Plant Germplasm Registration Notice*

The Plant Germplasm Registration Committee of ICAR in its XXXXIst meeting held on September 29th, 2020 at the National Bureau of Plant Genetic Resources, New Delhi approved the registration of following 78 germplasm lines out of 80 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. GQ-25 (IC0599273; INGR20001), a Rice (*Oryza sativa*) Germplasm with High Temperature Tolerance

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GQ-25 (Samba Mahsuri/SC5126-3-2-4) is a restorer line developed by Hybrid rice division, ICAR-Indian Institute of Rice Research. as Under NICRA project (http://www.icar-iirr.org:8000/), GQ-25 is identified as one of the promising genotypes under low nitrogen (N) field condition as expressed in terms of grain yield (filled grain weight per hill) and also for terminal high temperature stress tolerance (in terms of stable grain yield under high temperature stress). GQ-25 is a medium duration restorer line with 103-105 days to 50% flowering and medium slender grain type.

Morpho-agronomic characteristics:

Traits under Low N condition	
Plant Height (cm)	105
Tiller Number	11.33
Productive Tiller Number	8.33
Single Plant Yield#(grams) (year 1 and 2)	14.8; 15.4
1000 grain weight (grams)	19.97
Harvest Index	44.72
N% in Straw	0.35
N% in Grain	1.15
N% in Biomass	1.50
Agronomic Efficiency (AE) (kg/kg)	-47.45
Physiological Efficiency (PE) (kg/kg)	120.71
Agro Physiological Efficiency (APE) (kg/kg)	96.44
Apparent Recovery Efficiency (ARE) (%)	-50.49
Utilization Efficiency (UE) (kg/kg)	-61.46
Grain Yield Efficiency Index (GYEI)	0.79

Table 2. Agro-morphological and yield characters of GQ-25 under ambient and high temperature stress condition across the locations under AICRIP Plant Physiology trial

Trait	Grand Mean across the locations			
	2015a		2016b	
	Control	HTS	Control	HTS
Days to 50% Flowering	104	103	96	96
Days to Maturity	132	133	129	128
Grain Yield (grams/m^2)	487	361	489.50	366.25
Total dry matter (grams /m^2)	1182.75	1081	1192	1143.25
1000 grain weight (grams)	20.9	20.8	22	20

a - (CHN, IIRR, MTU, REWA, TTB); b - (IIRR, MTU, REWA, PTB)

Associated Characters and cultivation Practices: NUE: GQ-25 is found to be promising across the seasons and years since 2011(DRR Newsletter, 2013; Venkateswarlu, 2013; DRR Annual report, 2013) under low N field condition in terms of yield, yield related components, and Nitrogen Use Efficiency (NUE) indicators among the evaluated genotypes.

N metabolism genes expression analysis in GQ-25: Up regulation of OsAMT1;1 gene was observed in shoot (86%) and root of GQ-25 (63%) under hydroponics (Srikanth, 2015) and down regulation of OsNIA2gene in GQ-25 in root (64.5%) and up-regulation by 11.13% in shoot (11%) under field condition (Srikanth, 2016) were observed in low N in comparison to recommended N.

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High Temperature Stress: GQ-25 was evaluated for terminal high temperature stress tolerance in AICRIP Plant Physiology trials during 2015 and 2016 across the locations (Chinsurah, Hyderabad (IIRR), Maruteru, Pantnagar, Pattambi, Rewa and Titabar). During 2015, GQ-25 yielded 361 g/m2 under high temperature stress (CHN, IIRR, MTU, REWA, TTB) with 25% reduction over the ambient temperature (IIRR, 2016). Similar trend of yield reduction (25%) was also observed during 2016 for GQ-25 with the mean yield of 366.25 g/m2 under high temperature stress (IIRR, MTU, REWA, PTB (IIRR, 2017). Based on the Yield Stability Index (YSI) values, GQ-25 was selected as heat tolerant and showed non-significant stability variance (σi2) (IIRR, 2017).

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2. AD (Bio) 09518 (IC0635011; INGR20002), a Rice (*Oryza sativa*) Germplasm Carrying *xa5*, *xa13* and *Xa21* Genes for BB Resistance

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Evolving high yielding rice genotypes with durable resistance to bacterial blight (BB) is pertinent considering the extensive damage caused by the disease in most of the rice growing regions. AD (Bio) 09518, a new short duration bacterial blight resistance rice culture was developed through marker assisted selection. None of the popular varieties, ADT 43, ADT (R) 45, ASD 16 are resistant to this important disease. Pyramiding different resistance genes into a rice cultivar would make it an easier genetic resource for breeders to introgress the genes into their local adaptive cultivars. AD (Bio) 09518 is cross derivative of ADT 43 × IRBB60 harboring xa5, xa13 and xa21 with the yield potential of 5965 kg/ha, short duration and high resistance to bacterial blight has been developed through marker-assisted pedigree breeding (Perumalsamy *et al.*, 2010 and Sakthivel *et al.*, 2017). Marker assisted selection for BB resistance genes (xa5, xa13 and Xa21) using functional markers in F2, F3 and F4 generations of ADT43 x IRBB60 and selection of phenotypically superior genotypes with high resistance reaction against bacterial leaf blight leads to identification of this line. Under artificial screening in green house condition both at TNAU, Coimbatore and Indian Institute of Rice Research, Hyderabad, this genotype shows high resistance to bacterial blight. Out of the 12 pathogenic races tested, the culture is resistant to almost all (11) races of the BB pathogen. The culture also showed moderate resistance to blast, sheath rot and leaf folder. It has medium slender grains with high head rice recovery. The culture, AD (Bio) 09518 has amylose content of 25.48 per cent, soft gel consistency and good volume expansion.

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3. IET23814 (RPBIO5478-185M) (IC0635010; INGR20003), a Rice (*Oryza sativa*) Germplasm with High Zinc in Grains. Purple Leaves and Panicles

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RPBio5478-185M is an elite rice line with high grain zinc concentration in both brown (33.5 ppm Zn) and polished (31 ppm Zn) grain. It is a recombinant inbred line identified from the cross Madhukar × Swarna at IIRR, Hyderabad as part of project 3019 of ICAR-Network Project on Functional Genomics and Genetic Modification of crops (NPFGGM, previously NPTC). 185 M showed 102 ppm Zn in F7 unpolished rice using AAS method (Anuradha *et al.*, 2012) and 30 ppm since then consistently using XRF method (AICRIP 2013, 2014, Naik *et al.*, 2020). It showed the highest overall grain zinc concentration of 27.38 ppm in brown rice out of 12 entries in 2013 and 31.69 ppm in polished rice among 45 entries across 17 locations in 2014 in AICRIP-Bio fortification trials of 2013 and 2014 (AICRIP 2013, 2014; Agarwal *et al.*, 2018) (Table 1). It showed the highest overall grain zinc concentration (30.62 mg/Kg) in brown rice among the 68 lines tested in a combined analysis of 15 trials in 3 years and a mean grain yield of 3.08t/ha at 6 other locations with high and low soil zinc (Naik *et al.*, 2020).

It has purple basal leaf sheath, leaves and panicles. It is 129 cm tall, shows 50% flowering in 98 days to 107 days (Naik *et al.*, 2020) and has long bold grains with white pericarp. The range of Fe in this high zinc line was 7.64 to 14.73 mg/Kg in brown rice across 15 locations in 3 years and was considered among the 5 best breeding lines with high Zn or high Fe or both (Naik *et al.*, 2020). In the presence of ascorbic acid, 185M showed higher bioavailability of Fe (2 times) and Zn (3 times) than in Swarna (Raghu *et al.*, 2019). It shows 62% head rice recovery and good cooking quality traits such as alkali spreading value 4, amylose content 24.48% and gel consistency 50 mm (AICRIP 2013). It showed moderate resistance to sheath blight, blast, neck blast, sheath rot and tungro diseases (AICRIP, 2013).

Table 1. Mean Iron and Zinc concentration in unpolished / polished rice of 185M in AICRIP Biofortification trials 2013, 2014 and as reported by Naik *et al*. (2020).

Identity	AICRIP Biofortification trial-2013 (polished rice)*			AICRIP Biofortification trial-2014 (polished rice)*			Naik *et al.* (2020) mean of 15 trials in 3 years (2014, 2015, 2016) in unpolished rice*		
	Zn (ppm)	DFF (days)	Yield (t/ha)	Zn (ppm)	DFF (days)	Yield (t/ha)	Zn (ppm)	*dff* (days)	Yield (t/ha)
185M (IET23814 RPBio5478-185M)	20.56	99	2.45	31.69	98	2.72	30.62	107	3.08
Kalanamak micronutrient check	16.23	105	3.08	18.29	103	3.01	-----	-----	-----
Chittimuthyalu micronutrient check	15.78	109	2.38	21.49	104	3.29	-----	-----	-----
BPT5204 yield check	15.29	109	3.95	15.51	112	4.19	22.8	114	3.24

DFF- days to 50% flowering; dff- days to 40% flowering, *In 2013, Out of 12 entries across 5 zones in 17 locations 185M showed overall mean value of highest zinc 27.38 ppm in brown and 20.56 ppm in polished rice (AICRIP annual report 2013 vol.1 – 1.465). In 2014, out of 45 entries in 17 locations 185M showed overall mean value of highest zinc 31.69 ppm in polished rice (AICRIP annual report 2014 vol.1–1.572).

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4. Rice Tetra 5-40 (IC0635009; INGR20004), a Tetraploid Cytotype (2n=4x=48) of Rice (*Oryza sativa*)

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Rice, (*Oryza sativa* L.) is one of the major cereals catering to the food needs of the worlds' population. It is a diploid with 2n=2x=24 chromosomes and designated with AA genome. One of the major breeding strategies had been to gain heterosis in this crop is utilizing indica and japonica subspecies. In order to overcome the yield plateau, rice polyploidization is suggested as one of the approaches (Cai *et al.*, 2005, Tu *et al.*, 2007, Liu *et al.*, 2009). Rice polyploidization also have the potential to improve yield, enhancing fertility of inter-subspecific hybrids (indica x japonica) (Guo *et al.*, 2017, Tu *et al.*, 2007), enhanced vegetative growth, increased protein and total amino acid content (Song and Zhang, 1992), and enhanced resistance and epigenetic elements (Guo *et al.*, 2017). Rice tetraploids also offer new germplasm for polyploid rice breeding, understanding complex regulatory mechanisms associated with heterosis and fertility, as well as understanding ploidy-induced traits expression and as a source material for interspecific hybridisation utilising alien polyploid Oryza species (Kaushal and Ravi, 1998).

In an effort to generate tetraploidy in rice, anther-culture derived regenerants were utilized from a diploid rice line CR5-40. The regenerants were screened for their ploidy utilizing meiotic and flow-cytometry analysis (Mishra *et al.*, 2015). Amongst the tetraploid lines, a line viz. Rice Tetra 5-40 was selected and stabilized through eight generations of self-pollination, eliminating diploid revertants in each generation. There were no revertants since last four generations and the line got fixed for its tetraploid cytotype.

The line Rice Tetra 5-40 contained 2n=4x=48 chromosomes and possessed 1.8 pg sporophytic DNA content, representing double the content in diploid lines. These plants were believed to have originate from endo-polyploidized cells during tissue-culture cycle. Rice Tetra 5-40 line was also characterised for morphological traits such as pollen fertility (70%), spikelet fertility (55-60%) number of tillers/plant (16.0), plant height (95.7 cm), leaf length (57.6 cm) and width (2.0 cm), number of leaves/plant (5.5), panicles/plant (15.6), panicle length (21.5 cm), 100 seed weight (2.4 g) etc. The flowering initiated in 100 days, the seeds had awns, with total seed weight of 32.5 g per plant.

The line (Rice Tetra 5-40), thus represented a stabilized tetraploid line with potential for polyploidy research and interspecific hybridization with alien polyploid *Oryza* species. To the best of our knowledge, this is the first tetraploid rice registered in India.

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5. HI 8791 (IC0635014; INGR20005), a Wheat (*Triticum turgidum* subsp. durum) Germplasm with Resistance to Stem Leaf and Stripe Rusts. Resistance to Flag Smut. High Yield Potential.

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Globally, durum wheat occupies nearly 13 million hectares with production of 30 million tons (Kadkol and Sissons 2016) and a productivity of ~2.3 tons/ha. In India, Central and Peninsular zones are the major durum wheat growing regions. Rusts and other diseases affect durum wheat production in these regions. Developing new varieties having broader genetic base with resistance to multiple disease resistance along with high yield potential is the need of the day as these pathogens keeps on evolving leading to new virulent races. Identifying and utilizing multiple disease resistant along with high yielding genotypes is important in durum wheat improvement.

HI 8791 (HI1531/HI8498//HI8627), durum wheat genotype was developed, which is an erect genotype having strong waxiness on leaf sheath, peduncle and spikes. It is a dwarf genotype (85-90 cm) exhibiting medium late maturity (110-120 days). The grains are hard, amber coloured weighing 42-45 gm/1000 seeds. HI 8791 is a very high yielding genotype, with an average yield of 43.0 and 38.4 q/ha in National Initial Varietal Trials (NIVT) and Advanced Varietal Trials-I (AVT-I) respectively. It showed significant superiority of 16% to 2.6% in NIVT and AVT-I, respectively in comparison to check variety HI 8627 in Central Zone.

HI 8791 was found to be resistant to stem, leaf and stripe rusts; and flag smut in multi-location testing viz., Plant Pathological Screening Nursery (PPSN), Elite PPSN and Multiple Disease Screening Nursery (MDSN) from 2016 to 2019 (Table 1). The average co efficient of infection was below 7 for all three rusts over the years of testing. It showed high levels of adult-plant resistance to most prevalent and virulent pathotypes like 77-5 and 77-9 of leaf rust, 40A and 117-6 of stem rust, and 46S119 and 110S119 of stripe rust in isolated nurseries. It also showed immune response to flag smut (Table 2) over two years of testing at different locations. As the availability of multiple disease resistant high yielding genotypes is rare, HI 8791 can be used as potential resistance donor to breed varieties against these multiple pathogens (stem, leaf & stripe rusts; and flag smut) and also a source for high grain yield.

Table 1. Disease data of HI 8791 in comparison with check varieties over years

Year	Trial	Genotype	Stem rust		Leaf rust				Stripe rust	
			South		South		North		North	
			HS	ACI	HS	ACI	HS	ACI	HS	ACI
2015-16	NIVT 5B	HI 8791	TR	0.1	10MS	1.5	20MR	1.1	5MS	0.5
		HI 8627 (c)	5MR	0.5	10MS	1.3	20MR	1.3	40S	4.7
2016-17	AVT I	HI 8791	10MR	1.0	20MR	1.5	TMR	0.1	20MR	4.6
		HI 8627 (c)	10MR	0.8	20S	3.7	0	0	20MR	3.5
2017-18	EPPSN	HI 8791	5MR	1.0	40R	4.1	5S	1.0	10MS	2.3
2018-19	MDSN	HI 8791	30MS	6.6	20S	5.2	TR	0.1	20MS	5.2

(HS-Highest score, ACI-Average Coefficient of Infection)

Table 2. Disease score of Flag smut

Year	Trial	Genotype	Flag smut (%)					
			Ludhiana	Hisar	Durgapura	Karnal	HS	Average
2016-17	AVT I	HI 8791	0.0	0.0	0.0	0.0	0.0	0.0
		HI 8627 (C)	0.0	0.0	0.0	8.8	8.8	2.2
2018-19	MDSN	HI 8791	-	-	-		0.0	0.0

Source: ICAR-IIWBR – Crop Protection Report (2016-19).

