*., 2003) and aging (Chen *et al*., 2013). Common wheat cultivars across the world are white/amber in color. Nutraceutical colored wheat, rich in anthocyanin is quite uncommon. The grains of developed NABIMG-9 line are blue in color due to anthocyanins in the aleurone layer.

Donor line for blue grain trait was imported from Wheat Genetic and Genomic Resource Center (WGGRC) through NBPGR (EC866732-28H129, BW). This line was backcrossed once with high yielding Indian cultivar

Table 1. Stability of blue color observed in different years and locations

Name	Pedigree	Grain color 2013-2014 (NABI)	Grain color 2013-2014 (Kelong)	Grain color 2014-2015 (NABI)	Grain color 2014-2015 (Kelong)	Grain color 2015-2016 (NABI)
NABIMG-9	28H129/ 2*PBW621	Blue	Blue	Blue	Blue	Blue
PBW621	Recipient parent	Amber	Amber	Amber	Amber	Amber
BW EC866732)	Donor parent	Blue	Blue	Blue	Blue	Blue

Table 2. Yield and thousand kernel weight observed in different years and locations

Name	Yield 2013-2014 T/ha	TKW (g) 2013-2014	Yield 2014-2015(NABI)	TKW (g) 2014-2015 (NABI)	Yield 2015-2016 (Chaparchiri) Late sowing	TKW (g) 2015-2016 (Chaparchiri)
NABIMG-9	4.44	45.8	3.08	39.78	2.81	36.25
PBW621	6.1	42.8	5.15	41.2	2.93	36.25
BW EC866732)	2.9	29.6	2.68	27.23	1.14	26.0

Table 3. Agronomic traits of colored wheat line and high yield parent

Name	Plant height	Spike length	Splikelets per spike	Anthocyanin content (mg/kg)
NABIMG-9	111.6	7.6	17.2	114.1
PBW621	94.2	7.8	18	2.8

Compiled and edited by Anjali Kak and RK Tyagi, Division of Germplasm Conservation, ICAR-National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi-110012.

PBW621and followed by production of the stable blue colored line (F_9 generation). Developed colored wheat line has satisfactory yield potential and regional adaptation.

Morpho-agronomic characteristics: Stability of grain color was monitored for several generations. NABIMG-9 showed stable blue color in the seeds. Its yield and thousand kernel weight (TKW) were significantly higher than donor wheat cultivar. This line can be used directly for development of colored wheat products, alternately it can be used in future breeding programs.

References

Kris-Etherton PM, GR Beecher, TD Etherton, MD Gross, CL Keen and M Lefevre (2004) Bioactive compounds in nutrition and health-research methodologies for establishing biological function: The antioxidant and anti-inflammatory effects of flavonoids on atherosclerosis. *Annual Review of Nutrition*. **24**: 511-538.

Patel KK, A Jain and DK Patel (2013) Medicinal significance, pharmacological activities, and analytical aspects of anthocyanidins 'delphinidin': A concise report. *Journal of Acute Disease*. **2**(3): 169-178.

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Tsuda T, H Aoki, F Horio, T Osawa and K Uchida (2003) Dietary cyanidin 3-*O*-β-D-glucoside-rich purple corn color prevents obesity and ameliorates hyperglycemia. *Journal of Nutrition*. **133**(7): 2125-2130.

Chen CD, CR Abraham, N Aytan, R Bansal, A Dedeoglu, EL Giannaris, JD Hinman, M Kuro, H Li, JI Luebke, DL Rosene, JA Sloane and E Zeldich (2013) The anit-aging protein klotho enhances oligodendrocyte maturation and myelination of the central nervous system. *Journal of Neuroscience*. **33**(5): 1927-1939.

2. NABIMG–10–Purple (BW/2*PBW621) (IC0620915; INGR17002), a Wheat (*Triticum aestivum*) Germplasm with Purple Grain (pericarp) Color

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Anthocyanins are normal constituents in colored fruits and vegetables. These can act as antioxidants and help in prevention of cardiovascular diseases (Kris-Etherton *et al*., 2004), diabetes (Patel *et al*., 2013), inflammation, cancer (Arts *et al*., 2005), obesity (Tsuda *et al*., 2003) and aging (Chen *et al*., 2013). Common wheat cultivars across the world are white/amber in color. Nutraceutical colored wheat, rich in anthocyanin is quite uncommon. The grains of developed NABIMG-10 line are purple in color due to anthocyanins in the pericarp layer.

Donor line for purple grain trait was imported from Wheat Genetic and Genomic Resource Center (WGGRC) through NBPGR (EC866732-28H129, BW). This line was backcrossed once with high yielding Indian cultivar PBW621and followed by production of the stable purple colored line (F_9 generation). Developed colored wheat line has satisfactory yield potential and regional adaptation.

Morpho-agronomic characteristics: Stability of grain color was monitored for several generations. NABIMG-

Table 1. Stability of purple color observed in different years and locations

Name	Pedigree	Grain color 2013-2014 (NABI)	Grain color 2013-2014 (Kelong)	Grain color 2014-2015 (NABI)	Grain color 2014-2015 (Kelong)	Grain color 2015-2016 (NABI)
NABIMG-10	28H129/ 2*PBW621	Purple	Purple	Purple	Purple	Purple
PBW621	Recipient parent	Amber	Amber	Amber	Amber	Amber
BW EC866732)	Donor parent	Purple	Purple	Purple	Purple	Purple

Table 2. Yield and thousand-kernel weight observed in different years and locations

Name	Yield 2013-2014 T/ha	TKW (g) 2013-2014	Yield 2014-2015 (NABI)	TKW (g) 2014-2015 (NABI)	Yield 2015-2016 (Chaparchiri) Late sowing	TKW (g) 2015-2016 (Chaparchiri)
NABIMG-10	4.44	45.8	4.69	39.48	2.53	45.25
PBW621	6.1	42.8	5.15	41.2	2.93	36.25
BW EC866732)	2.9	29.6	2.68	27.23	1.14	26.0

Table 3 Agronomic traits of colored wheat line and high yield parent

Name	Plant height	Spike length	Splikelets per spike	Anthocyanin content (mg/kg)
NABIMG-10	84.2	7.4	16	65.4
PBW621	94.2	7.8	18	2.8

10 showed stable purple color in the seeds. Its yield and thousand kernel weight (TKW) were significantly higher than donor wheat cultivar. This line can be used directly for development of colored wheat products, alternately it can be used in future breeding programs.

References

Kris-Etherton PM, GR Beecher, TD Etherton, MD Gross, CL Keen and M Lefevre (2004) Bioactive compounds in nutrition and health-research methodologies for establishing biological function: The antioxidant and anti-inflammatory effects of flavonoids on atherosclerosis. *Annual Review of Nutrition*. **24**: 511-538.

Patel KK, A Jain and DK Patel (2013) Medicinal significance, pharmacological activities, and analytical aspects of anthocyanidins 'delphinidin': A concise report. *Journal of Acute Disease*. **2(3)**: 169-178.

Arts IC and PC Hollman (2005) Polyphenols and disease risk in epidemiologic studies. *The American Journal of Clinical Nutrition.* **81** (Suppl 1): 317-325.

Tsuda T, H Aoki, F Horio, T Osawa and K Uchida (2003) Dietary cyanidin 3-*O*-β-D-glucoside-rich purple corn color prevents obesity and ameliorates hyperglycemia. *Journal of Nutrition*.**133 (7)**: 2125-2130.

Chen CD, CR Abraham, N Aytan, R Bansal, A Dedeoglu, EL Giannaris, JD Hinman, M Kuro, H Li, JI Luebke, DL Rosene, JA Sloane and E Zeldich (2013) The anit-aging protein klotho enhances oligodendrocyte maturation and myelination of the central nervous system. *Journal of Neuroscience*. **33(5)**: 1927-1939.

3. NABIMG-11-Black (BW/2*PBW621) (IC0620916; INGR17003), a Wheat (*Triticum aestivum*) Germplasm with Black Grain Colour; (purple pericarp + blue aleuron)

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Anthocyanins are normal constituents in colored fruits and vegetables. These can act as antioxidants and help in prevention of cardiovascular diseases (Kris-Etherton *et al.,* 2004), diabetes (Patel *et al*., 2013), inflammation, cancer (Arts *et al.,* 2005), obesity (Tsuda *et al*., 2003) and aging (Chen *et al*., 2013). Common wheat cultivars across the world are white/amber in color. Nutraceutical colored wheat, rich in anthocyanin is quite uncommon. The grains of developed NABIMG-11 line are black in color due to anthocyanins in the aleurone and pericarp layers.

Donor line for black grain trait was imported from Wheat genetic and genomic resource center (WGGRC) through NBPGR (EC866732-28H129, BW). This line was back crossed once with high yielding Indian cultivar PBW621 and followed by production of the stable black colored line (F_9 generation). Developed colored wheat line has satisfactory yield potential and regional adaptation.