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6. HI 1619 (IC0635015; INGR20006), a Wheat (*Triticum aestivum*) Germplasm with Resistance to Leaf and Stripe Rusts, Karnal Bunt and Flag Smut. High Yield Potential.

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HI 1619 (W15.92/4/PASTOR//HXL7573/2*BAU/3/WBLL1), a bread wheat genotype with semi erect growth habit, having strong waxiness on leaf sheath, flag leaf, peduncle and spike. It is a medium tall (100-105 cm), medium late maturing (140-145 days) genotype. HI 1619 showed significant superiority in grain yield (46.9 q/ha) of 0.2- 5.9% over checks (WH 1142 - 44.3q/ha, HD 3043-44.7q/ha, PBW 644- 46.3q/ha and WH 1080-46.8q/ha) in NIVT and AVT-I restricted irrigation conditions of North Western Plains Zone trials.

HI 1619 was found to be resistant to leaf and stripe rusts, Karnal bunt and flag smut in multi-location testing from 2016 to 2019 (Table 1). It showed ACI values of below 7 for both leaf and stripe rusts. It showed high levels of adult-plant resistance to most prevalent and virulent pathotypes like 77-5 and 77-9 of leaf rust and 46S119 and 110S119 of stripe rust in isolated nurseries. It also showed resistance to other diseases like flag smut (Table 2) and Karnal bunt (Table 3). As the availability of multiple disease resistant high yielding genotypes is rare, HI 1619 can be used as potential resistance donor to breed varieties against these multiple pathogens and also a source of high grain yield.

Table 1. Field responses of HI 1619 to leaf and stripe rusts along with check varieties

Year	Trial	Genotype	Leaf rust				Stripe rust	
			South		North		North	
			HS	ACI	HS	ACI	HS	ACI
2015-16	NIVT 5A	HI 1619	10S	2.7	10S	2.5	20S	2.0
		DBW 110(c)	10S	1.8	10S	1.5	60S	15.6
2016-17	PPSN AVT	HI 1619	40S*	6.1	TMR	2.1	15S	1.8
		PBW 644 (c)	10S	3.8	10S	2.2	40S	17.6
		WH 1142 (c)	40S	8.1	40S*	8.1	5S	1.4
		HD 3043 (C)	20S	7.9	60S	16.9	60S	28.2
2017-18	EPPSN	HI 1619	30R	2.1	TS	0.2	10S	3.1
2018-19	MDSN	HI 1619	5MS	1.0	5S	1.7	40S	7.5

(HS-Highest score, ACI-Average Coefficient of Infection)

Table 2. Disease score of Flag smut

Year of testing	Trial		Flag smut (%)					
			Ludhiana	Hisar	Durgapura	Karnal	Highest Score	Average
2016-17	AVT I	HI 1619	0.0	2.0	10.5	2.1	10.5	3.7
		CHECK	15.0	36.6	28.6	23.5	36.6	25.9
2017-18	MDSN		-	-	-	-	3.5	-

Table 3. Disease score of Karnal bunt

Year of testing	Trial		Karnal bunt (%)					
			Jammu	Hisar	Delhi	Ludhiana	HS	Avg
2014-15	NIVT 5A	HI 1619	-	-	-	1.2	1.2	
		DBW 110 (C)	-	-	-	5.83	5.83	
2016-17	AVT I	HI 1619	0.0	0.0	0.0	1.0	1.0	0.3
		HD 2967 (C)	19.6	25	14.3	9.0	25	17.0
2018-19	MDSN	HI 1619	-	-	-	-	0.0	
		UP 2338					12.3	

Source: AICW&BIP – Crop Protection Report (2016-19)

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7. DBW 278 (IC0635016; INGR20007), a Wheat (*Triticum aestivum*) Germplasm with High Sedimentation Value under Very Late (January) Sown Conditions of Northern Plains. Additional Feature of Multiple Disease Resistance (Leaf Rust, Karnal Bunt and Flag Smut).

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The northern plains follow sugarcane-wheat, vegetable pea- wheat, potato-wheat crop rotations for which a wheat genotype is needed which can be sown under very late sown conditions especially in the month of January. In order to realise the higher yield levels in very little crop period, the early maturing habit coupled with bolder seeds is needed. The grain quality in this regard has immense value especially the product and nutritional quality. The wheat improvement programme for warmer area has focus of development of early maturing wheat genotypes that can withstand terminal heat stress during grain growth period and yield more than the other traditional cultivars. A bread wheat genotype DBW 278 has been developed in this programme and has been evaluated under Special trial on Very late (January) sown conditions (Spl-VLS) of the North western plains zone and north eastern plains zone for yield, disease resistance and quality traits. DBW 278 was identified as a promising high yielding and disease resistant genotype possessing high sedimentation value along with better grain protein content, grain appearance score as well as test weight.

The proposed genetic stock DBW 278 (PHS 714/UP 2425) was developed through modified pedigree method. The female parental line PHS 714 was germplasm line evaluated in IIWBR station trial during 2007-08 and UP 2425 was high yielding bold seeded variety for north western plains zone. The line DBW 278 was evaluated in preliminary yield trials and based on its performance, it was contributed in coordinated trials under AICRP on Wheat & Barley in Special trial under very late sown (January) conditions meant for NWPZ and NEPZ during 2017-18. The trial was conducted at 15 locations along with three check varieties DBW 14, DBW 71 and WR 544 and data from 13 locations namely Pantnagar, Ludhiana, Karnal, Hisar, Delhi, Bulandshahar and Nagina of NWPZ and Coochbehar, Varanasi, Kanpur, Barabanki, Sabaur and Pusa of NEPZ were pooled for analysis. The seed from Pantnagar, Ludhiana, Hisar, Delhi, Sabaur and Pusa were analysed for quality traits to estimate various quality parameters as per standard procedures adopted under AICRP on Wheat & Barley.

Yield improvement is the prime objective and the farmers require genotypes suitable to January sown conditions that can fit in crop rotation after potato, sugarcane, green pea, etc. The pooled results of north western plains zone and north eastern plains zone together indicated significant yield superiority of DBW 278 (32.5q/ha) over all the check varieties with highest yield potential of 43.8q/ha in January sown conditions as compared to all the check varieties (ICAR-IIWBR, 2018a). It also showed earliness, tall plant stature and bolder seeds. Tall plant height is desirable to get more straw yield for less time span and bolder seed s enhance the consumers' preference.

In addition to yielding ability, the quality parameters are becoming important due to consumer's preference for product making and value addition. For making good quality chapatti, the key quality traits are grain protein content (11-13%), grain hardness (40-75) and sedimentation value (30-60 ml). DBW 278 showed higher values of these key determinants while pooled the data of centres from NWPZ and NEPZ (ICAR-IIWBR, 2018b). It has mean sedimentation value of 67 ml with range of 66-70 ml which is >30.0% higher than the best check DBW 71 (51.1ml) indicating better gluten strength in DBW 278. It also possesses high grain protein content of 13.2% and desired level of test weight (77.5kg/hl), grain hardness index (75) and grain appearance score of 6.6 out of 10.0.

The entry DBW 278 also showed better resistance to leaf rust, leaf blight, powdery mildew, Karnal bunt, and flag smut diseases as compared to check varieties in multilocational evaluation under PPSN (ICAR-IIWBR, 2018c). It was categorised as resistant to leaf rust (ACI upto 10.0), Karnal bunt (Av upto 5.0) and flag smut (Av upto 10%) as per the AICRP on Wheat & Barley standards.

From the results, it is concluded that DBW 278 has high yield potential under January sown very late conditions alongwith better quality traits for chapatti and multiple disease resistance and thus, it can be used as potential donor for wheat improvement programmes for yielding ability and quality traits with special emphasis on adaptability to very late sown conditions.

Performance of DBW 278 and checks for yield traits, quality and disease resistance under very late sown conditions of northern plains

Traits	DBW 278	DBW 71 (C)	WR 544 (C)	DBW 14 (C)	CD (10%)
	Mean (Range)	Mean (Range)	Mean (Range)	Mean (Range)	
Yield & ancillary traits					
Grain yield (q/ha)	32.5 (17.2-43.8)	31.1(20.8-42.8)	27.7(16.2-40.0)	31.0 (20.4-40.5)	0.7
Days to maturity	97 (83-107)	99 (87-108)	95 (77-105)	97 (80-107)	
Plant height	90 (71-102)	80 (67-87)	85 (65-98)	76 (59-89)	
1000-grains weight	37.5 (28-43)	32.5 (24-44)	34.5 (24-39)	36.0(24-44)	
Quality					
Sedimentation (ml)	67.0 (65.6-69.7)	51.1 (47.9-54.1)	47.9 (41.7-50.7)	51.1 (46.8-54.4)	
Protein content (%)	13.2 (11.9-14.1)	12.8 (11.3-13.7)	13.3 (11.8-14.1)	12.9 (11.6-13.6)	
Grain appearance (GAS)	6.6 (5.5-8.0)	6.5(5.5-7.5)	3.4 (2.0-6.5)	5.6 (5.0-6.0)	
Test weight (Kg/hl)	77.5 (74.0-80.5)	76.3(72.0-78.5)	79.2 (74.0-83.0)	75.6 (70.2-79.0)	
Grain hardness index	75	83	83	86	
Disease resistance					
Brown rust (ACI/HS)	5.7(30S)	11.3(40S)	7.8 (30S)	14.0 (60S)	
Powdery mildew (Av/HS)	3(6)	4(8)	5(9)	3(7)	
Karnal Bunt (Av/HS)	4.0(7.1)	14.8(41.3)	4.5(11.4)	4.5(9.2)	
Flag smut (Av/HS)	1.4(5.7)	14.4(54.6)	10.8(37.5)	7.3(25.0)	

HS- Highest score ; ACI- Average coefficient of infection for rust diseases; Av- Average score for other diseases

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8. DBW 166 (IC0635017; INGR20008), a Wheat (*Triticum aestivum* subsp. *aestivum*) Germplasm with High Water Use Efficiency. Low Drought Susceptibility Index. Heat Tolerance with Lower Grain Yield Reduction under Heat Stress.

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Wheat being a primary staple food of India is cultivated in 30 m ha area (GOI, 2017; I. Sharma *et al.*, 2015). Wheat depends extensively on groundwater for irrigation. Recent decades have experienced a steady increase in the depth of the groundwater table in wheat growing regions of Indo Gangetic plains (Hira, 2009; Rodell *et al.*, 2009). The current water productivity of wheat is estimated to be about 0.8 - 1.06 kg m^{-3} in India (Meena *et al.*, 2015; Zwart *et al.*, 2010). Uncontrolled irrigation supported by subsidized/free electricity clubbed with low water productivity is leading to unsustainability of the traditional wheat cultivation (Humphreys *et al.*, 2010; Meena *et al.*, 2019).

The situation therefore calls for development of improved agronomic management options as well as identification of water use efficient genotypes with better yield. Looking at the necessity for wheat genotypes with high water productivity which can be readily adoptable at farmer's field, the present study has been undertaken aiming at identifying high WUE wheat genotypes under limited moisture conditions.

Seventy-one genetically diverse wheat genotypes were screened for high water use efficiency (WUE) under limited soil moisture level at 60 % of Cumulative Pan Evaporation (CPE) during 2015-16. Out of these best performing sixteen high WUE genotypes were shortlisted for a detailed field study during 2016-17 and 2017-18.

The proposed genotype (DBW166) had shown the high water use efficiency 2.00 kg m^{-3} during the two years of testing at 60and80% CPE and it was better than the check varieties HD2967, PBW550, WH1105 and DBW88 (Table1 and 2). The genotype was also higher yielding as compared to check varieties at 60% and 80% CPE treatment during both years.

DBW166 genotype was evaluated at multiple locations (total 17) in drought tolerance screening nursery (DTSN) for two years i.e 2015-16 to 2016-17. Based on drought sensitivity index (0.64) it has shown tolerance against the drought (Table-3) and was comparable with the tolerant check C-306 (0.55).

Table 1. Average Wheat WUE, of wheat genotype DBW166 in comparison on the basis of experiment during 2016-17and 2017-18

Genotypes	WUE 60%		WUE 80%		WUE Avg
	16-17	17-18	16-17	17-18	
	kg m^{-3}		kg m^{-3}		kg m^{-3}
DBW166	2.33	2.04	2.00	1.61	2.00
HD2967 (C)	2.19	1.78	2.15	1.42	1.89
PBW 550 (C)	2.03	1.43	1.65	1.26	1.59
WH1105 (C)	2.22	1.69	1.91	1.54	1.84
DBW 88 (C)	2.42	1.69	2.00	1.59	1.93

Table 2. Average Wheat grain yield, of wheat genotype DBW166 in comparison on the basis of experiment during 2016-17 and 2017-18

Genotypes	GY at 60%CPE		GY at 80% CPE		Avg GY
	16-17	17-18	16-17	17-18	
	kg ha^{-1}		kg ha^{-1}		
DBW166	4139	5128	4770	4931	4742
HD2967 (C)	3899	4467	5104	4350	4455
PBW 550 (C)	3619	3579	3919	3875	3748
WH1105 (C)	3945	4241	4519	4719	4356
DBW 88 (C)	4315	4255	4731	4869	4542

Table 3. Drought Sensitivity Index (DSI) of DBW166 tested in Drought Tolerance Screening Nursery (DTSN) during 2015-16 and 2016-17 (avg. values of 17 centres)

Genotype	2015-16	2016-17	Avg.
DBW166	0.99	0.29	0.64
C-306 (C)	0.61	0.49	0.55

9. RWP-2017-21 (IC0635018; INGR20009), a Wheat (*Triticum aestivum*) Germplasm with Heat Tolerance and Lower Grain Yield Reduction under Heat Stress.

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Wheat, a major staple crop of the world as well as of India, provides food and nutritional security to millions of the global population. It provides 55% of carbohydrates, and 21% of protein needs of daily human requirements at the global level. Wheat crop is exposed to many abiotic stresses like drought, heat, salinity etc. According to a special report on global warming, by the Intergovernmental Panel on Climate Change (IPCC), global temperatures are expected to continue to increase by a further 1.5°C between 2030 and 2052. The whole wheat-cropped area in India experiences heat, while the central and peninsular parts experience heat stress all through the crop season, significant parts of north-western and north-eastern plains experience terminal heat. Under controlled experiments, grain yield of wheat per spike was reduced by 3–4% per 1°C increase in temperature above 15°C. Hence, it is very much required to identify the genotypes tolerant to heat stress condition, further to develop heat tolerant varieties for cultivation to cope up with future climate change and global warming scenario.