Morpho-agronomic characteristics: Stability of grain color was monitored for several generations. NABIMG-

Table 1 Stability of black color observed in different years and locations

Name	Pedigree	Grain color 2013-2014 (NABI)	Grain color 2013-2014 (Kelong)	Grain color 2014-2015 (NABI)	Grain color 2014-2015 (Kelong)	Grain color 2015-2016 (NABI)
NABIMG-11	28H129/ 2*PBW621	Black	Black	Black	Black	Black
PBW621	Recipient parent	Amber	Amber	Amber	Amber	Amber
BW (EC866732)	Donor parent	Black	Black	Black	Black	Black

Table 2 Yield and thousand-kernel weight observed in different years and locations

Name	Yield 2013-2014 T/ha	TKW (g) 2013-2014	Yield 2014-2015 (NABI)	TKW (g) 2014-2015 (NABI)	Yield 2015-2016 (Chaparchiri) Late sowing	TKW (g) 2015-2016 (Chaparchiri)
NABIMG-11	4.44	45.8	4.71	37.26	3.285	32.5
PBW621	6.1	42.8	5.15	41.2	2.93	36.25
BW (EC866732)	2.9	29.6	2.68	27.23	1.14	26.0

Table 3 Agronomic traits of colored wheat line and high yield parent

Name	Plant height	Spike length	Splikelets per spike	Anthocyanin content (mg/kg)
NABIMG-11	92.6	7.1	15.6	198
PBW621	94.2	7.8	18	2.8

11 showed stable black color in the seeds. Its yield and thousand kernel weight (TKW) were significantly higher than donor wheat cultivar. This line can be used directly for development of colored wheat products, alternately it can be used in future breeding programs.

References

Kris-Etherton PM, GR Beecher, TD Etherton, MD Gross, CL Keen and M Lefevre (2004) Bioactive compounds in nutrition and health-research methodologies for establishing biological function: The antioxidant and anti-inflammatory effects of flavonoids on atherosclerosis. *Annual Review of Nutrition*. **24**: 511-538.

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Arts IC and PC Hollman (2005) Polyphenols and disease risk in epidemiologic studies. *The American Journal of Clinical Nutrition*. **81** (Suppl 1): 317-325.

Tsuda T, H Aoki, F Horio, T Osawa and K Uchida (2003) Dietary cyanidin 3-*O*-β-D-glucoside-rich purple corn color prevents obesity and ameliorates hyperglycemia. *Journal of Nutrition*.**133(7)**: 2125-2130.

Chen CD, CR Abraham, N Aytan, R Bansal, A Dedeoglu, EL Giannaris, JD Hinman, M Kuro, H Li, JI Luebke, DL Rosene, JA Sloane and E Zeldich (2013) The anit-aging protein klotho enhances oligodendrocyte maturation and myelination of the central nervous system. *Journal of Neuroscience*. **33(5)**: 1927-1939.

4. DDW 42 (IC0621692; INGR17004), a Wheat (*Triticum durum*) Germplasm with High Yellow Pigment Content (High Beta-carotene)

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High yellow pigment (YP) content, a desirable trait for end-use quality in durum wheat is being targeted particularly under durum breeding programs worldwide. This is a precursor of vitamin A, which is an essential ingredient for human health. The Beta-carotene also enhances the end product quality and aroma and thus preferred by the people in the market. For this purpose, DDW 42 (coming out of cross HI 8713/DBP 01-9// PDW 233), one of the promising durum line developed at ICAR-IIWBR, Karnal was evaluated at four locations each in central zone (CZ) and peninsular zone (PZ) along with two check varieties (AKDW 2997-16 and HI 8627) and 22 other lines during 2015-16under All India Coordinated NIVT-5B trial.

DDW 42 was ranked first at all the tested locations for YP content and was better in yield levels as compared to check varieties. Mean of YP content for DDW 42in CZ, was recorded as 8.2ppm, whereas it was 3.3ppm and 6.2ppm for check varieties namely AKDW 2997-16 and HI 8627 respectively. Similarly under PZ, mean YP content of DDW 42, AKDW 2997-16 and HI 8627 were noted as 8.1ppm, 3.3ppm and 5.6ppm, respectively (Table 1).

The highest YP content in DDW 42 was to tune of 9.4 ppm at Powarkheda in CZ and 9.0 ppm at Bagalkot in PZ. At national level DDW 42, AKDW 2997-16 and HI 8627 recorded 8.2, 3.4 and 6.0 ppm, respectively.

Table 1. Yellow pigment content and yield of proposed DDW 42 and checks over locations during 2015-16

Zone	Location	Yellow pigment content (ppm)			% Superiority over AKDW 2997-16	% Superiority over HI 8627	Yield (q/ha)		
		DDW 42	AKDW 2997-16 (C)	HI 8627 (C)			DDW 42	AKDW 2997-16 (C)	HI 8627 (C)
CZ	Dhanduka	**8.4**	4.1	6.8	104.9	23.5	25.6	23.4	29.3
	Indore	**7.4**	2.1	5.3	252.4	39.6	38.1	35.5	34.3
	Kota	**7.6**	2.9	5.6	162.1	35.7	33.6	53.7	49.0
	Powarkheda	**9.4**	4.2	7.0	123.8	34.3	45.1	34.8	33.6
	Mean	**8.2**	3.3	6.2	148.5	32.3	35.6	36.9	36.6
PZ	Dharwad	**8.3**	3.8	6.8	118.4	22.1	21.4	22.2	19.3
	Bagalkot	**9.0**	3.8	6.0	136.8	50.0	27.8	28.7	21.0
	Niphad	**7.2**	2.8	5.1	157.1	41.2	21.7	21.8	18.9
	Pune	**8.0**	2.9	4.6	175.9	73.9	-	-	-
	Mean	**8.1**	3.3	5.6	145.5	44.6	23.6	24.2	19.7
Mean (National)		**8.2**	3.4	6.0	141.2	36.7	30.5	31.4	29.3

Table 2. Other salient characteristics of the genotype DDW 42

Trait	Entry		Check varieties			
	DDW 42		AKDW 2997-16		HI 8627	
	CZ	PZ	CZ	PZ	CZ	PZ
Yellow pigment content (ppm)	**8.2**	**8.1**	3.3	3.3	6.2	5.6
Grain yield q/ha	**40.4**	23.6	40.0	24.2	37.0	19.7
Protein content (%)	**13.7**	**14.1**	13.2	13.6	13.6	13.7
Sedimentation value (ml)	**37**	**36**	33	34	31	31
Thousand grain weight (gm)	**45.0**	37	44.0	37	48.0	39
Test weight (kg/hl)	**85.0**	83.3	85.0	83.2	86.3	84.7
Other morpho-agronomic traits						
Days to heading (days)	79	68	70	61	75	71
Days to maturity (days)	122	108	123	108	124	110
Plant height (cm)	78	68	79	66	86	70
Grain appearance	6.6	6.8	6.4	6.3	7.0	6.6
Yellow berry incidence (%)	**4**	9	10	7	5	9
Threshability	Ey- M	Ey	M	Ey	M	Ey- M
Grain texture	SH	SH- H	SH	H	SH	H

Besides, the other salient features including quality attributes and agro-morphological traits of DDW 42 were found in acceptable range (Table 2) and thus it would serve as potential donor having improved background.

The new durum wheat genotype (DDW 42) possessed high yellow pigment as it showed 141.2% and 36.7% superiority for YP over check varieties (AKDW 2997-16 and HI 8627) respectively at national level, was also good for other desirable agro morphological and nutritional attributes and thus, DDW 42 would serve as a potential donor source to be utilized in future breeding programs aimed to improve YP content of durum varieties.

5. DDW 150 (IC0621693; INGR17005), a Wheat (*Triticum aestivum*) Germplasm with High Tolerance to Heat Stress

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The present climatic conditions pose serious challenge to wheat production in form of abiotic stress conditions. Among abiotic stresses, terminal heat stress during grain filling stage is of major concern as it reduces in grain size that ultimately result in yield losses. The wheat genotype DBW 150 developed from cross DBW 16/ GW 322 was identified as highly heat stress tolerant genotype based on physiological trait characterization. Both the parental lines are high yielding released cultivars (DBW 16 released for irrigated late sown conditions of the NWPZ and GW 322 for irrigated timely sown conditions of the central zone) of wheat being grown in respective zone. Moreover, production conditions (late sown of NWPZ and timely sown of CZ) of both the genotypes have almost similar maturity period and the wheat crop is exposed to terminal heat stress. This way parental adaptability to withstand in the stress condition has been combined in DBW 150.

The genotype DBW 150 was evaluated in coordinated yield trial of AICW&BIP during 2013-14 (NIVT-3) under irrigated late sown condition across different zones of India. The genotype was promoted to advanced varietal trial (AVT) for irrigated late sown condition of NWPZ during 2014-15. Simultaneously, it was evaluated in multi-locational heat tolerance trial (MLHT) that comprised AVT final year entries alongwith checks. DBW 150 was initially evaluated in 2014-15 in MLHT-1 in which it showed promising performance for heat stress tolerance as indicated by very low HSI (heat susceptibility index) score during 2014-15. It was promoted to MLHT 2 during 2015-16 and evaluated for various heat stresses related traits under multi-locational evaluation (Table 1).