RWP-2017-21 was selected at ICAR-Indian Institute of Wheat and Barley Research (ICAR-IIWBR) in 15th Heat Tolerance wheat yield international trial (15th HTWYT-5) during 2016-17 crop season. The HTWYT trial from CIMMYT was constituted mainly by considering the entries having traits for heat tolerance. RWP-2017-21 was one of the highest yielding entry in the 2016-17 HTWYT trial with 107 cm plant height and 43gm thousand grain weight. This promising entry was further used for evaluation in our national multi location heat tolerance trial (MLHT1) during the year 2017-18 crop season and was evaluated in Pune, Niphad, Parbhani and Junagadh centres which are found to be hot spot locations for heat stress. RWP-2017-21 was found to be promising and has showed HSI lower than checks, DBW150 and WH730 which are registered genetic stocks for heat stress and HD2932 which is a promising heat tolerant variety for late sown conditions. Further, the entry was again validated for the second year also in the MLHT trial in the same hot spot locations. The two years data was pooled and the pooled analysis showed that RWP-2017-21 was found be highly promising with lower heat sensitivity index (HSI) (0.93) and also recorded with lower yield reduction of 18% compared to checks (Table 1). Lower yield reduction under heat stress is the important character of a heat tolerant genotype. Thus, RWP-2017-21 will serve as a potential source to be utilized in future breeding programs to develop heat tolerant wheat varieties.

Table 1. The HSI of genotypes pooled over two years (2017-18 & 2018-19)

Genotype	HSI	Yield Reduction %
RWP-2017-21	0.93	18
DBW150(C)	1.01	19.4
HD2932(C)	0.98	18.8
WH730(C)	1.25	24

10. RW 5 (IC0635019; INGR20010), a Wheat (*Triticum aestivum*) Germplasm with Drought Stress and Heat Stress Tolerance.

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World-wide, climate change and shrinking water resources have identified drought as the most important abiotic stress affecting the productivity of field crops. Wheat is an important food crop in India often seriously affected by high temperature and water stress. In India, even though 90% of the wheat is grown under irrigated conditions, only one-third receives full irrigation while the rest is cultivated under partial irrigation. It is likely that water will become a limiting factor for sustained production of wheat in India. Wheat yields have been projected to reduce by an amount of 2292.6 (1000 metric ton) under irrigated conditions due to the impact of climate change and associated water scarcity by the year 2030. The whole wheat-cropped area in India experiences heat, while the central and peninsular part experience heat stress all through the crop season and significant parts of north-western and north-eastern plains experience terminal heat. Hence, it is needed to develop both drought and heat stress tolerant genotype to combat the climate change.

A recombinant inbreed line (RIL) RW 5 developed from the cross of RAJ 4014/WH 730 was tested in drought tolerance screening nursery (DTSN) of AICRP programme, under moisture stress during 2015-16 and 2016-17 crop seasons. The nursery was conducted across eight locations (Akola, Pune, Indore, Sagar, Kanpur, Ranchi, Karnal and Hisar). Phenotypic data such as, days to heading, days to maturity, plant height, productive tillers, grain yield and thousand grain weight were recorded. Based on the pooled analysis of two years data it was found that RW 5 showed lesser reduction (9.6%) in number of productive tillers and biomass (21.7%) as compared to check (C 306) under drought stress in comparision to irrigated condition. RW 5 is an early flowering genotype with a plant height of 73 cm. Harvest Index and grain yield reduction under moisture stress was at par with C 306(C), Test weight of RW 5 (40.4g) was numerically higher than C 306 (39.9g) with a spike length of 11 cm having 53 grains per spike. RW 5 showed a DSI value of 0.51 which is lower than popular drought tolerant variety C 306 (0.55). Since RW 5 was found drought tolerant across all four zones of the country, this depicts its wider adaptability as well. Hence, this genotype can be used as a potential donor in drought stress wheat breeding programme with an added advantage of reduced height compared to C 306.

The RW5 was also tested under MLHT trial during 2017-18 & 2018-19 crop seasons across 10 locations accounting for all 4 major wheat growing zones of India. It has showed lower HSI compared to the check WH730 with lower reduction in grain yield across zones. Hence, RW5 can serve as a potential donor parent simultaneously both for drought and heat tolerance in wheat hybridization programme.

Table 1. Mean drought susceptibility index (DSI) of RW 5 and C 306 (Pooled over years centre wise)

Genotype	DSI	Test Weight (g)	Harvest Index	Plant Height (cm)
RW 5 (RAJ4014/WH 730)	0.51	40.4	0.34	73
C 306 (C)	0.55	39.9	0.33	101

Table 2. The Pooled HSI of RW5 during MLHT 2017-18 &2018-19 crop seasons across zones

Genotype	HSI pooled CZ&PZ	HSI pooled NWPZ &NEPZ
RW5	1.07	1.02
WH730(C)	1.25	1.15

11. Karan Poshan 1 (33/2/1) (IC0635020; INGR20011), a Wheat (*Triticum aestivum*) Germplasm with High Grain Zinc Content (78.4 ppm).

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Worldwide over 2 billion people suffer from iron (Fe), zinc (Zn) and/or other (multiple) micronutrient deficiencies. In India, 48% of children under the age of 5-10 years have zinc/iron or some other micronutrient deficiency. Zinc is one of the important micronutrient for normal growth and development.

A set of 21 Amphidiploids with 4 international checks received from the University of Nottingham, United Kingdom under DBT-BBSRC project and 4 Indian checks (2 aestivum + 2 durum) were evaluated for zinc, iron, protein content, agronomic traits and disease resistance. They were planted continuously for 3 years in simple randomized block design with 4 rows of 2.5 meter plots in replication at IIWBR-Hisar farm and IIWBR-Karnal.

Agronomic traits like days to heading (DTH), days to maturity (DTM), plant height, (PHT), thousand grain weight (TKW), and chlorophyll content index were recorded. Zinc and iron estimations were performed using an Oxford instruments X-Supreme 8000. Karan Poshan 1 (33/2/1) was recorded highest grain zinc concentration (78.4 ppm) as compared to all the tested genotypes and both national and international check varieties. Percent superiority ranges from 58-118 over check variety.

Thus, Karan Poshan 1 (33/2/1) would be a potential source to be utilized in future breeding programs to develop bread wheat varieties with high grain zinc concentration.

Genotypes	Grain Zinc (ppm)	Percent Superiority Over Checks
Karan Poshan 1 (33/2/1)	78.4	-
T. aestivum cv. Paragon (C)	49.6	58
T. aestivum cv. High bury (C)	46.6	68
T. aestivum cv. Chinese spring (C)	43.6	80
T. aestivum cv. Pavon 76 (C)	47.7	64
MACS 6222 (C)	40.9	92
HI 8498 (C)	40.2	95
KRL 210 (C)	36.2	117
HD 2967 (C)	35.9	118

12. Karan Poshan 2 (98/3) (IC0635021; INGR20012), a Wheat (*Triticum aestivum*) Germplasm with High Grain Iron Content (62.9 ppm).

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Worldwide over 2 billion people suffer from iron (Fe), zinc (Zn) and/or other (multiple) micronutrient deficiencies. In India, 48% of children under the age of 5-10 years have zinc/iron or some other micronutrient deficiency. Iron is one of the important micronutrient for normal growth and development.

A set of 21 Amphidiploids with 4 international checks received from the University of Nottingham, United Kingdom under DBT-BBSRC project and 4 Indian checks (2 aestivum + 2 durum) were evaluated for zinc, iron, protein content, agronomic traits and disease resistance. They were planted continuously for

3 years in simple randomized block design with 4 rows of 2.5 meter plots in replication at IIWBR-Hisar farm and IIWBR-Karnal.

Agronomic traits like days to heading (DTH), days to maturity (DTM), plant height, (PHT), thousand grain weight (TKW), and chlorophyll content index were recorded. Zinc and iron estimations were performed using an Oxford instruments X-Supreme 8000. Karna Poshan 2 (98/3) was recorded highest grain iron concentration (62.9 ppm) as compared to all the tested genotypes and both national and international check varieties. Percent superiority ranges from 40-55 over check variety.

Thus Karna Poshan 2 (98/3) would be a potential source to be utilized in future breeding programs to develop bread wheat varieties with high grain iron concentration.

Genotypes	Grain Iron (ppm)	Percent Superiority Over Checks
Karna Poshan 2 (98/3)	62.9	-
T. aestivum cv. Paragon (C)	44.8	40
T. aestivum cv. High bury (C)	42.9	47
T. aestivum cv. Chinese spring (C)	41.4	52
T. aestivum cv. Pavon 76 (C)	41.7	51
MACS 6222 (C)	45.0	40
HI 8498 (C)	43.3	45
KRL 210 (C)	42.8	47
HD 2967 (C)	40.6	55

13. HS628 (IC0635022; INGR20013), a Wheat (*Triticum aestivum* subsp. *aestivum*) Germplasm with Resistance to all Pathotypes of Brown Rust except 77-8.

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Leaf rust, also known as brown rust, is caused by fungus Puccinia triticina Eriks, (Pt). It occurs worldwide wherever wheat is grown and probably causes more damage than any other wheat rust. The South Asian countries viz., India, Pakistan, Bangladesh and Nepal grow wheat in nearly 37million hectares (mha), of which 30mha are at risk of losses due to leaf/brown rust infestation (Huerta-Espino *et al.* 2011). Therefore, it is imperative to develop rust resistant plant genetic resources effective against brown rust in India. HS628, was developed from a cross HS240*2/FLW20(Lr19)//HS240*2/FLW13(Yr15) using Bulk-Pedigree method of breeding at Indian Agricultural Research Institute, Regional Station, Shimla. HS628 has shown resistance to all the pathotypes of brown rust except 77-8 (Table1). HS628 has shown adult plant resistance under epiphytotic conditions to brown rust (AC1=0.1 to 0.6) (Singh *et al.*, 2016). The field population of Pt pathotype in Northern India, lacks virulence for Lr19 (Bhardwaj and Singh 2019). HS628 has been postulated and validated to carry Lr19/Sr25 using STS markers PSY1-E1 and Gb (Pal *et al.*, 2018). HS628 has semi-erect growth habit, coleoptile pigmentation absents, semi-erect flag leaf attitude, auricle pigmentation absent, rudimentary hairs on auricle, waxy leaf sheath, non-waxy flag leaf, weak ear waxiness, weak waxiness of peduncle, tapering ear shape, medium ear length (11.0 cm), awns present, outer glume pubescence absent, medium shoulder width, medium beak length, ear colour white, plant height (89.5 cm), peduncle length (38.2 cm), takes 189 days to mature. It has lustrous semi-hard ovate shaped amber grains with 38g thousand grain weight. The rust resistance gene pool present in HS628 would prove useful gene source for developing potential rust resistant genotypes and/ or serve as potent donor for creating new usable variability against wheat rusts in India.

Table 1. Response of HS628 against brown rust pathotypes under Seedling Resistance Test during 2017-18.

77-5	77-9	77-7	77-10	104-2	12-5	77-8	16-1	77-2	12-2	12-7	11
0;	0;	0;	0;	0;	0;	3+	;	0;	0;	0;	0;

0; (naught fleck) / ; (fleck) / ;1 (fleck1)=Resistant, 3+=Susceptible

Table 2. Detection of Lr19/Sr25 using molecular markers in HS628

Genotype	Response to STS molecular marker	
	Gb	*PSY1-E1*
HS240	-ve	-ve
FLW20+*Lr19/Sr25*	+ve	+ve
HS628	+ve	+ve
FLW13	-ve	-ve

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14. GW 2014-596 (IC0633422; INGR20014), a Wheat (*Triticum sativum*) Germplasm with High Grain Protein content.

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Wheat is the second most important crop after rice both in terms of area and production in India. India produced a record 101.20 million tonnes of wheat from 29.55 million hectares with a productivity of 34.24 q/ha in the year 2018-19 (ICAR-IIWBR, 2019). There is growing concern to export wheat to have remunerative prices, this situation now calls for diversifying wheat breeding towards quality particularly bread and biscuit making. In this context grain protein content assumes significance as high protein is suitable for bread making and low protein content for biscuit-making (Hehn and Barmore 1965). Looking to this need breeding work for high protein content started at Wheat Research Station, Vijapur. Considering this aspect, cross was made using diverse genotypes (GIANT3//HW 921/CPAN 1934) and generation advancement was made using pedigree selection method (Allard, 1960). This genotype has been developed at Wheat Research Station, SD Agricultural University at Vijapur for high protein content.

Morpho-agronomic characteristics: GW 2014-596 has semi-erect growth habit with broad leaves. During the period of testing, it was tested at national level under quality component screening nursery (QCSN) during the 2015-16 to 2017-18 (ICAR-IIWBR. 2016, 2017 and 2018) across the zones, in which GW2014-596 found to be superior with 14.4% protein content over the years and locations to the check variety UP 2672 (13.7%).

Table 1. Performance of GW 2014-596 genotype during 2015-16 to 2017-18

	Grain protein content at 14% moisture			
Genotypes	2015-16	2016-17	2017-18	Average
GW 2014-596	14.8	14.04	14.3	14.4
UP 2672 (C)	14.4	13.7	13.1	13.7

Associated characters and cultivation practices: GW 2014-596 has very broad leaves and flag leaf attitude drooping type. Grain has bold, amber colour and oblong shape. Ear is having clavate shape and strong waxiness on ear and peduncle. It matures within 110 days the package of practices to be followed as per normal sown irrigated condition and standard agronomic practices is recommended for the cultivation of this genotype. This genotype is adapted to all over the country and resistant to black and brown rust.

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15. GW 2010 288 (IC0623434; INGR20015), a Wheat (*Triticum aestivum*) Germplasm with Number of grains per spike >60. Thousand grain weight > 45 g. Iron content >42 ppm.

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Genetic diversity is crucial for a breeder to create the variability (Johnson *et al.*, 1955) considering this aspect, cross was made using diverse genotypes (WR 196 / CMH83-2578) and generation advancement was made using pedigree selection method (Allard, 1960). This genotype has been developed at Wheat Research Station, S.D. Agricultural University at Vijapur for thousand grain weight, number of grains per spike and high iron content.

Morpho-agronomic characteristics: It has semi-erect growth habit with strong waxiness on peduncle. Ear of this genotype is white at maturity with parallel shape. Grains are hard, amber colour with oval shape. During the period of testing, it was tested at national level under yield component screening nursery during the 2011-12 to 2013-14 (Gyanendra Singh *et al.*, 2012, 2013 and 2014) across the zones, in which it was found promising for multiple traits viz., grains per spike, thousand grain weight and spike length. After found promising consecutively for three years of testing, it was identified for grains per spike, thousand grain weight and spike length and included in National Genetic Stock Nursery for two years of testing in 2014-15 and 2015-16 across the zones. (Singh *et al.*, 2015 and 2016).

Associated characters and cultivation practices: For biotic stress, it was found moderately resistant to black and brown rust in National Genetic Stock Nursery. As it matures within 120 days the package of practices to be followed as per normal sown irrigated condition and standard agronomic practices is recommended for the cultivation of this genotype.