This potential genotype possessing heat stress tolerance as indicated by lower value of HSI (0.35) compared to check varieties in the MLHT (Table 1). It also showed lowest reduction (4.99%) in grain yield under late sown conditions.

Under coordinated yield trials also this genotype showed comparable performance to check varieties for yield and other agronomic characteristics thereby showing its suitability as promising genotype for late sown conditions possessing high degree of tolerance to heat stress.

The centre-wise HSI pooled over two years also indicated suitability of DBW 150 under heat stress environment and HSI of 8 heat stress locations (Durgapura, Dharwad, Hisar, Indore, Faizabad, Kanpur, Pantnagar and Sagar) was less than 1.0 (indicator of heat tolerance). As compared to four checks namely DBW 107, IC 138852, UAS 360 and UAS 361, the proposed entry DBW 150 showed tolerance to heat stress at all above 08 locations covering major wheat growing zones and thus was found better as evident by HSI and reduction in yield. The ideal locations for heat tolerance included Sagar, Niphad, Junagarh, Indore, Hisar, Durgapura and

Table 1. Performance of DBW 150 for heat stress parameters in MLHT under AICW&BIP (2015-16)

Traits	Entry	Checks in MLHT (2015-16)			
	DBW 150	DBW 107	UAS 360	UAS 361	IC 138852
Heat susceptibility index (HSI)	**0.35**	1.35	0.92	1.12	1.54
Reduction in yield under late sown (%)	**4.99**	19.27	13.08	15.93	21.99

Table 2. Location-wise heat sensitivity index (HSI) and yield reduction (%) of DBW 150 at different locations in MLHT (pooled over years)

Centre	HSI	Yield Reduction (%)	Centre	HSI	Yield Reduction (%)
Sagar	-0.87	-10.7	Durgapura	0.64	15.5
Dharwad	0.49	11.8	Hisar	0.80	21.1
Kanpur	-0.31	-5.8	Pantnagar	-0.01	-0.1
Indore	0.71	17.0	Faizabad	0.84	22.8

Table 3. Mean performance of DBW 150 and checks for agronomic characteristics during 2014-15

Traits	DBW 150	WH 1021 ©	WH 1124 ©	HD 3059 ©	DBW 90 ©
Days to heading	81	82	80	82	80
Days to maturity	125	124	123	124	123
Plant height (cm)	89	90	86	89	85
1000-grains weight (g)	33	33	35	37	35

Dharwad and at above all these hot spot locations, the proposed genotype has showed superiority over at least one or more check entries.

The genotype DBW 150 will serve as potential donor parent for transferring heat stress tolerance coupled with high yield level in wheat improvement programmes for climate resilience.

6. FLW10 (IC0621833; INGR17006), a Wheat (*Triticum aestivum*) Germplasm with Resistance to Yellow Rust Carrying *Yr10*+ in WH542 Background

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Rusts are economically the most important diseases of wheat as they pose major threat to wheat production in most of the wheat growing areas of the world. The most effective and environmentally sound strategy to manage these diseases is through the deployment of resistant cultivars (Bhardwaj *et al*., 2016). A large number of wheat cultivars have become susceptible to new pathotypes of rusts particularly yellow rust (Prashar *et al*., 2007). At Regional Station ICAR-IIWBR, Shimla FLW10 was developed from the cross WH542/Moro. Moro, a yellow rust differentials, possesses *Yr10* which provides resistance to all the yellow rust pathotypes reported in India. The *Yr10* gene in Moro is in winter wheat background and cannot be utilized directly in breeding programme, hence it has been transferred into spring wheat variety WH542 for facilitating the wheat breeders in NWPZ, NEPZ and NHZ to develop wheat genotype resistant to yellow rust.

FLW10 was tested at seedling stage under controlled conditions against the virulent and prevalent pathotypes of yellow rusts, it gave immune (0;) type of reaction (Table 1). When tested for adult plant reaction (APR) to yellow rust, FLW10 was found to be completely resistant FLW10 was also tested for its response to brown and black rusts and it was found to be resistant to black rust. The rust resistance genes like *Yr*9/*Lr*26/*Sr31* and *Yr10* has been confirmed in FLW10.

Plants of FLW10 have waxiness on leaf sheath, peduncle and glumes. This line is short statured (75cm), medium duration (118 days) with amber coloured grains having thousand-grains weight of 39.7g under Karnal conditions.

References

Bhardwaj SC, P Prasad, OP Gangwar, Hanif Khan and Subodh Kumar (2016) Wheat rust research- then and now. *Indian J. Agric. Sci.* **86**(10):1231-1244.

Prashar M., SC Bhardwaj, SK Jain, and D Datta (2007) Pathotypic evolution in *Puccinia striiformis* in India during 1995-2004. *Australian J. Agr. Res.* **58**: 602-604.

Table 1. Seedling resistance tests (2013-2016) of FLW10 to most virulent pathotypes of yellow and black rusts

	Yellow rust pathotypes								Black rust			
Pathotype	38S102	47S102	47S103	46S102	46S103	46S119	78S84	110S119	34-1	40A	40-1	117-1
Score	0;	0;	0;	0;	0;	0;	0;	0;	0;	2-	2-	2-

7. FLW16 (IC0621834; INGR17007), a Wheat (*Triticum aestivum*) Germplasm with Resistance to Yellow Rust Carrying *Yr5* in UP2338 Background

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Stripe rust, caused by *Puccinia striiformis* f. sp. *tritici* (Pst), is a destructive disease of wheat (*Triticum aestivum*) worldwide. Growing resistant cultivars are the most preferred method to control the disease. However, wheat cultivars usually become susceptible within a few years of release due to rapid evolution and/or increase of previously rare races. Only few *Yr* genes provide complete resistance to all the known pathotypes in Indian sub-continent (Prashar *et al*., 2007). The *Yr5* gene confers resistance to all races of the stripe rust pathogen of wheat in. FLW16 has been developed from cross UP2338/TSA(*Yr*5) at ICAR-IIWBR regional station Shimla through limited backcross followed by pedigree selection. TSA (*Triticum spelta album*) is a *spelt* wheat genotype. The transfer of unexploited *Yr5* in UP2338 background would facilitate development of yellow rust resistant wheat genotypes suitable for yellow rust prone wheat grown zones of Northern India.

In seedling resistance test FLW16 was found to be immune (0;) against the most virulent and prevalent pathotypes of yellow rust (Table 1). Its adult plant reaction (APR) shows complete resistance to yellow rust when tested under polyhouse conditions at Shimla during the years 2013, 2014 and 2015. It was also found to be moderately resistant to black rust. FLW16 carries *Lr26*, *Sr31*, *Yr9* and *Yr5* genes for wheat rust resistance.

The plants of FLW16 have light waxiness on leaf sheath and peduncles. It has plant height of 78cm with maturity duration of 120 days, amber coloured grains and thousand grains weight of 38.1g under Karnal conditions.

References

Bhardwaj SC, P Prasad, OP Gangwar, Hanif Khan and Subodh Kumar (2016) Wheat rust research – then and now. *Indian J. Agric. Sci.* **86(10)**:1231-1244.

Prashar M, SC Bhardwaj, SK Jain and D Datta (2007) Pathotypic evolution in *Puccinia striiformis* in India during 1995-2004. *Australian J. Agr. Res*. **58**: 602-604.

Table 1. Seedling resistance tests (2013-2016) of FLW16 to most virulent pathotypes of yellow and black rusts

	Yellow rust pathotypes								Black rust			
Pathotype	38S102	47S102	47S103	46S102	46S103	46S119	78S84	110S119	34-1	40A	40-1	117-1
Score	0;	0;	0;	0;	0;	0;	0;	0;	0;	2-	2-	2-

8. FLW 21 (IC0621836; INGR17008), a Wheat (*Triticum aestivum*) Germplasm with Resistance to Yellow and Brown Rusts Carrying *Yr15*+*Lr24* in Background of UP2338

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Common wheat (*Triticum aestivum* L.) is the most important food crop directly linked to food security in India. The rust pathogens of wheat are shifty and capable of acquiring virulence against resistance genes, and are able to spread rapidly between widely separated wheat production areas. Deployment of highly effective and durable rust resistance genes is considered eco-friendly and sustainable management (Bhardwaj *et*

Table 1. Seedling resistance tests (2013-2016) of FLW21 to most virulent pathotypes of yellow and brown rusts

Pathotypes	Yellow rust								Brown rust							
	38S102	47S102	47S103	46S102	46S103	46S119	78S84	110S119	12-5	77A	77-2	77-5	77-7	77-8	77-10	104-2
Score	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;

al., 2016). The genes normally act independently and when multiple resistance genes in the same genotype are challenged with a pathotype avirulent to all, the strongest resistance phenotype is normally manifested (Knott, 1989). However, combination of two or more resistance genes sometimes results in a lower or more resistant infection type (IT) than is conditioned by the most effective gene (Samborski and Dyck, 1982).