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16. UP 2994 (IC0635426; INGR20016), a Wheat (*Triticum aestivum*) Germplasm for High Protein Content (Av. 14.33%). High Iron (Fe) Content (49 ppm) and Zinc Content (43.5 ppm). Hectolitre weight 80.7kg/kl and Sedimentaion value: 59.5ml.

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Improving the nutritional quality of staple food crops is now getting attention for combating the prevailing malnutrition in a very large population in developing countries. Since wheat is one of the major staple foods around the world and is the major source of nutrients such as protein and micronutrients, wheat and its nutrients are the target traits for improvement whenever strategies to improve nutrient deficiencies are addressed. UP 2994 was evaluated in quality component screening nursery (QCSN/QCWBN) continuously for three years (2016-

17, 2017-18 & 2018-19) and it possessed/showed high protein content consistently for three years, i.e. 15.1% in 2016-17, 14.0% in 2017-18 and 13.9% in 2018-19, with a mean protein content of 14.33%. In addition to high protein content, it also possesses high iron content of 49.0 ppm, which is higher by 4.20 ppm in comparison the best check, WB 2 (44.8 ppm). It is also rich in another important micronutrient i.e. zinc, with 43.5 ppm. This material was developed at GBPUA&T, Pantnagar by pedigree breeding method. The parentage of this material is HUW 636/PBW 651. UP 2994 has been observed possessing other desirable quality traits in national nurseries during 2016-17 and 2018-19 viz., the grain appearance score (6.7), hectolitre weight (80.7 kg/hl) and sedimentation value (59.5 ml) averaged over 3 years. High protein content along with high sedimentation value makes this germplasm will help in the production of wheat varieties with enhanced bread making quality.

Morpho-agronomic characteristics of UP 2994: Foliage colour of UP 2994 is dark green with intermediate growth habit and there is no anthocyanin pigmentation of auricle. Its flag leaf attitude is semi erect type with medium length and width of flag leaves. It possesses medium length ears and has tapering ear shape in profile. It takes an average of 81 days for 75% flowering. It is superior in tillers numbers (107 tillers/meter), 1000 grain weight (41g) and grain yield (433g/m^2) to all the checks viz., UP 2672, C 306, NIAW 1415 and HS 490.

Associated characters and cultivated practices: UP 2994 has been observed possessing other desirable quality traits in QCSN/QCWBN during 2016-17 and 2018-19 viz. the grain appearance score (6.7), hectolitre weight (80.7 kg/hl) and sedimentation value (59.5 ml) averaged over 3 years. UP 2994 is developed using pedigree selection method and hence it is ready to use genetic stock in hynbridization programme without any linkage drag in developing high yielding wheat varieties with enhanced nutritional status.

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17. QST1910 (IC0635697; INGR20017), a Wheat (*Triticum aestivum*) Germplasm with Drought Tolerance and Low Drought Sensitivity Index.

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Recurrent drought associated with climate change is one of the important constraints to global wheat productivity. Efforts to mitigate drought through breeding resilient wheat varieties are underway across the globe. However, progress is hampered because of complexity of the trait, as the trait is controlled by many genes with significant environmental influence. Drought stress affects wheat yield, particularly in central and peninsular India. Therefore, identification and development of drought tolerant wheat germplasm lines is of prime importance in recent past. In this direction under the AICRP on wheat and Barley, 32nd Drought Tolerance Screening Nursery (DTSN) comprising 25 wheat genotypes including 5 checks (C306, MP3288, DBW110, K1317, and NI5439) was conducted at 15 centres to identify wheat genotypes having tolerance to drought stress. The nursery was sown in 5 × 5 simple lattice design both under drought and irrigated conditions on the same date. Except pre-sowing irrigation, no irrigation was given under drought treatment, while recommended numbers of irrigations were provided under irrigated treatment.

QST1910 was developed at ICAR-Indian Institute of Wheat and Barley Research (ICAR-IIWBR) by crossing HD2967/WH1080. QST1910 recorded the lowest Drought Sensitivity Index (DSI) in all the tested centers compared to the drought tolerant check varieties. QST1910 found to be superior with DSI of 0.65 compared to drought tolerant check varieties viz., DBW 110 (0.81), C 306 (0.83), K1317 (1.36), MP 3288 (1.36), and NI 5439 (1.44). The percent DSI superiority of QST1910 over check varieties was 19.8% (DBW 110), 21.7% (C 306), 31.6% (K1317), 52.2% (MP 3288), 54.9% (NI 5439). QST1910 was also superior to all the 5 check varieties for percent yield reduction, plant height, grain filling duration, productive tillers, and days to heading

Thus, QST1910 would be a potential source to be utilized in breeding programs to develop drought tolerant bread wheat varieties.

Table 1. Pooled analysis of DSI and agro-morphological traits of DTSN genotypes during 2019-20.

Trait/ Component	Test Genotype	Checks				
	QST1910	DBW110	C306	K1317	MP 3288	NI 5439
Pooled DSI	0.65	0.81	0.83	0.95	1.36	1.44
% DSI superiority of QST1910 over checks	-	19.8	21.7	31.6	52.2	54.9
% Yield reduction	16.3	20.4	20.9	23.9	34.0	36.2
Plant height (cm)	80	93	81	89	84	85
Grain filling duration	48	44	40	44	44	44
Productive tillers	73	66	69	71	70	66
Days to heading	67	71	74	69	68	71
Days to maturity	115	115	114	113	112	115
Thousand grain weight (g)	36	36	35	40	38	34
Grain number per spike	42	41	46	51	46	45
Grain weight per spike (g)	1.7	1.6	1.7	2.3	1.9	1.6

18. BHS 474 (BBM 777) (IC0635023; INGR20018), a Barley (*Hordeum vulgare*) Germplasm with Resistance to all Pathotypes of Yellow Rust and Brown Rust in Seedling and Adult Plant Stage. Seedling Resistance against all Pathotypes of Black Rust except for Pathotype 11.

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BHS 474 (BBM 777) is barley (*Hordeum vulgare* L.) line resistant against stripe, leaf and stem rust. It has shown highest degree of resistance against all the prevailing pathotypes of stripe and leaf rust at seedling stage and is resistant to both the rust at adult plant stage. BHS 474 (BBM 777) also possesses seedling resistance against all the pathotype of stem rust except for pathotype 11. This line is developed following pedigree method of breeding involving crosses between barley local germplasm line BLG132 and barley genetic stock BHS369 at ICAR-IARI, Regional Station, CHC, Amartara Cottage, Tutikandi Center, Shimla (H.P.)

BHS 474 (BBM 777) has semi erect growth habit with medium maturity (172 days) under Northern Hill condition. The average yield is 2.3 t/ha under rainfed condition of Northern Hill Zone of All India Co-ordinated trials. The distinguish features of BHS474 (BBM 777) are six-rowed; hulled; semi-erect growth habit; semi-erect flag leaf attitude; green leaves; white colour of ear at maturity and thousand grain weight of 39 grams.

Table 1. Reaction to major diseases

Diseases	Condition	Year	Response of Proposed Genetic stock 474 (BBM777)
Stripe Rust (Resistant to yellow rust)	IBDSN (APR)	2017-18	ACI= 0 HS= 0
	NBDSN (APR)	2018-19	ACI=0.9 HS=5S
	NBDSN (Seedling)	2018-19	R (Resistant)
Leaf Rust (Resistant to brown rust)	NBDSN (APR)	2018-19	HS= 5S
	NBDSN (Seedling)	2018-19	R (Resistant)
Stem Rust (Seedling Resistant to black rust)	NBDSN (Seedling)	2018-19	MR - R (Moderately Resistant to Resistant) except for pathotype *11*

ACI= Average Coefficient of incidence; HS= Highest Score; IBDSN= Initial Barley Disease Screening Nursery; NBDSN= National Barley Disease Screening Nursery

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19. DWRB207 (DWRFB19) (IC0635698; INGR20019), a Barley (*Hordeum vulgare*) Germplasm Highly Resistant to Stripe Rust. High 1000 Grain Weight (47.5g). Low Protein Content (9.5).

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Resistance to yellow rust and high thousand grain weight (TGW) are important traits for improvement of grain yield in barley. Yellow rust caused by *Puccinia striiformis* Westend. f.sp. hordei Erikss. & Hen. (Psh) is an important foliar disease in barley which causes yield loss in the range of 5% to 25%. In addition to yield, yellow rust also affects the grain quality under severe incidence. Early incidence of yellow rust can cause severe losses to the crop in Indian conditions and sometimes, it prevents the emergence of the ear head or grain formation (Prakash and Verma, 2009). Disease can be controlled by fungicides; however, it is costly approach for a low input crop like barley and hazardous to the environment. Use of resistant varieties against yellow rust is an economical and environment friendly approach to minimize the yield losses. Hence, it becomes imperative to develop yellow rust resistant germplasm for barley improvement.

Thousand grain weight (TGW) is an important contributing trait for improvement of grain yield. It is widely used as a standard indicator for grain development and quality (Kumar *et al.,* 2017). At ICAR-IIWBR, Karnal, DWRB207, has been identified having high resistance to yellow rust coupled with higher thousand grain weight during crop season over diverse conditions.

DWRB207 (IC0635698) evaluated as DWRFB19 is hulled barley developed by hybridizing exotic (CDC Manley) and indigenous (BCU2881) barley genotypes following pedigree method making selection of individual plant from F2 to F5 generations. Selection was made for yellow rust resistance under artificial inoculated conditions during course of its development. DWRB207 was tested as DWRFB19 in coordinated screening nurseries (IBDSN) during 2016-17 and 2017-18 and it revealed highly resistance against yellow rust. In field conditions, this genotype had highly resistant response at all locations in IBDSN testing under artificial rust epiphytotic conditions (Singh *et al.*, 2019), while, infector showed highly susceptible reactions against yellow rust in both consecutive years (Table 1A). The Seedling Resistance Test (SRT) was conducted at IIWBR-RS Flowerdale, Shimla during 2017-18 and 2018-19. DWRB207 exhibited resistant reactions against all the yellow rust races viz., 6S0, 7S0, G, M, 24, 57 and Q in the present study.

Table 1A. Rust reaction of DWRB207 in IBDSN under artificially inoculated conditions

Genotype	Year of testing	Durgapura	Ludhiana	Bajaura	Jammu	Karnal	HS	ACI
DWRB207 (DWRFB19)	2016-17	0	0	0	0	0	0	0.0
	2017-18	TR	TR	TR	0	0	0.12	TR
Infector	2016-17	100S	60S	80S	60S	80S	100S	76.0
	2017-18	100S	60S	60S	80S	60S	100S	72.0
Seedling resistance test		Pathotypes						
Genotype	Year	6S0	7S0	G	M	24	57	Q
DWRFB19	2017-18	0;	0;	0;	0;	0;	0;	0;
	2018-19	0;	0;	0;	0;	0;	0;	0;

HS= highest score, ACI= average coefficient of infection, 3+ =susceptible, 3, 3- = moderately susceptible, 2, 2+ = moderately resistant, 0;/;/1/2- = Resistant

Table 1B. Thousand grain weight (g) under multi location ICW&BIP trial during 2018-19

Character	Genotype	Hisar	Kanpur	Faizabad	Mean
1000-grain weight (g)	DWRB 207	47.5	53.6	41.26	47.5
	NDB 1173(C)	43.1	38.0	34.76	38.6
	NDB1445(C)	41.1	34.0	36.6	37.2
	RD2552(C)	41.8	37.8	40.84	40.2
	RD2794(C)	44.7	40.6	38.74	41.3
	RD2907(C)	44.9	47.0	38.16	43.3

In addition to the stripe rust resistance the genotype is also having higher thousand grain weight (47.5 g) averaged under multi-location AICW&BIP trial during 2018-19 (Table 1B).

Agro-morphological characteristics: DWRB207 flowers in 92 days and matures in 130 days on an average. Its average plant height is 100 cm, spike length (7.3 cm), containing 68 grains per spike. It is moderate tillering type genotype with 88 tillers/meter.

Therefore, this genotype, identified on the basis of field and SRT analysis, may be used as donor parent in resistance breeding for yellow rust as well as for higher thousand grain weight.

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20. UPB 1070 (IC0635430; INGR20020), a Barley (*Hordeum vulgare*) Germplasm Resistant to Yellow Rust (ACI0.0). High Yield Potential in NHZ (29.2 q/ha). High Bold Grain Percentage (89.4%) and other Good Agronomic Traits.

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Barley is an important crop also adapted in the marginal and stressed affected environments. Yellow rust is a devastating foliar disease of barley, caused by *P. striiformis* f. sp. *hordei*. It causes severe yield losses particularly in Northern hills and adjoining plains. Due to multicyclic nature of the disease and marginal status of the crop chemical control is not feasible, resistance breeding is highly required for combating this disease. The durability of genetic resistance is under constant threat by the natural variation and novel mutation in the pathogen, resulting in the ongoing erosion of resistance genes in cultivation. For combating the threat of yellow rust, identification and deployment of novel sources of resistance is required in the existing breeding programs. UPB 1070 is recognized as a confirmed source of yellow rust resistance with an ACI of 0.04 in National Barley Disease Screening Nursery, 2017-18 and ACI of 0.0 in Elite Barley Disease Screening Nursery in 2018-19. with a sound agronomic background. It was developed at G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand through pedigree breeding method utilizing hybridization between two parental lines viz; Dolma and BH 947 followed by selection.

Morpho-agronomic characters: UPB 1070 was tested in Co-Ordinated Trials (AVT-RF-NHZ) in North Hills Zone under timely sown rainfed conditions during 2017-18 with an average yield of 29.2 quintals per hectare. UPB 1070 showed superiority in yield over the checks, BHS 352, BHS 400 and VLB 118 in AVT-RF-NHZ during 2017-18. It is a six rowed yellow grain colour barley with 103-154 days to heading, 140-197 days to maturity with a plant height of 47-100 cm, 44-238 tillers per meter and 33-46 gm 1000 grain weight.

Associated characters and cultivation practices: In addition to yellow rust resistance, UPB 1070 showed moderate level of resistance against leaf blight and it also exhibited highest bold grain percentage (89.4 %) in Co-Ordinated Trials (AVT-RF-NHZ) 2017-18, a trait which determines the overall grain plumpness, an associated trait of malt quality. It is adaptable for hilly areas.

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21. LMDR-2 (IC0635024; INGR20021), Maize (*Zea mays*) Germplasm Resistant to Maydis Leaf Blight and Moderately Resistant to Charcoal Rot of Maize.

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Maize (*Zea mays* L.) an important cereal crop is subjected to extensive yield losses due to fungal diseases at different growth stages. Among them, maydis leaf blight caused by Drechslera maydis occurring at pre flowering stage and charcoal rot caused by Macrophomina phaseolina occurring at post flowering stage of the crop are the major factors threatening maize production in Northern India (Kaur *et al.*, 2010). Thus, it is essential to identify useful sources possessing multiple disease resistance in maize as selection and breeding for resistance is the most economical method of delivering control for farmers.