At ICAR-IIWBR regional station FLW21 was developed with highly effective resistance genes for yellow, brown and black rusts for utilization in wheat breeding programme for all Zones of India. FLW21 is derived from double cross UP2338/Centurk//UP2338/CN25087(*Yr15)*. Centurk is a popular winter wheat variety from Nebraska, USA and carries linked genes *Lr24/Sr24*. Line CN25087 carrying *Yr15* originates from *T. dicoccoides*. Use of FLW21 will facilitate wheat breeders in developing rust resistant genotypes for all wheat growing zones in India.

FLW21 showed immune (0) reaction in seedling resistance test with most virulent pathotypes of brown and yellow rusts (Table 1). FLW21 also showed resistance to black rust. Adult plant reaction of FLW21 showed resistance against all the three rusts. The rust resistance genes postulated in FLW21 are *Lr24/Sr24*, *Lr26*/*Sr31*/*Yr*9 and *Yr15*. The plants of FLW21 have waxiness on leaf sheath, peduncle and glumes. The plants are semi-erect with average plant height of 91cm, maturity duration of 122 days with thousand-grain weight of 37.3g.

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9. FLW22 (IC0621837; INGR17009), a Wheat (*Triticum aestivum*) Germplasm with Resistance to Brown (*Lr*28) and Yellow Rusts (*YrChina84*) in the Background of WH542

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Among several constraints towards realizing the potential yield in wheat, the rust diseases pose major threat to wheat production worldwide including India. All the three rusts of wheat, stripe rust caused by *Puccinia striiformis,* leaf rust incited by *Puccinia triticina* and stem rust caused by *Puccinia graminis* Pers. f.sp. *tritici* are occurring in designated wheat zones in India and cause significant losses in wheat production. Wheat rusts have been controlled effectively with the deployment of resistant wheat cultivars for the last several decades (Tomar *et al*., 2014).

Keeping in view the need to utilize diverse rust resistance gene the genotypes FLW22 was developed at IIWBR regional station, Shimla through pedigree method. Developed through double cross WH542/*Lr28*//WH542/China84-40022. China84-40022 possesses undesignated stripe rust resistance gene *YrChina84*. *YrChina84* provides resistance against all the pathotypes of yellow rust found in India. Use of FLW22 in wheat breeding programme will diversify resistance gene for brown and yellow rust in India.

Table 1. Seedling resistance tests (2013-2016) of FLW22 to most virulent pathotypes of yellow and brown rusts

Pathotypes	Yellow rust								Brown rust							
	38S102	47S102	47S103	46S102	46S103	46S119	78S84	110S119	12-5	77A	77-2	77-5	77-7	77-8	77-10	104-2
Score	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;

In seedling resistance test, FLW22 showed immune (0) reaction against virulent pathotypes of yellow and brown rusts (Table 1). It also exhibited resistance against all the three rusts in adult plant reaction (APR) tests during three years i.e., 2013 to 2015. FLW22 has been confirmed to carry *Lr28*, *Lr26*/*Sr31*/*Yr9* and *YrChina84* genes which provide resistance to all the three rusts of wheat.

Plants of FLW22 have slight waxiness on leaf sheath, peduncle and glumes. It has semi-erect growth habit with average plant height of 90cm and average maturity duration of 118 days, amber coloured grain with soft texture having thousand-grain weight of 37.4g.

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10. FWW2 (IC0621838; INGR17010), a Wheat (*Triticum aestivum*) Germplasm with Resistance to Brown Rust carrying *Lr19*+*Lr24* in the Background of PBW343

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Rusts are important diseases of wheat (*Triticum aestivum* L.) throughout the world. The preferred way of controlling the disease is through the use of resistant varieties. There are several genes that can express resistance to this disease. However, changes in pathogen virulence can render them useless for breeding after some time (Bhardwaj *et al*., 2016). The emergence of the Ug99 group of stem rust races (TTKSK, TTKSF, TTKST, TTTSK) has reaffirmed the need to deploy diverse and effective resistance sources to safeguard wheat production (Pretorius *et al*., 2000). Keeping in view the need to deploy diverse resistance gene against brown and black (including Ug99) rusts the genotype FWW2 was developed for utilization by wheat breeders in India.

FWW2 is derived from cross PBW343/PH137 wherein PH137 contributes rust resistance genes *Lr19/Sr25* and *Lr24/Sr24*. FWW2 having two gene based resistance would be useful in diversifying resistance for brown and black rusts in all wheat growing zone of India.

Seedling resistance test against most virulent and prevalent pathotypes under controlled conditions showed that FWW2 is immune (0) to brown rust (Table 1). It also showed resistance against black rust. The adult plant reaction (APR) tests for three years (2013 to 2015) showed resistance to brown and black rusts. FWW2 carries *Lr19/Sr25*, *Lr24/Sr24*, *Lr26*/*Sr31/Yr9* genes for resistance to wheat rusts. *Sr25* also confers resistance to Ug99 virulences of stem rust (Singh *et al*., 2015). The plants of FWW2 have waxiness on sheath of flag leaf, peduncle and glumes. It has semi-erect growth habit with average plant height of 85cm and matures in 118 days having amber coloured grains with thousand-grain weight of 40.6g.

Table 1. Seedling resistance tests (2013-2016) of FWW2 to most virulent pathotypes of brown and black rusts

	Brown rust pathotypes							Black rust			
Pathotypes	12-5	77-2	77-5	77-7	77-8	77-10	104-2	34-1	40A	40-1	117-1
Score	0;	0;	0;	0;	0;	0;	0;	0;	2-	2-	2-

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11. Local Wheat Hango (LWH) (IC0621839; INGR17011), a Wheat (*Triticum aestivum*) Germplasm Universally Susceptible to Yellow, Brown and Black Rusts

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The bread wheat germplasm 'Local Wheat Hango (LWH), was collected from village Hango in Kinnaur district of Himachal Pradesh in the year 2002. This local wheat variety is susceptible to all the three rusts of wheat under field condition. The susceptible reaction of LWH was examined in comparison with another susceptible wheat variety 'Agra Local'. Agra Local has been used as universally susceptible variety since last about eighty years. Of late, Agra Local was observed to reveal resistant response against three pathotypes of *Puccinia triticina* (Datta *et al*., 2008) causing brown rust of wheat. In addition, few yellow rust pathotypes also exhibited low sporulation on it. This feature of Agra Local showed that it was not 'universally susceptible' to all pathotypes of brown, black and yellow rusts.

The germplasm LWH was tested for its response against all pathotypes of brown, black and yellow rusts. The susceptible reaction of LWH to all existing pathotypes of the three rusts revealed its universally susceptible nature. Thus, LWH can be safely used in genetic studies on resistance to all the three rusts of wheat (Bhardwaj *et al*., 2006).

The plants of this genotype have pink coleoptiles, erect habit, light green foliage and average plant height of 88cm. The auricles lack pigmentation, but are pubescent. The ear is clavate having short awns; outer glumes have no pubescence; lemma has square shape shoulder, medium beak length and strong beak curvature. There is slight waxiness on leaf sheath and peduncle. Grains are amber coloured with soft texture. Seeds are small, elliptical shaped with deep crease.

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12. DWRB137 (IC0620682; INGR17012), a Barley (*Hordeum vulgare* L.) Germplasm Highly Resistant to Stripe Rust (*Puccinia striiformis* f. sp. hordei) at Seedling and Adult Plant Stages Coupled with Short Plant Height

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DWRB137 (DWR28/DWRUB64) is an advance six-row feed barley strain, which is directly utilizable genetic resource for stripe rust with desirable plant height. It was evaluated for disease reactions at multi-locations for consecutive three years viz. *rabi*, 2013-14 to 2015-16, under Initial Barley Disease Screening Nursery (IBDSN) and National Barley Disease Screening Nursery (NBDSN), respectively. During *rabi*, 2013-14, the genotype DWRB137 was evaluated by code BK1321 at five locations namely Bajaura, Durgapura, Dhaulakuan, Ludhiana and Karnal in IBDSN. The genotype DWRB137 exhibited highly resistant response (0 reaction) for yellow rust under artificial disease epiphytotic conditions (Anonymous, 2014). Whereas, the recent check varieties of NWPZ namely BH902 and BH946 exhibited susceptible yellow rust reactions of 30S and 10S, respectively (Table 1). During *rabi*, 2014-15 and 2015-16, DWRB137 was again evaluated for disease resistance under artificial inoculations in NBDSN. DWRB137 reconfirmed resistance response to yellow rust (0 reaction) during both the seasons at all the centers (Anonymous, 2015; Anonymous, 2016). In seedling resistance test (SRT) DWRB137 showed resistant reactions for all the barley stripe rust races *viz.* 57, 24, M, G and Q consecutively for two years *i.e. rabi*, 2014-15 and 2015-16.

DWRB137 exhibited the desired plant height of 78 cm (62-93), which is highly desirable as barley is a lodging prone crop. Average days to heading, maturity and 1000-grain weight for DWRB137 were recorded as 82 days (67-93), 127 days (118-135) and 44 g (36-49), respectively in AVT-TS-FB-NWPZ coordinated trial, during *rabi*, 2015-16. The grains are hulled, elongated and light yellow in colour.