LMDR-2 inbred line was developed through pedigree selection and inbreeding for six generations. At the end of six selfing and evaluation, uniform progenies were identified and their selfed seeds were bulked which were multiplied in isolation. This inbred line has been developed at Punjab Agricultural University, Ludhiana. This is late maturing line. The plant length is short with low ear placement. Its tassel is light with curved branches and sparse spikelets. Silks are green. Leaves are narrow and straight. Ears are small conical. Grains are orange, round flint with straight kernel rows. 1000 kernel weight is small. Under artificial inoculation conditions, its mean disease score to maydis leaf blight is 3.0 following 1-9 scale of Hooda *et al.* (2018) as given in Table 1A. This line has been found resistant to this disease. Regarding its reaction to charcoal rot, under artificial conditions its mean disease score is 3.7 on 1-9 scale (Hooda *et al.*, 2018) found to be moderately resistant to this disease Table 1B. This genotype has been found highly promising possessing multiple disease resistance to maydis leaf blight and charcoal rot of maize.

Table 1A. Disease reaction of promising germplasm against Maydis Leaf Blight of Maize during *Kharif* 2017 and 2018

Proposed Name	Inbred	Maydis Leaf Blight (1-9)*						Mean over the years (4 Expts)
		2017			2018			
		Karnal	Ludhiana	Mean (2 Expts)	Karnal	Ludhiana	Mean (2 Expts)	
LMDR-2	LL-49	1.0	3.5	2.2	3.8	4.0	3.9	3.0
Susceptible check	CM 600	8.0	8.0	8.0	8.0	8.8	8.4	8.2

*1-3-Resistant; 3.1-5.0- Moderately resistant; 5.1-7.0-Moderately Susceptible; 7.1-9.0-Susceptible

Table 1B. Disease reaction of promising germplasm against charcoal rot of maize during *Kharif* 2017 and 2018

Proposed Name	Inbred	Charcoal Rot (1-9)*						Mean over the years (4 Expts)
		2017			2018			
		Delhi	Ludhiana	Mean (2 Expts)	Hyd	Lud	Mean (2 Expts)	
LMDR-2	LL-49	3.3	3.0	3.1	4.6	3.8	4.2	3.7
Susceptible check#		7.0	6.6	6.8	3.8	5.9	4.8	5.8

*1-3-Resistant; 3.1-5.0- Moderately resistant; 5.1-7.0-Moderately Susceptible; 7.1-9.0-Susceptible
#Sus check: 2017- CM 501 (Delhi); CM 140 (Ludhiana); 2018- CM 600

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22. VR 1081 (IC0635027; INGR20022), a Finger Millet (*Eleusine coracana*) Germplasm Resistant to Finger Blast.

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Finger millet, VR 1081 is finger blast resistant line developed by crossing blast resistant variety GPU 28 with blast resistant germplasm GE 4931. The cross was performed in 2005 for developing blast resistant high yielding variety and subsequent selections were made through pedegree method from F2 to F6. It was promoted at F8 stage to Preliminary Yield Trial in 2013. It belongs to medium maturity with medium plant height medium number of productive tillers/plant. It is comparable with the check, Sri Chaitanya (VR 847) for grain and fodder yield.

The entry, VR 1081 along with other test entries and two checks were tested under high disease pressure under field conditions for consecutive five years from 2014 to 2018. It recorded NIL incidence of Finger blast among all the 3000 entries tested for finger blast resistance and also showed resistance to neck blast (8.2 % Pooled data). VR 1082 has recorded. -100% (less incidence) of finger blast over resistant check, Sri Chaitanya (VR 847) & susceptible check, Champavathi (VR 708) while it recorded -91.5% (less incidence) of neck blast over susceptible check, Champavathi (VR 708). Hence, VR 1081 is unique in terms of finger blast resistance and moreover it also recorded higher grain and fodder yield and hence can be used directly as a source for development of high yielding, finger blast resistant varieties.

23. IPAC 79 (IC0626208; INGR20023), a Pigeon Pea (*Cajanus cajan*) Germplasm Tolerant to Waterlogging Stress and Resistant to Phytophthora Stem Blight Disease.

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Pigeonpea [*Cajanus cajan* (L.) Millisp.] often encounters over-flooding at seedling stage, especially in low-lying areas. Upon exposure to submergence for 3 to 4 days, the crop experiences hypoxia with considerable injury to roots, eventually causing death of the plant (Sultana *et al.*, 2012). Further, the weather conditions during seedling stage, such as intermittent rains and moderate temperatures of 25±1^{o}C favor occurrence of Phytophthora stem blight (PSB) and the ensuing diseases causes' significant loss in crop yield (Kannaiyan *et al.*, 1984; Pande *et al.*, 2011). To the best of our knowledge, no registered pigeonpea genotype is available for water-logging tolerance and PSB resistance. In view of this, we have identified a pigeonpea genotype (IPAC 79) showing remarkable tolerance against both water logging and PSB on the basis of observations recorded over four years (2011-12, 2012-13, 2013-14 and 2017-18) at IIPR, Kanpur. The genotype IPAC 79 is an advance line derived from the cross 'Bennur local/ BRG 1'. It was found to be tolerant up to 96 hours of waterlogging, when the screening conducted after 20 days seedling stage. Under water-logged conditions, the genotype showed 53.8% survival as compared to only 0.6 % survival in sensitive line (ICPL 7035), and 11.2% &18.6% survival in national check varieties viz. Bahar and NDA 1, respectively. It is important to note that IPAC 79 was also resistant to PSB.

Morpho-agronomic characteristics of IPAC 79: The genotype is a tall (210 cm), compact and late maturing (261 days) with purple pigmentation on the stem. It bears streaked and diffused red flowers, purple sticky pods with black seed coat and test weight of about 12.3g/100 seed. The average yield of IPAC 79 is 21.3 quintals/ha in replicated trials conducted at IIPR Kanpur.

Associated physiological characters and cultivation practices: After multiple cycles of waterlogging, the chlorophyll content of IPAC79 remained less affected (18% reduction) even after 4th cycle of stress as compared to ICPL 7035 (50% reduction). Leaf nitrogen balance index (NBI) reduced by 50% in ICPL 7035, whereas only 20% reduction was found in IPAC 79. The root capacitance decreased from 0.86 nf to 0.61 nf in IPAC 79, the extent of reduction was greater in ICPL 7035 (from 1.02 to 0.2 nf), implying an irreversible damage in roots due to higher absorption of minerals and other nutrients from soil. No accumulation of anthocyanin was observed in the leaves of IPAC 79 as opposed to sensitive genotype that accumulated significant anthocynin on exposure to waterlogging. The pigeonpea is sown with the onset of monsoon. The field should be prepared with required tillage practices by adding 5 tons of FYM and NPK of 20:40:40 kg/ha. The seed rate of 12-15 kg/ha is required for sowing with spacing 75×30 cm. This genotype has good worth as a donor of waterlogging tolerance and PSB resistance along with superior yield attributing traits. IPAC 79 will have good utility in crossing programmes of pigeonpea breeding. This genotype has immense commercial value in the ecological niches of terai region of Uttar Pradesh where there is high rainfall and high incidence of Phytophthora stem blight.

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24. RCEA 14-5 (IC0635029; INGR20024), a Pigeonpea (*Cajanus cajan*) Germplasm with No Natural Outcrossing. Twisted Standard Petal Wrapped over Wings. Free Stamens (Non-Diadelphous Condition).

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Pigeonpea [*Cajanus cajan* (L.) Millsp.] is a partially allogamous pulse crop with natural out-crossing varying from 5 to 70 percent. Natural out-crossing is the major source of varietal contamination in pigeonpea and, in order to maintain genetic purity of cultivars, seed multiplication in isolated blocks/poly net house is necessary. This consumes a lot of resources, eventually increasing the cost of seed production. However, genetic purity of a variety can also be maintained through incorporation of 'selfing' traits into desirable cultivars (Choudhary and Nadarajan, 2011). The genotype 'RCEA 14-5', which was derived from a cross IPA 203 × ICPL 87154 by pedigree method, holds high promise as it has shown zero percent natural out-crossing. It combines several unique features such as twisted flowers having the standard tightly wrapped with wings, significantly enlarged keels partly surrounding the standard enfolding the two wing petals and free stamens (non-diadelphous condition), making it highly unattractive to both pollinivore and/or nectarivore insects (Choudhary *et al.*, 2015; Saxena *et al.*, 2016).

Morpho-agronomic characteristics: The developed genotype bears similarity with one of its parents 'IPA 203' which is a leading variety of long-duration pigeonpea for the north-east plain zone. However, it differs from 'IPA 203' for various morpho-agronomic traits (Table 1).

Table 1. Morpho-agronomic Characteristics of 'RCEA 14-5'.

Characters	RCEA 14-5	IPA 203
Stem Colour	Green	Green
Leaf shape	Lanceolate	Lanceolate
Growth habit	Indeterminate	Indeterminate
Plant type	Compact	Semi-compact
Plant height*	Medium (1.75 m)	Tall (2.0 m)
Standard petal colour	Golden yellow	Yellow
Keel petals	Large	Relatively small

Characters	RCEA 14-5	IPA 203
Stamen configuration	Free (non-diadelphous)	Diadelphous (9+1)
Flower configuration	Twisted, tightly wrapped standard with wings	Normal
Natural outcrossing*	Zero	> 15%
Pod colour	Light green with dark streaks	Dark green with black streaks
Seed strophiole	Absent	Present
100 seed wt (g)*	9.10	12.20
Yield (t/ha)*	1.75	1.74

*Mean value based on data of station trials conducted at Darbhanga (2014-15) and Ranchi (2016-17 & 2017-18).

Associated characters and cultivation practices: The unique combination of selfing traits (twisted flowers due to wrapping of standard and keel with wings, and free stamens) considerably delay opening of flower buds and provide many-fold barriers to foraging insects including honeybees, thereby ensuring cent per cent seed set through self-pollination in 'RCEA 14-5'. The cultivation of this genotype will preclude the necessity of seed replacement at regular intervals. The general cultural practices recommended for 'IPA 203' (Choudhary, 2016) may be adopted for cultivation of this genotype too. Alternatively, the genotype 'RCEA 14-5' may be utilized as the donor for "cleisto" traits in future pigeonpea improvement programme.

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25. IPAV 16-1 (IC0635030; INGR20025), a Pigeonpea (*Cajanus cajan*) Germplasm with High 100 Green Seed Weight of 50-52 g. High 100 Dry Seed Weight of 22.5-23.04 g. Compact Plant Type with Green Colour Stem, Yellow Colour Flowers, Brown Colour Pods of 9.5 to 10.25 cm Length Packed with 5-6 Seeds/Pod.

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Pigeonpea [*Cajanus cajan* (L.) Millisp.] is an important grain legume in the semi-arid tropics of Asia and Africa due to its climate adoptability and high dietary protein (20-22%) content. India is world's largest producer (3.59 mt) and consumer of pigeonpea (http://agricoop.gov.in/2018-19). Pigeonpea is consumed in the form of vegetable during green seed stage in the southern and northeastren states like Karnataka, Telangana, Andhra Pradesh, Tamilnadu, Maharashtra, Gujarat, Tripura and Nagaland and matured dry grains in the form of dehulled cotyledons (dal) after essential postharvest milling process in the whole country.

Seed weight being an important yield attributing trait in pigeonpea plays vital role in the final harvest and economic gain for farmers (Satheesh *et al.*, 2013). Pigeonpea green pods are harvested for different purposes like for direct use as vegetable or canning. Near cities where they can be readily marketed are harvested as vegetable. Fully developed seed having 100 green seed weight of >45 grams are mostly preferred by consumers for vegetable purpose (Saxena *et al.*, 2010). However, the most of the released varieties having the 100 green seed weight of 20-30 grams therefore they are less desired by the consumers. Narayanan *et al.* (1981) proved that the large dry seeded pigeonpea varieties (100 dry seed weight >15g) produces larger and more vigorous seedlings, which will have an advantage in crop establishment under adverse conditions. Keeping this in view the present line IPAV 16-1 would be the potential donor for future line of breeding for high 100 seed weight and vegetable purpose.

Morpho-agronomic characteristics: The line IPAV16-1 was a pure line selection from JBP 13. Initially a set of 15 genotypes were selected based on the vegetable traits (pod and seed size and weight) and allowed the natural inter mating among the genotypes, then after each genotype was selected for high 100 seed weight and advanced generations through plant to progeny row till the line became stable. Subsequently, during 2014 and 2015 cropping season all the advanced pure lines were characterised for wilt resistance, seed nutritional quality and agronomic traits. The line IPAV 1 recorded higher mean values for number of pods/harvest (161.30), pod length (9.81 cm) and number of seeds/pod (5.73) (Satheesh *et al.*, 2016). In 2016 cropping season the line IPAV 1 was tested under ICAR-IIPR, Kanpur station trial as IPAV 16-1 along with the dual purpose (vegetable and grain) released variety BRG 1 and reported high 100 seed weight line ICP 12746 (Upadhyaya *et al.*, 2010) as checks and recorded the data on yield and yield attributes. The results on 100 seed dry and green weight was high in IPAV 16-1 i.e., 23.04g and 52.00g respectively while the better check ICP 12746 recorded 18.03 and 44.8 g/100 dry and green seed weight respectively. Based on the accumulated data over the seasons, IPAV 16-1 was subjected to evaluation for 100 seed weight during 2018-19 cropping season by the germplasm identification committee of ICAR-IIPR, Kanpur. The committee recommended the registration of the line as donor for high 100 seed weight.

IPAV 16-1 is a compact branching semi determinate plant produces 13-15 numbers of primary branches with plant height ranging from 200-215 cm. The plant has green colour stem and absence of leaf pubescence on both the surfaces. IPAV 16-1 produces 9.5-10.5 cm long uniform dark brown colour pods packed with 5-6 seeds per pod. Presence of pod surface wax and stickiness helps in less attack by the pod borer and pod fly complex. IPAV 16-1 produces 1.8-2.0 cm long yellow coloured flowers with no streaks on its standard petal (Fig. 1). The 100 green seed weight ranged from 50-52 grams while the dry seed weight is 22.5-23.04 grams. The dry seeds are oval shaped, having mosaic brown colour seed coat. The genotype IPAV 16-1 attains its 50 % flowering in 120 to 125 days and matures in 180-185 days.

Associated characters and cultivation practices: Pigeonpea is sown with the onset of monsoon. The field should be prepared well with recommended tillage practices by adding 5 tonnes of FYM and NPK of 20:40:40 kg/ha. The seed rate of 12-15 kg/ha is required for sowing with the spacing of 75×30 cm. The line IPAV 16-1 holds great promise for use as donor of high 100 seed weight (50-52g & 22.5-23.04g for green and dry seeds respectively) in pigeonpea breeding programme. The line IPAV 16-1 has immense commercial value as donor for vegetable breeding programme.

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26. GFB-3 (IC0635031; INGR20026), a French Bean (*Phaseolus vulgaris*) Germplasm with Anthracnose Resistance.

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Anthracnose is considered most common bean diseases (*Phaseolus vulgaris* L.) caused by *Colletotrichum lindemuthianum* (Sacc. & Magnus) Scrib. Diseases causing massive loss in crop yield worldwide, preferably in the regions with prevailing high humidity and moderate temperature (13 to 27ºC). Uttarakhand has rich biodiversity for French bean. 100 accessions of French bean germplasm were collected from six district of Garhwal regions and screened for resistance to anthracnose disease.

On screening with SCAR markers GFB-3 accession amplified with three primers SF-10, SAS-13 and SZ-04 and was found having three genes (Co-10, Co-42, Co-6) for anthracnose resistance. For in vitro screening three weeks old plants were inoculated with spore suspension (106 conidia/ml) of the pathogen *C. lindemuthianum* to check resistance against *C. lindemuthianum* (Fig. 1). Disease reactions were rated visually using a scale from 1 to 9. The plants scored from 1 to 3 were considered resistant.

Four field trials were conducted to test the anthracnose disease incidence. No disease was observed in three field trials. In one trial the disease incidence was very low that was 1.00 (Prabha *et al.*, 2020). Out of the germplasm screened, Accession GFB-3 has multiple genes for anthracnose resistance with good qualitative and quantitative characters (Table 1).

Table 1. Qualitative and quantitative characters of the French bean accessions GFB-3

Accession	Seed colour	Flower colour	Seed length (mm)	Seed diameter (mm)	Pod length (cm)	Number of seed per pod	Pod colour at physiological maturity	Days to 50 % maturity	100 seed weight (gm)
GFB-3	White with light green spot	White	10.1	3.6	11.72	6.4	Green	69	29.10

Reference

Prabha D, N Chamoli, YK Negi and JS Chauhan (2020) Newly Identified Anthracnose Resistant French Bean (*Phaseolus vulgaris*) Accessions from Garhwal Hills of Uttarakhand. *Int. J. Curr. Microbiol. App. Sci.* **9(02)**: 2748-2751. doi: https://doi.org/10.20546/ij cmas.2020.902.31

27. GFB-30 (IC0635032; INGR20027), a French Bean (*Phaseolus vulgaris*) Germplasm with Anthracnose Resistance

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Uttarakhand has rich biodiversity for French bean which is unexplored. Anthracnose disease is a serious constraint to the French bean growth and yield. 100 accessions of French bean germplasm were collected from six district of Garhwal regions and screened for resistance to anthracnose disease.

Accession GFB-30 was amplified with four primers SF-10, SAS-13, SH-18 and SZ-04 was found having three genes (Co-10, Co-42, Co-6) related to anthracnose resistance. Accessions were screened under controlled conditions. For *in vitro* screening three weeks old plants were inoculated with spore suspension of the pathogen *C. lindemuthianum* to check resistance against *C. lindemuthianum*. Disease reactions were rated visually using a scale from 1 to 9.

Four field trials were conducted to test the anthracnose disease incidence. No disease was observed in three field trials. In one trial the disease incidence was very low that was 1.25 (Prabha *et al.*, 2020). Accession GFB-30 has multiple genes for anthracnose resistance with good qualitative and quantitative characters (Table 1).

Table 1. Qualitative and quantitative characters of the French bean accession GFB-30

Accession	Seed Colour	Flower colour	Seed length (mm)	Seed diameter (mm)	Pod length (cm)	Number of seed per pod	Pod colour at physiological maturity	Days to 50 % maturity	100 seed weight (gm)
GFB-30	White with black spot	Purple	8.4	4.2	10.94	7.6	Yellowish green with red spots	62	25.34

Reference

Prabha D, N Chamoli, YK Negi and JS Chauhan (2020) Newly Identified Anthracnose Resistant French Bean (*Phaseolus vulgaris*) Accessions from Garhwal Hills of Uttarakhand. *Int. J. Curr. Microbiol. App. Sci.* **9**(02): 2748-2751. doi: https://doi.org/10.20546/ij cmas.2020.902.31

28. GJG 0922 (IC0635033; INGR20028), a Chickpea (*Cicer arietinum*) Germplasm with Wilt Resistance.

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Chickpea (*Cicer arietinum* L.) is an important pulse crop grown during *rabi* season in tropics and spring in the temperate region of the world. Chickpea is grown on about 10.56 million ha producing 11.37 million tonnes of seed with productivity of 1077 kg/ha in India (Anonymous, 2019). Chickpea attacked by numerous root pathogens, of which the most destructive is *Fusarium oxysporum* f. sp. *ciceri* causing vascular wilt. The disease is soil borne in nature. Chickpea yield is affected by several diseases but wilt caused by *Fusarium oxysporum* f. sp. *ciceri* is a very serious disease and causes losses occurred up to 10 percent in yield (Dubey *et al.*, 2007). This genotype was found to be resistant in wilt sick plot at ICRISAT, Kanpur, Jabalpur, Rahuri and Junagadh during different years (2012-13, 2014-15, 2016-17, and 2018-19) of testing.

The line GJG 0922, was developed at Pulses Research Station, Junagadh Agricultural University, Junagadh using wilt resistant source by pedigree method of selection in a segregating population of a cross (GJG 9920 × FG 703).

Morpho-agronomic characteristics of GJG 0922

Entry	Year	Yield (Kg/ha)	Maturity days	100 seed wt. (g)
GJG 0922	2011-12	1699	106	29.9
	2012-13	1920	103	23.1
Mean		1809	104	26.5

(Source: AICRP report of Chickpea: 2011-12 and 2012-13)

Associated characters and cultivated practices: GJG 0922 is resistant to Fusarium wilt disease and has semi spreading growth habit. It has a single flower per peduncle. The seeds are brown in colour and angular in shape. Large seed size (26.5 g/100 seeds). It falls in medium maturity group (104 days) and has an average yield 1809 kg/ha.

Recommended cultivation practices: Seed rate: 70 Kg/ha; Spacing: 45×10 cm; Fertilizer dose: 20:40:00 N:P:K

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29. PMF-1 (IC0635701; INGR20029), a Lentil (*Lens culinaris*) Germplasm with Five Flowers (Penta-Flowering) and Pods Per Peduncle in a Few Flowering Nodes.

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In lentil, with very limited variation, mostly three or occasionally four flowers per peduncle (FPP) bearing habit is commonly observed in the cultivated lentil. However, as reported for various legumes, development of five or more FPP, while maintaining the seed size, looks an attractive option for yield manipulation (Mishra *et al.*, 2020). Penta-flowering was never considered a trait to study, due to unstable expression through generations, environmental influence, and poor conversion to penta-pods. At global level, ICAR-IARI, New Delhi is pioneer for the identification of first stable penta-podded cultivated lentil genotype PMF-1 during *rabi* 2017-18. The flowering expression was again validated at IARI, N. Delhi and ICARDA, Amlaha (Bhopal) in *rabi* 2018-19, and also under partially controlled glasshouse of Phytotron at IARI, New Delhi (2018-19). The PMF-1 was identified from an ICARDA nursery genotype (2011S 56104-5) received from Lebanon which was derived from a cross 'ILL1005 × ILL7012'. The identified genotype will help in the genetic studies pertaining to the expression of flowers per peduncle in cultivated lentil.

Morpho-agronomic characteristics: PMF-1 is an early maturing genotype, requiring nearly 105-110 days for the seed maturity. Lentil normally bears one to three flowers per peduncle, while PMF-1 recorded sequential appearance of penta-flowering peduncles at multiple flowering nodes. The 9th node was the first node expressing four FPP while expression of five FPP was observed between 12th to 17th nodes. In 2018, the expression of five and six FPP was recorded from 13th to 23rd February; whereas in 2019 this was observed from 25th February to 5th of March when the mean environmental temperature was mostly in the range of 12–18 °C. Thus, besides genetic factors, temperature was also found influencing the MF expression.

Associated characters and cultivation practices: PMF-1 is an early maturing (105-110 days) and bold seeded (100 seed weight 3.1-3.2 g) genotype. The seed-coat is grey coloured while cotyledons are red coloured. The optimum temperature for seed germination is about 22±2oC, while spacing of 30×10 cm is optimum when planted in rows. Due to its erect plant habit, prolific branching and first flowering node not before 9th node, this can be used as a genotype for mechanical harvesting too. Standard cultivation practises can be adopted to raise a healthy crop.

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30. DC 8441-5 & DC 41-5B (IC0632603 & IC0632604; INGR20030), an Ogura Based Cytoplasmic Male Sterile Line of Cauliflower (*Brassica oleracea* var. *botrytis*) in Early Maturity Group (25-30ºC) of Indian Cauliflower. Dwarf Plant Type and Good Combiner for Earliness and Curd Yield.

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Cauliflower (*Brassica oleracea* var. *botrytis* L.; 2n= 2x=18) is an important widely grown vegetable crop in India. The cytoplasmic male sterility system (CMS) introgressed in cauliflower (Sharma *et al.*, 2005) has been found to be stable, easy to maintain and economically viable genetic mechanism compared to that of self incompatibility system. The CMS lines of inter- (early, mid or late) and even intragroup maturity can't be used across the group or even within the group across weekly maturity for hybrid breeding as it leads to genetic drift. The 'DC 8441-5' line is an indigenously developed CMS line of early maturity group of Indian cauliflower. It has refined Ogura male sterile cytoplasm and free from any floral deformities. This CMS line was developed by transferring refined Ogura cytoplasm (male sterile) into nuclear background of an elite inbred line 'DC 41-5' after 10 generations of backcrossing.

Morpho-agronomic characteristics of CMS line 'DC 8441-5': The CMS line 'DC 8441-5' is the second CMS line of early maturity group (October first fortnight) of Indian cauliflower with refined Ogura male sterile cytoplasm (Table 1). It reaches marketable stage in a period of 65 – 75 days after transplanting in North Indian plains. It produces light yellow small to medium size normal flowers with good nectar volume. It bears normal sepals, petals and stigma. In 'DC 8441-5', anthers are shriveled and devoid of pollen mass indicating complete male sterility. Flower opening is proper and have well developed nectaries which enhance honey bees visit. Seed yield of CMS line is 17.82 g/plant in 1:1 ratio (CMS line: fertile maintainer line) which was at par with the fertile maintainer. The CMS line 'DC 8441-5' produces cream white compact and solid curds of medium size (net curd weight = 510.8 g) like its maintainer line 'DC 41-5' (452.5 g). The marketable curd yield of CMS line (24.8 t/ha) is at par with its maintainer line DC-41-5 (22.6 t/ha) (Table 1). It has shown potential for curd yield, earliness, curd compactness in early maturity group of Indian cauliflower (Verma and Kalia, 2011). Hence, it can be useful in commercial hybrid seed production.

DC 41-5: male fertile maintainer line of CMS line 'DC 8441-5': The 'DC 41-5' is a promising genotype of early maturity group of Indian cauliflower. It is suitable for sowing in June first week and transplanting in July second fortnight. It starts curd formation during last week of September which gets ready for harvest in mid of the October month in plains (Delhi condition). Plants are dwarf, spreading type, low spreading type and leaves are dark green. It produces cream white compact and solid curds (Table 1).

Table 1. Important horticultural traits and seed yield of 'DC 8441-5' CMS line and its maintainer

Traits	8441-5 (CMS line)	DC-41-5 (fertile line)
Maturity group	Early	Early
Days to 50% maturity	1st Fortnight of October	1st Fortnight of October
Marketable curd weight (g)	670.6 g	643.4 g
No. of pods/plant	863.0	993.4
Seed yield/plant (g)	17.82	20.50
Curd length (cm)	9.1	9.4
Curd width (cm)	11.8	13.5
Plant height (cm)	41.0	38.1
Plant spread (cm)	46.7	41.4
Gross plant weight (g)	1101.8	1006.0
Net curd weight (g)	510.8	452.5
Marketable curd yield (t/ha)	24.8	22.6

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31. DC 8498 & DC 98-10B (IC0632601 & IC0632602; INGR20031), a Cytoplasmic Male Sterile Line of Cauliflower (*Brassica oleracea* var. *botrytis*) in the Early Maturity Group (25-30°C) of Indian Cauliflower. Carry Ogura Sterile Cytoplasm. Good Combiner for Earliness and Curd Yield.

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Cauliflower (*Brassica oleracea* var. botrytis L.; 2n= 2x=18) is an important Cole crop in India grown almost all the year round in every nook and corner of the country. In early maturity group of Indian cauliflower, the curd initiation and development takes place at a temperature range of 25-30 °C. In order to encash intragroup maturity variability of this heat tolerant group, hybrid breeding is important. For facilitating affordable hybrid seed production, genetic mechanisms, such as self-incompatibility (SI) and cytoplasmic male sterility (CMS) have been exploited Major share of demand of hybrid seeds in India is being met through imports (Sharma *et al.*, 2005) as there is only one SI based hybrid 'Pusa Kartik Sankar' in early group so far from public sector developed indigenously. Since SI system is vulnerable to temperature fluctuations, therefore in the era of climate change chances of occurrence of natural sibs in F1 hybrids get increased forfeiting purpose of hybrid breeding. Alternatively, cytoplasmic male sterility system (CMS) introgressed in cauliflower (Sharma *et al.*, 2005) has been found to have high potential in hybrid breeding. Hence, conversion of elite adapted inbred lines into CMS lines will be instrumental in developing indigenous hybrid seed industry for cauliflower. The CMS line DC 8498-10 is such indigenously developed early maturity group CMS line of Indian cauliflower with refined Ogura male sterile cytoplasm introgressed into nuclear background of an elite inbred line 'DC 98-10' after 10 generations of backcrossing, which is free from any floral deformities.

Morpho-agronomic characteristics of CMS line DC 8498-10: The CMS line DC 8498-10 is the first CMS line with refined Ogura male sterile cytoplasm in Early maturity group (September end –mid November) of Indian cauliflower (Table 1 & Fig.1). It matures in a period of 60–70 days after transplanting in north Indian plains. It produces light yellow medium size normal flowers with good nectar volume. It bears normal sepals but size of petals is less than its fertile counterpart 'DC 98-10'. It has shrivelled anthers and no pollen mass seen in anthers indicating complete sterility. Good honey bee visit was observed in ' CMS-8498-10'. Seed yield of CMS line is 22.7 g/plant in 1:1 ratio (CMS line: fertile maintainer line) which was at par with the fertile maintainer. Like its maintainer 'DC 98-10', the ' CMS 8498-10' also produced cream white compact and solid narrow elliptic curds of small to medium size (net curd weight = 549.4 g) which is at par with early group. The marketable curd yield of CMS line (25.8 t/ha) is at par with its maintainer line DC-98-10 (23.3 t/ha) (Table 1). The CMS line showed potential in hybrid breeding of early cauliflower (Verma and Kalia, 2011). Hence, it can be used in commercial hybrid seed production.

DC 98-10: male fertile maintainer line of CMS line DC 8498-10: The 'DC-98-10' is a promising genotype of early maturity group of Indian cauliflower. It is suitable for sowing in June first week and transplanting during second fortnight of July under north Indian conditions. It starts curd formation during first week of October and ready to harvest last week of October to first fortnight of November. Plants are medium dwarf, semi-erect, medium in spread and leaves are bluish green. It produces cream white compact and solid curds (Table 1).