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Table 1. Multi-location adult plant resistance (APR) for stripe rust reactions (artificial inoculations) of DWRB137 and checks over three years

Year	Location	DWRB137	Checks (NWPZ)		Check (CZ)	Infector
			BH902	BH946	BH959	
First year (2013-14)	Bajaura	0	30S	0	0	100S
	Dhaulakuan	0	0	0	0	100S
	Durgapura	0	0	10S	30S	100S
	Ludhiana	0	0	0	0	40S
	Karnal	0	10MS	0	10MR	80S
Second Year (2014-15)	Durgapura	0	tMR	10MR	40MS	100S
	Bajaura	0	0	10S	0	100S
	Almora	0	5S	10MS	20MS	60S
Third Year (2015-16)	Bajaura	0	20S	10MR	20S	100S
	Ludhiana	0	10S	0	0	60S
	Durgapura	0	10MS	5S	10S	100S
	Karnal	0	5MR	0	5MS	60S
	Jammu	0	10S	5MR	0	80S
	Almora	0	20S	5S	10S	80S
Three years HS		0	30S	10S	40MS	100S

Sudheer Kumar, R Selvakumar, SC Bhardwaj, Subhash Katare, Rekha Malik, Ajay Verma, and Indu Sharma. ICAR-IIWBR, Karnal, India. P. 275.

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13. DQL-2105-1 (IC0621103; INGR17013), a Maize (*Zea mays L.*) Germplasm with Moderately Resistant to Maydis Leaf Blight (MLB) (disease mean score 2.13 on the scale of 1-5). Moderately Resistant to Turcicum Leaf Blight (TLB) (disease mean score 2.58 on the scale of 1-5). Tryptophan Content 0.69% in Protein

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Maize is the third most important cereal crop of the country after rice and wheat and is valued as food, feed, fodder and industrial raw material. In view of maize being produced under very diverse ecology in our country, development of high yielding hybrids with in-built resistance and tolerance to diseases, pests and various climatic stresses; and development and fine-tuning of production ecology are our top priorities.

Maydis Leaf Blight (MLB) and Turcicum Leaf Blight (TLB) are the most important diseases of India. MLB is also known as Southern Maize Leaf Blight. It is caused by the fungi *Bipolaris maydis*. This foliar disease is reported from most of the maize growing regions. It is a most serious disease in warm and wet temperate and tropical areas. 70% of the yield losses have been reported in the maize growing areas due to this disease. Symptoms and severity of this disease depends on the pathogen race and host germplasm. TLB is also known northern corn leaf blight. This disease is caused by the fungi *Exserohilum turcicium*. This foliar disease occurs in high humidity and moderate temperature areas. It also results in 70% loss in the yield.DQL 2105-1 is a late maturing quality protein maize line moderately resistant to Maydis Leaf Blight and Turcicum Leaf Blight. It is derived from HQPM-7, a quality protein maize population.

Morpho-agronomic characteristics: DQL 2105-1 is a late maturing quality protein maize inbred line with moderately resistant to Maydis Leaf Blight and Turcicum Leaf Blight, medium ear placement, straight attitude of lateral branches, sparse spikelets of tassel, yellow, flint and conico-cylindrical kernels. This line is derived from HQPM-7, a quality protein maize population by following pedigree breeding. Under hot spot locations (Delhi, Ludhiana and Karnal) for Madyis Leaf Blight and Turcicum Leaf Blight, the line displayed a mean disease score of 2.13 and 2.58 while the susceptible check 3.98 and 4.67 and resistance check 1.58 and 1.83, respectively. Hence, this QPM line was found to be superior for traits viz; MLB, TLB and Tryptophan. The inoculation procedure followed as given by Sekhar and Kumar, 2012 on the rating scale of 1-5.

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14. DQL 2048 (IC0621104; INGR17014), a Maize (*Zea mays L.*) Germplasm with Moderately Resistant to Maydis Leaf Blight (MLB) (disease mean score 2.65 on the scale of 1-5). Moderately Resistant to Turcicum Leaf Blight (TLB) (disease mean score 2.33 on the scale of 1-5). Tryptophan content 0.71% in Protein

Ramesh Kumar[1], Jyoti Kaul[2], KS Hooda[1], Dharam Paul[1], Vinay Mahajan[1], Sunil Neelam[4], Chikkappa G Karjagi[3], Bhupender Kumar[3], Ganapti Mukri[2], SB Singh[5], Harleen Kaur[6], N Mallikarjuna[7], R Devlash[8], Avinash Singode[9], Nirupma Singh[2], R Ambika Rajendran[2], Abhijit Kumar Das[1], Yathish KR[1], Vishal Singh[1], Usha Nara[6], Vinod Kumar[2], Khushbu Jain[2] and DS Olakh[1]

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DQL 2048 is a medium maturing quality protein maize line moderately resistant to Maydis Leaf Blight and Turcicum Leaf Blight. It is derived from HQPM-1, a quality protein maize population.

Morpho-agronomic characteristics: DQL 2048 is a medium maturing quality protein maize inbred line with moderately resistant to Maydis Leaf Blight and Turcicum Leaf Blight, medium ear placement, straight attitude of lateral branches, dense spikelets of tassel, yellow and flint kernels. This line is derived from HQPM-1 a quality protein maize population by following pedigree breeding. Under hot spot locations (Delhi, Ludhiana and Karnal) for Madyis Leaf Blight and Turcicum Leaf Blight, the line displayed a mean disease score of 2.65 and 2.33 while the susceptible check 3.98 and 4.67 and resistance check 1.58 and 1.83, respectively.Hence, this QPM line was found to be superior for traits viz; MLB, TLB and Tryptophan.The inoculation procedure followed as given by Sekhar and Kumar, 2012 on the rating scale of 1-5.

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15. PDL-1 (IC0621470; INGR17015) a Lentil (*Lens culainaris* Medikus) Germplasm with Drought Tolerance

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16. SGS 389 (IC0621690; INGR17016), a Sorghum (*Sorghum bicolor* (L.) Moench) Germplasm with Six Stamens and Two Gynoecia and Twin Seeds

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The sorghum [*Sorghum bicolor* (L.) Moench] spikelet normally contains one gynoecium and three stamens. During the germplasm evaluation study performed at Indian Grassland and Fodder Research Institute (IGFRI) in the rainy season of 2012, a novel genotype (identity SGS 389) bearing six stamens and two gynoecium was observed which is a trait reported here for the first time. Critical examination of all the plants of the genotype revealed that this unique trait had 100% expressivity and 100% penetrance. The panicles of 60 plants were enveloped from heading to completion of flowering stage. During the rainy season of 2013, self seeds of each plant were planted in paired rows of 4 m length. No within line and between line variation was observed for the unique trait among the self progenies (Joshi *et al*., 2013; Joshi *et al*., 2015). The panicles of 15 plants were enveloped from heading to completion of flowering stage in each row. Rigorous examination of sessile spikelets in individual plants of each selfed progeny during the rainy season of 2014 revealed that the novel trait is stably inherited, suggesting its genic control. Interestingly, all the spikelets having six stamens and two gynoecia also produced two seeds instead of one, in contrast to the normal sorghum generating one seed per spikelet. Thus production of two seeds per spikelet indicates that all the six stamens and two gynoecia were fertile.

In sorghum deviations from normal floral structures *viz*., spikelet shoots, scaly proliferation, polyembryony and fertile pedicellated spikelets have been observed. However, these deviations are governed by environmental factors and are not hereditary (Stephens, 1936). Furthermore, reports on development of more than one seed/spikelet are available in some American genotypes but these instances are very rare, moreover the spikelet contained one fertile flower in each cases (Karper, 1931). However, the novel genotype reported in the present study is unique as it produces twin seeds but the spikelet bears six stamens and two gynoecia. The novel trait reported in the present study is genetically controlled and stably inherited over the years and generations (Joshi *et al*., 2015). Both way (direct and reciprocal) crosses were attempted between the novel genotype and the normal genotype (three stamens and one gynoecium) to understand the genetic control of the trait. To the best of our knowledge it is the first report on a sorghum genotype having six stamens and two gynoecia. The reported genetic stock seems to be a homeobox mutant. It is extremely useful in deciphering the genetic control and regulatory mechanism of floral structure development and embryogenesis in sorghum in particular as well as grasses in general.

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17. JP-96 (IC0621469; INGR17017), a Castor (*Ricinus communis* L.) Germplasm with Pistillate Line; Good Combiner

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Castor (*Ricinus communis* L.) is an important industrial non-edible oilseed crop grown in various countries throughout the world. Castor oil is used for number of industrial products. During the year 2014-15, the area under castor crop in India was 10.99 lakh ha, which contributed 13.51 lakh metric tonne production with a productivity of 1229 Kg/ha. Gujarat is the leading state in the country with respect to area, production and productivity of castor covering an area of 7.34 lakh ha with the production to 10.69 lakh tonne and average productivity of 1454 Kg/ha (Anonymous, 2015). Genetic diversity of parents is a prerequisite for the development of high yielding hybrids in castor. Efforts initiated at Main Oilseeds Research Station, Junagadh Agricultural University, Junagadh to enhance the diversity of pistillate lines using diverse parents led to identification of the genetic stock JP-96 in a segregating population of the cross JP-66 x 454 with the unique trait of a single male flower at the tip of the spike. Heritability of the trait was observed more than 90% in the population of nearly 80-100 plants every year. This pistillate line was utilized by many centres for hybrid development and gave good hybrids. SHB-896, one of the hybrids from Sardarkrushinagar was performing well in State and AICRP trials having JP-96 as female parent. The proposed stock has other distinct morphological characters like green stem, triple bloom, long (65-75cm), compact spike with spiny capsules (Table 1). The genetic stock has a potential to use in the heterosis breeding as a diverse source of pistillate line and will also be further useful in the study of sex polymorphism in castor and development of genetic stocks for distinct sex expression.

Table 1. Chief botanical and morpho-agronomic traits of JP-96

Sr.	Character	Description
1	Internode type	Elongated
2	Leaf shape	Flat
3	Leaf lascination	Shallow
4	Petiole length	Long (31-40 cm)
5	Petiole surface	Smooth
6	Spike shape	Cylindrical
7	Spike compactness	Compact
8	Capsule spininess	Dense
9	Capsule length (cm)	2-3
10	Location of branch	Basal/ all over
11	Branching pattern	Divergent
12	Seed shape	Oval
13	Seed coat colour	Dark brown/ Blackish
14	Seed mottling	High
15	Seed caruncle	Small
16	Plant height (cm)	70-80
17	Length of primary spike (cm)	65-75
18	Number of nodes upto primary spike	16-18
19	Number of capsules on primary spike	70-80
20	Days to 50% flowering	66-75
21	Days to maturity of primary spike	130-140
22	Number of effective spikes per plant	5-7
23	100-seed weight (g)	33-35
24	Oil content (%)	48-49

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18. PT-141 (IC0621691; INGR17018), a Toria (*Brassica rapa* var. *toria*) Germplasm with Earliness of Maturity; Earliness of Flowering

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Amongst three ecotypes of *Brassica rapa* namely toria, yellow sarson and brown sarson, former, due to its shorter maturity duration, has been traditionally grown as catch crop between rainy (*kharif*) and winter (*rabi*) season crops. Maturity duration of existing toria varieties ranges from 90-95 days. Any source of extra earliness of flowering and maturity in toria will help to develop varieties combining these unique features, which will pave the way for their diversification to new growing situations and regions.

A local germplasm of toria collected from Chamba block of District Tehri, Uttarakhand showed variability for earliness of flowering and maturity. This collection after purification and selection for earliness of flowering and maturity, and uniformity for height and associated characters gave rise to an extra early maturing line of toria named PT-141(Ram Bhajan *et al*., 2013).

Morpho-agronomic characteristics: PT 141 is very early in flowering initiation (~18 days) as well as maturity (56-60 days) (Table-1). Flowering period is considerably reduced which increases synchrony both within and between racemes of a plant. It is known that earliness is associated with increased photoperiod insensitivity (day neutrality) in different crop plants including oilseeds (Singh and Sharma, 1996). Earliness, or day neutrality, of varieties also increases their adaptability.

Extra earliness of flowering/maturity of PT 141 will enable to design a plant type of toria which is high yielding, short stature and extra early maturing. Extra early maturity of this line make it more suitable for use

Table 1. Main features of PT-141 vis-à-vis of PT-303 of toria

Characters	PT-141	PT-303 (check)	SEm±	CV (%)
Altitude of collection site (m)	2229	-	-	-
Days to flowering initiation	18	36	1.61	5.61
Days to maturity	56	95	1.70	6.55
Plant height (cm)	30.8	122	4.45	12.22
Length of main raceme	19.48	49.04	1.29	5.73
Primary branches/plot	3.80	4.93	0.30	9.53
Secondary branches/plot	5.00	6.15	0.49	10.24
Siliqua length (cm)	5.40	5.59	0.21	6.99
Seeds/siliqua	10.60	15.61	0.41	4.61
Siliquae on main raceme	18.00	26.32	0.94	7.14
Siliquae/plant	69.60	131.00	3.72	13.25
1000-seed weight (g)	2.08	2.87	0.10	7.25
Seed yield/plant (g)	2.11	4.22	0.28	12.22

as catch crop and regain the toria area declined in the recent past mainly due to introduction and large scale cultivation of long duration high yielding varieties of rice, in the major rice growing belt of northern India.

Associated characters and cultivation practices: PT 141, besides being early in flowering and maturity, it is dwarf statured than the check variety PT-303 (Table 1) and exhibits satisfactory growth, seed and siliquae set under delayed sowing in the month of November as well. However, sowing after September delays its maturity duration.

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19. CR 143-2-2 (IC0513420; INGR17019), a Rice (*Oryza sativa)* Breeding Line Tolerant to both Vegetative and Reproductive Stage Drought Stress

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The breeding line (CR 143-2-2) was developed at ICAR-NRRI, Cuttack by making a cross between Bala × Lalnakanda 41 following pedigree selection method. This showed tolerance to vegetative as well as reproductive stage drought stress consistently for several years after rigorous screening under simulated moisture stress in the field in NRRI Main Institute and its substation CRURRS, Hazaribag. Under simulated stress during vegetative

Table 1. DUS Characteristics of Rice Germplasm 'CR 143-2-2'

Characteristics	CR 143-2-2 (IC0513420)
Blade colour	Dark Green
Blade pubescence	Pubescent
Basal leaf sheath colour	Pale green
Ligule shape	2-cleft
Ligule length	0.9
Ligule colour	White
Collar colour	Pale green
Auricle colour	Pale green
Internode colour	Green
Flag leaf angle	Descending
Culm angle	Intermediate
Culm strength	Strong (No lodging)
Panicle exsertion	Well exserted
Panicle axis	Droopy
Panicle type	Intermediate
Secondary branching	Heavy
Apiculus colour	Straw

Characteristics	CR 143-2-2 (IC0513420)
Stigma colour	White
Leaf length (cm)	33.6
Leaf width (cm)	1.4
Culm length (cm)	94.3
Culm diameter(cm)	0.5
Number of EBT	8
Panicle length (cm)	25
Awning	Absent
Sterile lemma colour	Straw
Grain length (mm)	8.3
Grain breadth (mm)	3.2
l/b ratio	2.59
Grain shape	Medium
Maturity duration (days)	115
Yield (t/ha)	3.0 (normal) ; 1.6-2.0 (under stress)
Drought scoring (in SES scale)	1

and reproductive stage, CR 143-2-2 was observed to be tolerant with least leaf death score of SES "0" and "1", had high and stable grain yield of around 2.0 t/ha with lowest reduction in yield (10%), highest drought index (90.3)/lowest drought susceptibility index (0.47), high water retention capacity (>70%), highest grain filling (68%) with less impaired translocation at 10-13% soil moisture content and soil moisture tension of -55 to -60 kPa during the stress period (Ramakrishnayya and Swain, 2005; Swain *et al*., 2013). This line also has considerably produced good yield under moderate stress and control conditions (Verulkar *et al*., 2010). It has high *per se* performance for more than one root traits under control and stress conditions. Based on its stable performance, it is being used as a tolerant check in all drought related experiments across the globe. Many breeding lines have been derived taking it as a donor parent and are under study for developing drought tolerant varieties.

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20. COMS 14A & COMS 14B (IC0612955 & IC0612956; INGR17020), a Rice (*Oryza sativa)* CMS line/Maintainer Line with Higher Rate of Medium Slender Grain Type. Good Cooking Quality

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Wild Abortive (WA) cytoplasm was found to be the most stable and about 95% of rice hybrids in the world were based on this single source of cytoplasm for sterility (Virmani, 1998). The major constraint to the popularization of hybrid rice in India is its poor grain quality, though the yield potential is 20% higher than that of inbred varieties. Developing new CMS lines in the background of agronomically adapted and popular varieties is the need of the hour. ADT 43, a derivative of IR50/Improved White Ponni, is a short-duration and popular variety with good grain quality. ADT 43 was crossed with IR69616 A in the hybrid rice breeding programme at Department of Rice, Tamil Nadu Agricultural University, Coimbatore. The hybrid was evaluated in the test-cross nursery during *kharif,* 2000. The hybrids IR69616 A/ADT43–showed a maintainer reaction with 100% pollen sterility at the flowering stage. The male parent, ADT 43 was used as recurrent parent in the backcrossing program. New CMS lines developed through substitution backcrossing have been reported by Ingale *et al.* (2004). After repeated backcrossing of six generations (Rabi 2003), new CMS line, COMS14 A (IR69616 A/ADT43) was developed with better floral characteristics.