Table 1. Important horticultural traits and seed yield of CMS line DC 8498-10 in comparison to the fertile maintainer line DC 98-10

Traits	DC 8498-10	DC 98-10
Maturity group	Early	Early
Days to 50% maturity	September end – October mid	September end – October mid
Gross plant weight (g)	1118.9	1085.3
Marketable curd weight (g)	705.2	607.7
Net curd weight (g)	459.4	453.6
Marketable curd yield (t/ha)	25.8	23.3
Curd length (cm)	9.1	10.2
Curd width (cm)	12.0	11.9
Plant height (cm)	48.6	47.2
No. of pods/plant	883.5	974.2
Seed yield/plant (g)	22.7	24.5

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32. VRRAD-201 (IC625064) & VRRAD-202 (IC625065) KS/BS-37/ (IC0625064 & IC0625065; INGR20032), a Cytoplasmic Male Sterile (CMS) Line Radish (*Raphanus sativus*). Good Combiner and Higher Heterosis for Yield, Root Length and Root Weight.

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Radish (*Raphanus sativus* L.) belonging to Brassicaceae family is a most reliable year-round vegetable crop grown worldwide for fleshy edible roots and soft leaves. It has various category, broadly varying in leaf shape or leaf division incision (lyrate, sinuate, entire), root colour (white, red, purple), root shape (triangular, cylindrical, apically bulbous, elliptic), and vernalization requirement (temperate, tropical). Coloured radishes make salad decorative and nutritious, and good source of polyphenols and anti-oxidative properties (Singh *et al.*, 2017). Globally, the uses of F1 hybrids of many vegetables have increased manifold during last few decades, including India. Heterosis (hybrid vigour) is of direct interest for development and commercialization of F1 hybrids in various vegetable crops which is being facilitated by cytoplasmic male sterility (CMS) and self-incompatibility (SI) in radish. But, SI system in most of the radish genotypes is very weak and unstable and there is always chance to get undesirable number of sibs in hybrid seeds; hence CMS system is mostly preferred.

CMS was first identified in a cultivar of Japanese radish by Ogura (1968) popularly known as Ogura-CMS, and thereafter it has been transferred into various backgrounds of different Brassica vegetable. Although it is the most important salad crop in India because of availability of roots round the year, yet it is unfortunate that none of the radish CMS lines by Public Sector Institutes is available on public domain in our country till date because of less priority for research in this crop. Keeping in view of the importance and advantage of CMS lines especially in easy maintenance of female parent, harnessing heterotic vigour for economic traits, and cheaper & quality seed production of F1 hybrids; ICAR-IIVR, Varanasi, UP has been developed CMS lines by back cross method. The Ogura- CMS line 'VRRAD-201 or A Line' (IC0625064), First Ogura-CMS line from Public Sector in India, was developed by crossing CMS plants from open population with an elite line 'VRRAD-202 or B Line or Maintainer Line' (IC0625065) which is having better combining ability and higher heterosis for economic traits (Singh *et al.*, 2018). Significant heterotic hybrids for yield, longer roots, earliness, vigour consistency and uniformity have also been reported by many researchers (Kutty and Sirohi 2003, Kochetov and Sinyavina 2019).

VRRAD-201 possesses desirable leaf shape i.e. sinuate type of leaf morphology (leaf division incision), develops root during winter, spring and summer seasons, having white and triangular root, bears whitish-purple flower, and ready to seed harvest in about 4 months after transplanting of stecklings. The quantitative traits of economic importance of CMS line 'VRRAD-201' during winter season of 2016-2019 were observed such as gross plant weight 258.5-275.0 g, root weight 181.2-190.0 g, root length 24.8-26.0 cm, shoot length 35.9-38.4 cm, root diameter 3.3-3.6 cm, number of leaf 9.9-10.7, 40.2-52.4 days to first root harvest, marketable yield 53.9-60.2 t/ha, 34.2-38.1 days to 50% flowering, 381-410 number of pods/plant, 4.2-4.5 number of seeds/pod and 1000 seed weight of 12.8-13.5 g. Moreover, economic parameters of its maintainer 'VRRAD-202' during 2016-19 were realized as 252.1-270.0 g gross plant weight, 171.3-182.5 g root weight, 22.5-24.3 cm root length, 35.1-37.1 cm shoot length, 3.2-3.7 cm root diameter, 10.5-11.1 number of leaf, 41.8-52.9 days to first root harvest, 50.6-59.1 t/ha marketable yield, 30.1-33.5 days to 50% flowering, 360-382 pods/plant, 4.0-4.5 number of seed/pod, and 11.8-12.2 g of 1000 seed weight.

In conclusion, newly developed robust CMS line 'VRRAD-201' would be very effective in harnessing heterotic potential, developing F1 hybrids, and cost-effective commercial hybrid seed production in radish.

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33. BIL-53 (IC0631247; INGR20033), a Pre Breeding Line Watermelon (*Citrullus lanatus* var. *citroides*) Derived from the Cross *C. lanatus* var. *citroides* × Arka Manik Possessing Resistance to WBNV Disease.

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In India, watermelon is a major cucurbit and an important crop cultivated in an area of 82 thousand hectares with a production of 20.38 lakh tonnes (NHB) (http:/www.nhb.gov.in). The productivity levels are constrained by the occurrence of various diseases. Important among them, is a thrips transmitted Watermelon Bud Necrosis disease caused by a Tospovirus (Family: Bunyaviridae). It was first recorded during 1991 infecting watermelon at Indian Institute of Horticultural Research (IIHR) Bangalore, India (Singh and Krishnareddy, 1996) and thereafter it has been characterized as a new tospovirus species belonging to serogroup IV that infects several other cucurbits, such as cucumber, ridge gourd and muskmelon (Jain *et al.*, 1998; Mandal *et al.*, 2003; Jain *et al.*, 2007; Kumar *et al.*, 2010). The incidence ranges between 39-100% with yield loss of 60-100 % (Krishna Reddy and Singh, 1993). The field symptoms of WBNV in watermelon initially develop as chlorotic mottling, yellow spots or patches, and mild crinkling of leaves. Subsequently, necrosis of buds in the growing tips results in dieback of vines. In the young crop, rapid dieback and wilting of plant happens causing a total yield loss. Since, WBNV is prevalent in major watermelon growing areas in India, there is an immediate need to develop varieties/hybrids possessing resistance to this disease. In this direction, efforts are underway at Indian Institute of Horticultural Research, Bengaluru to develop varieties resistant to WBNV. During 2011-13, we established a natural screening protocol for WBNV and identified *C. lanatus* var. *citroides* (Citron) as a source of resistance. It was crossed to Arka Manik to develop RIL and BIL populations. These were evaluated under natural epiphytotic conditions for WBNV incidence during summer seasons of 2016, 2017 and 2018. Among them, BIL-53 (31% PDI@48DAS, 761 AUDPC and 96.67% survival) was found to be on par with the resistant parent 'Citron' (36.95% PDI@48DAS, 797.54 AUDPC and 83.33% survival) and recorded significantly lower WBNV incidence compared to susceptible parent Arka Manik (59.76% PDI@48DAS, 1278.89 AUDPC and 30.00% survival) and commercial check NS-295 (75.12% PDI@48DAS, 1711.83 AUDPC and 11.90% survival) in terms of PDI, AUDPC and survival over three years of screening. Thus, BIL-53 can be used as a prebred line for breeding resistance to WBNV.

34. VMB-16-10-Non Spiny Brinjal (IC0635040; INGR20034), a Brinjal (*Solanum melongena*) Germplasm with Purple Colour and Green Tinge at Distal End of the Fruit. Non-spiny Nature.

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Brinjal (*Solanum melongena* L.) is an important and widely consumed solanceous vegetable of Indian grown round the year. The spines in the all parts of the plant are a major constraint during picking and highly difficult to harvest of brinjal (VRM-1 Mullukathiri). It is a pure line selection from Elavambadi village of Vellore District. Spines are present in the leaf, stem and calyx of the fruit VRM -1 is high yielding (30-35 t/ha) and most suitable for Northern zone of Tamil Nadu. For developing non spiny brinjal the crossing work was attempted between non spiny (Senur local) × local type spiny (VRM 1) during 2008 to develop non-spiny fruits. The fruit set was ranged from 80-90 percent. Direct and reciprocal crosses (ie. Spiny × non-spiny and Non-spiny × spiny) were attempted to study the inheritance of non-spiny character from spiny brinjal. In both crosses non-spiny character was obtained. Even spiny × non-spiny crosses expressed more number of non-spiny plants. Non spiny types were forwarded to further generation and obtained homozygocity.

Morpho-agronomic characteristics: Non-spiny brinjal is a cross derivative of Spiny × non Spiny brinjal (Senur local type). Spines are absent in the leaf, stem and calyx of the fruit but the quality of the fruit remains same as VRM-1 Spiny Brinjal. Yield is about 40-45t/ha and performs well under wide range of soil with good drainage facility and suitable to cultivate in all three seasons (*Kharif*, *Rabi* and summer) It is of medium duration (140-150 days) and is cluster bearing in nature. Fruits are oval in shape, glossy pink in colour with green tinge in the distal end. Single fruit weigh about 120-150g and the flesh content is more and seed content is less. Suitable for all types of culinary preparations, especially highly suitable for preparations of side dish to biryani. Tolerant to drought conditions and high temperature prevailing during summer months. It is found to be highly resistant to Little leaf incidence and moderately resistant to Tobacco mosaic virus (TMV) and fruit and shootborer.

Associated characters and cultivation practices: Out of the best performing crosses, the cross consecutively performed well over generations for growth, yield and non-spiny nature. It can be used as donor in the appropriate breeding programme for developing non spiny brinjal types with retaining spiny brinjal taste in terms of quality.

35. Kashi Kale-1 (VRKALE-1 or IC0632940) (IC0632940; INGR20035), a tropical type Collard Green (*Brassica oleracea* var. *acephala*) Germplasm that Bolts, Flowers and Sets Seeds in Spring Season at Varanasi, Uttar Pradesh. No Vernalization Requirement to Stimulate/Induce Bolting and Flowering. Fast Growing and High Leaf Yield Potential i.e. 45-50 t/ha.

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Kale (*Brassica oleracea* L. var. *virdis* L.; formerly *B. oleracea* L. var. *acephala* DC.) is typically a temperate cole crop, classified as a biennial vegetable because of vernalization requirement, grown for its soft and tender leaves, and named as Gobhi Sag in Hindi (Singh *et al.*, 2017). Smooth leafed kale, popularly known as Karam Sag, is commonly grown by amateur kitchen gardeners of Kashmir and Himachal Pradesh. Kale is one of the most nutritious vegetables containing high levels of vitamin A, omega-3 fatty acids, lutein & zeaxanthin, vitamin C, and is a good source of vitamin B complex and minerals. Kale has a higher bio-availability of Ca than milk; and lower content of fat and oxalic acid. Like all Cole crops, except tropical cauliflower, kale requires vernalization (5-10 °C for 30-65 days) to stimulate/ induce bolting (Verma and Sharma, 2000; Myers 2003). In contrast to low temperature requirement, ICAR-IIVR, Varanasi, UP has developed an unique genotype named as Kashi Kale-1 (VRKALE-1 or IC 0632940) which is tropical type–first of its kind in the world that bolts, flowers and sets seeds during spring season of Varanasi, UP having 11-24 °C temperature, 54-91% RH and 5.5 h day light during January-February i.e. 60 days before flowering. Nevertheless, two national check varieties, namely Siberian Kale and Kanyari Local did not flower during 2013-14 and 2014-15. However, seeds of Kashi Kale-1 could be easily produced in non-traditional areas i.e. sub-tropical conditions.

The uniqueness of this genotype 'Kashi Kale-1' could explicitly be classified as tropical annual kale. It is very easy to grow, sprouts quickly, grows fast and produces smooth leaves profoundly. The fresh, soft, tender and crispy leaves are cooked to make saag and soups. Kashi Kale-1 is ready for first leaf picking in 24-27 days after transplanting. The leaves are glossy green, smooth, petiolate, and have profuse axillary buds, and its leaf yield potential is very high i.e. 45-50 t/ha. Newly identified novel genotype 'Kashi Kale-1' initiates flowering in mid-February i.e. 130-135 days after transplanting and continue for next 30-40 days. The inflorescence is racemose type, and flowers borne on the main stem and its branches with long pedicel of 2.91 cm. Flowers are typically cruciferous, having 4 sepals (light green, 0.92 cm long), 4 petals (bright yellow, 1.55×0.65 cm size), 6 stamens (0.98 & 0.65 cm), 1.30 cm long style and 2 carpels along with superior ovary, septum and 2 rows of campylotropous ovules. Pod maturity starts from 3rd week of April and ready to harvest in next 12-15 days depending on the climatic conditions. Seeds are small, globular, smooth and dark brown in colour, and 1000 seed weight is 2.45 g. Like tropical of Indian cauliflower which evolved in India and being grown commercially in tropical and subtropical conditions; in future, it is expected that tropical kale will certainly play a pivotal role in expanding the adoption, popularity and genetic base of kale.

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36. RS-11 (IC0523059) (IC0523059; INGR20036), a Watermelon (*Citrullus lanatus*) Germplasm with Resistance to *Fusarium oxysporum* f. sp. *niveum* race 1 and race 2 Performed Good as a Rootstock

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Fruit rind colour: medium green with dark green mosaic, indistinct stripes. Flesh colour: reddish pink. Seed colour: brown with dark brown pitting. Resistant to *Fusarium oxysporum* f. sp. *niveum* race 1 [recorded a mean survival of 82.14% at 28 days' post-inoculation with 5 ml spore suspension (@ 1×105 conidia per ml)] and race 2 [recorded a mean survival of 79.76% at 28 days' post-inoculation with 5 ml spore suspension (@ 1×105 conidia per ml)]. Root fresh weight 2.73 gm, root dry weight 432.50 gm, root depth 48 cm, hypocotyl length 9.08 cm, hypocotyl diameter 4.25 mm, number of secondary roots 4.75. Vine length of the commercial scion when RS-11 used as rootstock is 383.4 cm (33.06% increase) as compared to the non-grafted control (288.15 cm). Yield per plant of commercial scion when RS-11 used as a rootstock is 6.71 kg (89.54% increase) as compared to non-grafted control (3.54 kg).

37. IC096496 (IC096496; INGR20037), an Early Flowering Linseed (*Linum usitatissimum*) Germplasm

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Linseed or flaxseed (*Linum usitatissimum* L.) is multipurpose crop grown mainly for seed oil and stem fiber. Linseed is gaining popularity over the years owing to high content of health promoting compounds such as high lignan and omega-3 fatty acid. In India, linseed is grown as Rabi crop mainly in rain-fed soils, with limited input and in utera cultivation by resource poor farmers. Linseed being a long day plant requires longer day length for initiation of flowering which often delays the maturity time. In this context, early flowering trait is important in linseed as in other long day plants to facilitate early maturity. Early flowering is also a desirable trait to escape linseed bud fly, a major insect pest of linseed in central India causing losses up to 90%. In this perspective, germplasm accession IC0096496 has been identified for early flowering. In IC0096496, 50% flowering and completion (95% flowering) occurred at 58.6 and 64.2 days, respectively, which is significantly earlier than the early maturing check variety RLC76 (Table 1). This accession also possesses additional agronomically important traits such short height (<50 cm) (desirable for seed type linseed varieties) and higher thousand seed weight (7.9 g) compared to RLC76. Yield per plant was 5.5 g and seed oil content was found to be 39.6% for IC0096496. This accession has bushy growth habit, blue colored tubular flowers with twisted aestivation. The capsules were non-dehiscent with lustrous brown seeds.