This CMS line is of the duration of 115 days with semi dwarf plant type. The panicle exertion percentage is 75.00% with stigma exertion of 75.4% and wide angle of glume opening which makes the line with higher out crossing potential highly amenable for commercial exploitation (Manonmani *et al*., 2012). The grain quality of the CMS line is highly preferable with intermediate amylose content, soft gel consistency and intermediate Gelatinization Temperature. Grain type of the line is medium slender with 1000 grain weight of 15 grams. This type of grain character is highly suitable for market demands of south India. This line was also tested for its physiological efficiency in expressing the yield potential in many of the cross combinations (Malarvizhi *et al*., 2001). The stability of the line was tested across the locations viz., Chinsurah, West Bengal (Nath *et al*., 2016) and Madurai proved that it maintains the 100 % sterility. This new line can be further exploited to develop medium slender rice hybrid with higher yield potential.

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21. COMS 24A & COMS 24B (IC0612957 & IC0612958; INGR17021), a Rice (*Oryza sativa)* Germplasm with CMS Line/Maintainer Line with Higher Rate of Stigma Exsertion. Long Slender Grain Type. High Out Crossing Rate

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Hybrid rice varieties demonstrated 15-20% higher yield comparing to the inbred varieties. The first attempt in India for hybrid rice research was initiated as early as 1987 with the introduction of two CMS lines such as V20A and Zhen Shan 97A from IRRI. Another two CMS lines namely IR58025A and IR62829A were introduced from IRRI in 1991 and the development of new CMS lines in well adapted and high yielding improved varietal background was initiated in 1994. In the initial phases of hybrid rice technology in India, the number of promising hybrids was negligible mainly because of non-adaptable CMS lines that were used in developing hybrids resulted in hybrid impurity and un acceptable grain quality. Therefore, an attempt was carried out with the objective to develop adaptable CMS line with high out crossing rate to develop superior rice hybrids. Keeping this mandate, a new CMS line was developed from the culture CB 97036. The culture CB 97036 was used as a male parent with IR 79156 A and the hybrid was found to be 100% sterile. The hybrid was examined for its floral traits and was found to be promising for its out crossing traits and hence it was back crossed to its recurrent parent, CB 97036 for five generations. Each generation the plants were carefully chosen with good floral traits with complete sterility.

Morpho-agronomic characters: This CMS line is with the flowering duration of 120 days, semi-dwarf plant height (76 cm). This CMS line, COMS 24 A was evaluated along with other CMS lines and was found to be promising for its characters viz., pollen sterility (%), glume angle, panicle exertion, stigma exertion and natural out crossing (Manonmani *et al*., 2012). This line was utilized for developing hybrid combinations with many restorers. The line was evaluated under multi-locations at Coimbatore, Madurai and Aduthurai (Mahalingam *et al*., 2013) and it had reported a stable sterility.

Associated characters and cultivation practices: This line was found to be promising for its seed produceability (Anon, 2014). Staggering recommended for this A & B line is 0, +3, +6 and +9. Other package of practices is as like that of other CMS line seed multiplication. One of the hybrid combination, TNRH 206 (TNAU CMS 24 A/CB 206 R) maturing in 130-135 days was found to be superior in yield and grain quality traits. This hybrid was recommended for on farm testing (Anon, 2012).

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22. DML 339 (IC0612721; INGR17022), a Maize (*Zea mays* L.) Germplasm with Resistance to Charcoal Rot (disease mean score 2.8 on the scale of 1-9). Mean Anthesis Silking Interval of 2.0 days

and

23. DML 1019 (IC0612704; INGR17023), a Maize (Zea mays L.) Germplasm with Resistance to Charcoal Rot (disease mean score 2.3 on the scale of 1-9) in QPM background. Mean Tryptophan (0.90%) and Lysine (3.73%)

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The charcoal rot caused by *Macrophomina phaseolina* is the devastating component of post flowering stalk rot (PFSR) complex which may cause 25 to 32 % yield loss in maize. With availability of different types of corns *viz.*, normal, quality protein maize (QPM), sweet corn, popcorn and babycorn, the availability of resistance sources for major diseases in their genetic background is always preferable. Therefore, the study was carried out to identify stable sources of charcoal rot resistance by multi-environments screening of 137 inbred lines (135 test entries and two checks) including QPM, popcorn and normal under artificially created epiphytotics at hot-spot locations. The resistance sources were identified in normal and QPM genetic backgrounds, however the almost all popcorn lines were sowing high susceptibility for the target disease on 1-9 rating (Sekhar & Kumar 2012: Anonymous 2016; Kumar *et al*., 2016). The two inbred lines, one each in normal (DML339), and QPM (DQL1019), developed at ICAR-IIMR, from selfing of desirable plants in NZBOPH (12) & HQPM-1, respectively followed with ear to row selection continuously for six generations were identified resistant to charcoal rot disease (Table 1). They were registered as unique germplasm for charcoal rot resistance in normal and QPM genetic backgrounds.

Morpho-agronomic and associated characteristics: DML 339 (IC no. 0612721/ INGR17022) is a late maturing charcoal resistant line in normal maize

Table 1. Stable sources of resistance against charcoal rot disease in maize

	Inbred name	Rabi 2012-13 (Hyderabad)-E1	Kharif 2013 (Delhi)-E2	Kharif 2013 (Hyderabad)-E3	Kharif 2015 (Delhi)-E4	Mean	Remarks	DTA	DTS	ASI
	DML 339	2.8	2.4	2.1	2.7	2.5	R	58.5	60.5	2.0
	DQL 1019	2.3	2.2	2.5	2.7	2.4	R	61.5	64.5	3.0
	DQL 1005	2.5	2.0	3.0	3.2	2.7	R	59.0	61.0	2.0
	DML33	2.3	2.8	3.0	5.4	3.4	MR	59	61.5	2.5
	DML 289	3.0	2.3	2.8	4.7	3.2	MR	53.5	57.5	4.0
	DML50	5.0	2.4	4.8	3.7	4.0	MR	51.0	55.5	4.0
	DQL 1022	4.3	1.8	4.5	3.9	3.6	MR	63.0	65.5	2.5
	DML315	4.1	3.1	4.0	2.8	3.5	MR	55.5	59.0	3.5
	CM117-4(RC)	3.1	2.7	3.0	2.4	2.8	R	57.5	60.5	3.0
	WOSC (SC)	7.0	7.0	7.6	7.2	7.2	S	57.0	60.5	3.5
		1.2	1.3	1.3	1.8	1.4	-	2.3	3.0	1.3
LSD (*P*=0.01)										

E*= Environments, Days to anthesis (DTA), Days to silking (DTS), ASI: Anthesis silking Interval, C = Check; Rating scale: 1.0-3.0 resistance (R); 3.1-5.0 moderately resistance (MR), 5.1-7.0 moderately susceptible (MS) and ≥7.1 susceptible (S).

genetic background on scale of 1-9 (Table 1), with low Anthesis Silking Interval (ASI) i.e. 2.0 days, medium ear placement, semi erect leaves, dense spikelets of tassel, yellow and semi-dent kernels. This line has good productivity and hence can be a better female parent in hybrids breeding programme.

DQL 1019 is a late maturing quality protein maize (QPM) showing resistance to charcoal rot disease on scale of 1-9. This line has low Anthesis Silking Interval (ASI) i.e. 3.0 days, medium ear placement, drooping leaf attitude of blade, yellow kernels, and medium cob length. This line has good productivity and hence can be a better female parent in hybrids breeding programme.

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24. IML-PFSR-R3 (IC0593934; INGR17024), a Maize (*Zea mays* L.) Germplasm Resistant to Multiple Disease Post Flowering Stalk Rots, Turcicum Leaf Blight and Maydis Leaf Blight. Stiff and Stay Green Character of Stalk. High Oil Content > 5.0 (5.53%).

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IML–PFSR-R3: Pedigree - (JCY3-7-1-2- 3b-1-1-2-3-1-1-1-1) is inbred line, source of resistance to Post flowering stalk rots of maize caused by *Macrophomina phaseolina* and *Fusarium moniliforme* (Rakshit *et.al* 2011). The primary source of this material is JCY series (pools) from PAU Ludhiana. From this material this inbred line was developed at IIMR New Delhi for desirable character following pedigree breeding methodology. The source material (pools) was received from PAU Ludhiana under collaborative programme. The development of inbred line and multi location evaluation of the genotype was done in hot spot locations at Hyderabad, Udaipur, Delhi and Ludhiana against PFSR from 2010 to 2013 under artificial epiphytotic condition. Maintenance and multiplication of inbred line was done at Indian Institute of maize research New Delhi and winter nursery Hyderabad.

Morpho-agronomic characteristics: Plant exhibited stay-green character, stiff, strong stem, purple brace root, with light purple silk, sparse spikelets, normal silk, Plant length – long, ear conico cylindrical; Grains are semi dent, yellow round in shape with desirable plant type and good agronomic traits like; optimum ear placement, stiff stalk, good pollen shed. The inbred was consistently resistant against PFSR. The disease reaction recorded from 1.0 to 4.2 on 1-9 rating scale (1 is highly resistant, 9 is highly susceptible) across the location during 4 years of testing. Other additional characteristic feature that the high oil content i.e. 5.59 % (dry weight basis).

Stem is green, stiff robust. Resistant against PFSR which is an economically important disease causes reduction of 18.7% in cob weight and 11.2%in 1000-grain weight in infected plants (Cook 1978). The losses due to this disease in India have also been calculated to range from 10 to 42% (Payak and Sharma 1978; Desai *et al.,* 1991; Harlapur *et al.,* 2002).

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25. OMU 005 (IC0503186; INGR17025), a Jute (*Corchorus olitorius* L.) Germplasm with Super Fibre Wedge Length and Diameter

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Due to limited variability of morpho-agronomic characters in jute, fibre anatomy characters are gaining importance in selection of superior genotypes, as many of these characters have high correlation with fibre yield (Satya *et al*., 2011). The jute fibre is a phloic fibre being arranged in a triangular wedge like shape in the bark which grows longitudinally in the stem. As fibre yield cannot be directly evaluated from a plant that is allowed to form seed, the fibre wedge related characters are highly important for non-destructive sampling and selection of superior genotypes with high fibre yield. However, there is little information on variability of fibre wedge characters in jute and no genetic source is identified for high fibre wedge length and diameter in tossa jute.

We have identified a tossa jute mutant genotype OMU 005 (National ID IC0503186, Registration No. INGR17025) superior for two characters, fibre wedge length (1.25 mm) and fibre wedge diameter at base of the wedge (0.61 mm). The genotype consistently outperformed popular cultivar JRO 524 for these two characters during 2012-2015 (Table 1).

Morpho-agronomic characteristics: Morpho-agronomic characterization revealed that the mutant (OMU 005) has plant height: 3.09 m; basal diameter: 1.0 cm; dry fiber percentage: 9.5% and harvest index: 24.7. Plant bears numerous green cylindrical dehiscence capsules having 3 locules filled with small chocolate brown colored seeds with 1.93 gm per 1000 seed weight. Seed was found to be non-dormant with high germination rate (98%).

Table 1. Mean performance of OMU 005 and JRO 524 for fibre yield related anatomical traits over four years (2012-2015)

Anatomical traits	OMU 005	JRO 524
Bark cross-section length (mm)	1.55	1.07
Fibre wedge length (mm)	1.25	0.89
Fibre wedge diameter at base (mm)	0.61	0.37
Fibre bundles / wedge at wedge base	9.59	7.01
Number of fibre cells / bundle	25.10	17.75

Source: ICAR-CRIJAF Annual report 2014-15 (Satpathy *et al.*, 2015)

Associated characters and cultivation practices: The genotype OMU 005 also has high bark cross section length and number of cells/fibre bundle. It also bears high number of fibre bundles per fibre wedge. Cultivation practice during experimentation followed standard crop management practices of cultivated jute species. At molecular level, OMU 005 could be differentiated from other mutant genotypes with closest relative being OMU 009 (Satya *et al*., 2014).

It responses well to standard cultivation practice of tossa jute with seed rate of 300-400 g/ha, row spacing of 30 cm and fertilizer requirement of N:P:K (60:40:40), and harvesting at 120 days after sowing. Flowering is asynchronous, initiates under short day (from September onwards) and seeds are harvested during November-December.

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26. OMU 007 (IC0503703; INGR17026), a Jute (*Corchorus olitorius* L.) Germplasm with Superior Bark Cross Section Length

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As jute fibre is formed in the secondary phloem (bast), bark cross section length (bark diameter) length is an important indicator of fibre yield in jute, which also shows high correlation with basal diameter, another widely used selection criterion for jute genetic improvement (Satya *et al*., 2011). However, basal diameter includes both bast and core diameter, while fibre is only formed in the bast region. Thus bark diameter (representing only the bast region) seems to be a better criteria for selection while targeting fibre yield improvement. Importance of using such anatomical attributes in *tossa* jute (*C. olitorius* L.) fibre improvement had been realized long back, but such traits could not be targeted due to unavailability of suitable genetic source.

OMU 007 is a mutant line originating from JRO 632 that shows considerable higher bark diameter (1.65 mm) than other mutant genotypes and the commercial popular variety JRO 524 (1.07 mm).

Morpho-agronomic characteristics: Morpho-agronomic characterization revealed that the mutant OMU 007 is a dwarf one with plant height: 2.10 m; basal diameter: 1.4 cm; dry fiber percentage: 5.8% and harvest index: 30.3. The mutant bears numerous large and leathery tobacco shaped leaves and green cylindrical non-dehiscence capsules having small chocolate brown colored seeds with 1.41 gm per 1000 seed weight. Seed found non-dormant and can immediately germinate after sowing without any treatment.

Associated characters and cultivation practices: OMU 007 also shows superiority for other fibre anatomy traits such as fibre-wedge length, fibre wedge diameter, number of fibre bundles/fibre wedge and number of fibre cells per fibre bundle over popular variety JRO 524 (Table 1). Molecular genetic studies established this genotype to be distinct from JRO 524 and also form other mutant genotypes available at ICAR-CRIJAF germplasm repository (Satya *et al*., 2014). Using 23 SSR markers, OMU 007could be differentiated from other mutant genotypes at a distance of D = 0.88 in a dendrogram, with closest relative being OMU 001 and OMU 004.

Table 1. Mean performance of OMU 007 and JRO 524 for fibre yield related anatomical attributes during 2012-2015

Anatomical traits	OMU 007	JRO 524
Bark cross-section length (mm)	1.65	1.07
Fibre wedge length (mm)	1.16	0.89
Fibre wedge diameter at base (mm)	0.55	0.37
Fibre bundles / wedge at wedge base	8.69	7.01
Number of fibre cells / bundle	26.49	17.75

Source: ICAR-CRIJAF Annual report 2014-15 (Satpathy *et al*., 2015)

It responses well to standard cultivation practice of tossa jute with seed rate of 300-400 g/ha, row spacing of 30 cm and fertilizer requirement of N:P:K (60:40:40), and harvesting at 120 days after sowing. Flowering is asynchronous, initiates under short day (from September onwards) and seeds are harvested during November-December.

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27. OMU 018 (IC0503297; INGR17027), a Jute (*Corchorus olitorius* L.) Germplasm with High Number of Fiber Cells/Fibre Bundle

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Jute fibre is formed as bundle of fibre cells in the secondary phloem of the bark. each bundle comprises of numerous cells and these bundles are connected to each other providing the meshy structure of jute fibre. Thus number of fibre cells per fibre bundle is an important criterion influencing fibre yield of jute (Satya *et al*., 2011). More number of fibres in a bundle increases fibre bundle strength, a desirable character for spinning and developing geotextiles. Importance Despite being an important character, breeding for higher number of fibre cells per fibre bundle could not be targeted due to non-availability of suitable source genotype.

While screening tossa jute mutants for anatomical traits correlated with fibre yield for a period of four years, OMU 018 a mutant genotype was identified that shows considerable higher number of fibre cells/fibre bundle (28.39) compared to other genotypes and including popular variety JRO 524 (17.75).

Morpho-agronomic characteristics: Morpho-agronomic characterization revealed that the mutant (OMU 018) is a tall plant with height: 3.02 m; basal diameter: 1.2 cm; dry fiber percentage: 6.8% and harvest index: 27.8. The mutant bears numerous red colored cylindrical non-dehiscence capsules having small deep brown colored seeds with 1.96 gm per 1000 seed weight. Seed found non-dormant and can immediately germinate after sowing without any treatment.

Associated characters and cultivation practices: The genotype also shows superiority for other fibre anatomy traits such as bark-cross section length, fibre-wedge length, fibre wedge diameter, and number of fibre bundles/fibre wedge (Table 1). Molecular genetic studies established this genotype to be distinct from JRO 524 and also form other mutant genotypes available at ICAR-CRIJAF germplasm repository (Satya et al., 2014). It responses well to standard cultivation practice of tossa jute with seed rate of 300-400 g/ha, row spacing of 30 cm and fertilizer requirement of N:P:K (60:40:40), and harvesting at 120 days after sowing. Flowering is asynchronous, initiates under short day (from September onwards) and seeds are harvested during November-December.

Table 1. Mean performance of OMU 018 and JRO 524 for fibre yield related anatomical attributes from 2012-2015

Anatomical traits	OMU 018	JRO 524	SD
Number of fibre cells / bundle	28.39	17.75	4.25
Bark cross-section length (mm)	1.39	1.07	0.28
Fibre wedge length (mm)	1.15	0.89	0.24
Fibre wedge diameter at base (mm)	0.51	0.37	0.09
Fibre bundles / wedge at wedge base	8.35	7.01	1.12

Source: ICAR-CRIJAF Annual report 2014-15 (Satpathy *et al*., 2015)

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Satya P, AK Mahapatra and RK Maiti (2011) Fiber anatomy structure: a good predictor for fiber yield and fiber quality in *Corchorus capsularis*. *International Journal of Bio-resource and Stress Management* **2**(3): 263-267.

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