Table 1. Flowering time data of linseed accession IC0096496 over five years

Year	Location	Days to 50% flowering		Days to 95% flowering	
		IC0096496	RLC76 (Check)	IC0096496	RLC76 (Check)
2014-15	NBPGR, New Delhi	58.0	77.2	66.0	96.7
2015-16	NBPGR, New Delhi	61.0	78.3	68.0	100.5
2016-17	NBPGR, New Delhi	60.0	83.7	65.0	94.0
2017-18	NBPGR, New Delhi	62.0	85.0	66.0	90.7
2018-19	NBPGR, RS- Akola,	52.0	67.0	56.0	73.0
Mean		58.6**	78.2	64.2**	90.9

** Statistical significance according to t-test (**P < 0.01)

38. DRMRTJ 2016 (IC0635042; INGR20038), an Indian mustard (*Brassica juncea*) Germplasm for Tetralocular Siliquae. Long Main Shoot (119.67 cm). High Siliqua Density (1.09).

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Indian mustard (*Brassica juncea* L.) is an important oilseed crop of India. In spite, impressive productivity gains; there is compelling need to further increase the productivity of the crop to meet the growing needs. This can be achieved through creation of novel genetic variability and effective utilization of germplasm resources. Indian mustard generally has bilocular siliquae, composed of two carpels with a partition. Therefore, it is highly desirable to have germplasm lines with tetralocular siliquae for enriching the present gene pool.

The genotype DRMRTJ 2016 having tetra-locular siliquae (composed of four carpels) was derived through interspecific hybridization between *B. juncea* (NRCDR 2) and *B. napus* (NRCGS-1) at ICAR-DRMR, Bharatpur. It was isolated as a pure line through pedigree selection and found promising for long main shoot and high siliqua density. DRMRTJ 2016 was tested for successive three years (ICAR-DRMR Annual Report, 2017-19) at ICAR-DRMR, Bharatpur. Pooled summary over the years indicates that proposed genotype DRMRTJ 2016 has long main shoot (119.6 cm), more number of siliquae on main shoot (130.4) and high siliqua density (1.09) along with more number of seeds / siliqua (22.3) compared to tetralocular check Geeta (Table 1). Tetralocular siliquae is a rare trait in Indian mustard which we are lacking in germplasm repository. Hence, genotypes with this unique trait will be a very good addition to existing gene pool to understand the genetics of the trait in order to increase more number of seeds per siliquae as this will further act as sink for increasing number of seeds per siliquae. Furthermore, the seed yield is a complex trait depends on various component traits like no. of siliquae/plant, siliquae on main shoot and siliquae density. Since, the proposed genetic stock is having long main shoot and high siliqua density over check. Therefore, this genotype with a combination of useful traits (tetralocular siliquae, long main shoot and high siliquae density) can be used as a donor in Indian mustard yield improvement programmes.

Table 1. Mean performance of proposed genetic stock DRMRTJ 2016 and check for different agro-morphological traits during 2016-17 to 2018-19.

Characters	Mean	
	DRMRTJ 2016	Geeta
Main shoot length (cm)	119.67	83.00
Siliqua density	1.09	0.89
Siliquae on main shoot	130.40	73.60
Plant height (cm)	257.93	216.40
Primary branches	13.07	10.47
Siliqua length (cm)	4.28	3.89
Seeds / siliqua	22.37	18.70
1000-Seed weight (g)	5.37	5.16
Oil content (%)	38.92	39.44
Seed yield/plant (g)	31.93	24.13
Days to maturity	149.67	147.33

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39. DRMR-WFYSM 15 (IC0635041; INGR20039), an Indian Mustard (*Brassica juncea*) Germplasm for White Flower. Yellow Seed Coat Colour. Appressed Siliqua Orientation.

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Indian mustard (*B. juncea* L.) is an important oilseed crop of India, contributes nearly 1/3rd of the total edible oil pool of the country. There is limited genetic variation especially for flower colour and seed coat colour in B. juncea. It generally has yellow flower and brown seed colour. Therefore, development of genotypes with new variability for these specific traits will be highly useful in breeding programmes for crop improvement and genetic studies. Thus, the genotype (DRMR-WFYSM 15) with a combination of three important traits viz., white flower, yellow seed coat colour and appressed siliqua orientation has been developed at ICAR-DRMR, Bharatpur. The proposed genotype DRMR-WFYSM 15 was derived through physical mutagenesis of Indian mustard cultivar Kranti by irradiation (at BARC, Mumbai) with gamma rays (100kr). Genotype DRMR-WFYSM 15 was tested at ICAR-DRMR for three successive years during 2016-17 to 2018-19 (ICAR-DRMR Annual Report, 2017-19). The pooled data over the years presented in Table 1. The genotype matures in 124 days and has average seed yield/plant is 21.3g, 1000 seed weight 4.28g, oil content 42.28%, number of seeds per siliqua 16.02 and plant height 175.5 cm.

Maintenance of genetic purity of varieties in Indian mustard is a problem due to often cross-pollinated nature, insect pollination mainly due to honeybee and large number of off-types. The white flower trait when transferred in a high yielding variety than it can be used as a visual marker during seed production programme to rouge out the off-types. Since, there is limited genetic variability for flower colour and seed coat colour in *B. juncea*, the proposed genetic stock DRMR-WFYSM 15 will add a new germplasm source in the repository for these traits. This genotype will be highly useful in breeding programmes and genetic studies since three very specific traits are present in a single genetic background. Apart from this, it has high oil content (42.28%) and matures early in 124 days.

Table 1. Mean performance of proposed genetic stock DRMR-WFYSM 15 for different agro-morphological traits during 2016-17 to 2018-19

Character	Mean of three years
Plant height (cm)	175.53
Primary branches (no.)	6.07
Main shoot length (cm)	73.83
Siliquae on main shoot (no.)	45.23
Siliqua length (cm)	4.50
Seeds / siliqua	16.02
1000-seed weight (g)	4.28
Oil content (%)	42.28
Seed yield / plant (g)	21.32
Days to maturity	124.00
Petal colour	White
Seed colour	Yellow
Siliqua orientation	Appressed

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40. DRMR-C-16-6 (IC0635043; INGR20040), an Extra Dwarf (85 cm height) African Mustard (*Brassica carinata*) Germplasm with High Oil Content (41.3%) and Early Maturity (127 days).

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Brassica carinata A. Braun (BBCC, 2n = 4x = 34), Ethiopian mustard or Karan Rai, is resistant to a wide range of diseases like Altenaria blight, white rust, stem rot and pests and is tolerant to many abiotic stresses particularly moisture stress. Besides having several agronomically important traits such as non-dehiscent siliquae and a much more developed and aggressive root system it could not find favour with farmers largely due to tall plant type, long duration, small seed size and low oil content as compared to popularly grown species i.e. Indian mustard (*B. juncea*). Hence, the high yielding genotypes with dwarf stature, short duration, high content and bold seed size are highly needed in this crop. Therefore, Inter-specific hybridization was initiated at ICAR-DRMR in 2010-11for widening of gene pool in Brassicas to tap genetic diversity and develop desirable lines of lines of Karan rai. Indian mustard variety NRCDR-2 was crossed with B. carinata genotype NRCKR 304. A desirable segregant with an extra dwarf (< 100 cm) plant type, long siliquae length, high test weight, early maturing (<130 days) and high oil content (>41%) was selected from segregating generation and was further advanced and maintained through progeny selection till stabilization of traits of interest (Kumar *et al.*, 2019). Further this line was evaluated for important traits in four environments (ICAR-DRMR Annual Report, 2019) along with parents and popular cultivar of Karan rai (Kiran) (Table 1).The salient features of DRMR-C-16-6 are plant height (85 cm), maturity (127.8 days) and oil content (41.3%) compared to NRCKR 304 (159 cm, 134.5 days, 40.5%), Kiran (234 cm, 162.7 days, 39.0%) and NRCDR-2 (206 cm, 143.5 days, 41.4%).This line can be utilized as a donor in breeding programmes for development of early maturing dwarf genotypes of Karan rai and it can be used in molecular breeding programme for development of mapping population for plant height.

Table 1. Average performance of DRMR-C-16-6, over four environments during 2016-17 to 2018-19.

Traits	Pooled (4 Environment)			
	DRMR-C-16-6	NRCKR304	Kiran	NRCDR-2
Days to maturity	127.8	134.5	162.7	143.5
Plant height	84.8	158.8	234.0	206.0
Primary branches	9.4	5.5	9.2	6.5
Secondary branches	21.9	13.9	21.3	15.5
Main shoot length	60.0	88.9	38.3	89.1
Siliqua length	3.7	3.8	3.4	5.3
Seeds per siliqua	15.5	16.3	12.7	16.1
1000 seed weight (g)	4.7	5.2	3.2	5.3
Oil content (%)	41.3	40.5	39.00	41.4

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41. RDV 29 (IC0589658) (IC589658; INGR20041), an Indian Mustard (*Brassica juncea*) Germplasm with Resistance to Powdery Mildew Disease

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Among various biotic stresses, particularly the fungal diseases, powdery mildew of Indian mustard, caused by *Erysiphe cruciferarum* Opiz. Ex. Junell., has been reported to cause significant yield losses, sporadically, depending on the prevailing agro-ecological conditions. This disease was once considered to be of minor importance, but in the recent years, it became widespread throughout the mustard growing regions of India particularly in the states like Uttar Pradesh, Rajasthan, Jammu & Kashmir, Haryana and Gujarat and in other non-traditional mustard growing areas such as Maharashtra, Karnataka and Andhra Pradesh. All the Indian mustard cultivars currently being cultivated in different states of India are highly susceptible to this disease. This fungus can infect any above-ground plant parts and can cause heavy yield losses by reducing plant growth and consequently, the quantity and quality of seeds (Kumar and Saharan, 2002; Meena *et al.*, 2014). In India, earlier attempts to identify resistant source to powdery mildew of Indian mustard were failed as all the *B. juncea* genotypes evaluated were found to be highly susceptible to this important pathogen and whatever the resistant sources reported belonged to other related species and allied genera with no reports available about its resistance in *B. juncea*, which is an important oil yielding species in Indian context. Keeping in view the economic importance of powdery mildew disease in Indian mustard, research initiatives have begun at ICAR-Indian Agricultural Research Institute, Regional Station, Wellington, which is a hot spot for this disease inter alia many other crop diseases.

With an aim to identify resistant source, 1,020 Indian mustard accessions were evaluated against *E. cruciferarum* PMN isolate, at Wellington, The Nilgiris, Tamil Nadu, India under natural hot spot conditions. The study identified one accession (RDV 29) with complete resistance against *E. cruciferarum* PMN isolate for the first time, which was consistent in five independent evaluations (Table 1). Genetic analysis of F1, F2 and backcross populations obtained from the cross RSEJ 775 (highly susceptible) × RDV 29 (highly resistant) for two season revealed that the resistance is governed by two genes with semi-dominant and gene dosage effect (Nanjundan *et al.*, 2020). The outcome of this study viz. newly identified powdery mildew-resistant Indian mustard accession (RDV 29) and information

Table 1. Reaction of Indian mustard accession RDV 29 and four check varieties to *Erysiphe cruciferarum* during five independent evaluations at ICAR-IARI, Regional Station, Wellington.

Entry/Checks tested	Disease reaction at 80 DAS*				
	Evaluation I	Evaluation II	Evaluation III	Evaluation IV	Evaluation V
	(*Kharif* 2016)		(*Rabi* 2016-17)		(*Rabi* 2017-18)
	(DOS:10-06-2016)	(DOS:11-11-2016)	(DOS:07-12-2016)	(DOS:01-02-2017)	(DOS:18-12-2017)
RDV 29	Highly resistant	HR	HR	HR	HR
KLM 4	Partially resistant	PR	PR	PR	PR
RSEJ 775	Highly susceptible	HS	HS	HS	HS
RH 0704	Highly susceptible	HS	HS	HS	HS
NRCDR 02 (Check 1)	Moderately susceptible	MS	MS	MS	MS
NRCDR 601 (Check 2)	Moderately susceptible	MS	MS	MS	MS
GIRIRAJ (Check 3)	Moderately susceptible	MS	MS	MS	MS
ROHINI (Check 4)	Moderately susceptible	MS	MS	MS	MS

Note: *Disease scoring as per Nanjundan *et al.*, (2020). Plant Pathology Journal, Vol. 36(2), Page 115.

on inheritance of resistance will provide the base for development of powdery mildew-resistant cultivars of Indian mustard.

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42. Palm No. 47 (IC0635046; INGR20042), an Oil Palm (*Elaeis guineensis*) Germplasm for Medium Height Increment.

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There is no source of high yielding and short stature mother palms in India. Productivity and harvesting are the two major gaps in oil palm production in India. After eight years of palm age it is very difficult to harvest bunches manually by climbing palm due to its tall in stature. The present identified palm has a highest yield (221.30 kg) and medium height increment (33.00 cm) in comparison to other progenies by taking moving average (Yield: 103.77 kg, Height increment: 31.81 cm) of the same cross.

The utilization of high-yielding genetic base as a planting material has been proven to be the most efficient and sustainable means of increasing the yield output of existing oil palm genetic base (Arolu *et al.*, 2017). This genetic stock recorded highest yield and short stature compared with other progenies. However, it can be used as a mother parent for the development of high yielding and dwarf oil palm hybrids.

The uniqueness and novelty of this accession of *Elaeis guineensis* Jacq. is confirmed on the basis of its yielding behavior and dwarf stature which are a desirable traits to the farmers. Fruit form of this palm is also confirmed through molecular markers. This accession can further be used for oil palm improvement programmes. The seeds of the accession (Palm number: 47) obtained from the institute exotic germplasm block in research farm of ICAR-Indian Institute of Oil Palm Research, Pedavegi, Andhra Pradesh.

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Arolu IW, MY Rafii, MM Hanafi, Z Sulaiman, HA Rahim, M Marjuni, MD Amiruddin, MIZ Abidin and R Nookiah (2017) Breeding of high yielding and dwarf oil palm planting materials using *Deli dura* × *Nigerian pisifera* population. *Euphytica*, 213:154.

43. Palm No. 33 (IC0635047; INGR20043), an Oil Palm (*Elaeis guineensis*) Germplasm with More Number of Bunches and Slow Vertical Growth

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Till date there is no source of high yielding and dwarf mother palms in India. The breeding efforts to improve the varieties with high fresh fruit bunches (FFB) yields is major concern to increase palm oil productivity. Reduced height increment, superior oil quality as well as more number of bunches are also important considerations. Productivity and harvesting are the two major gaps in oil palm production in India. After eight years of palm age it is very difficult to harvest bunches manually by climbing palm due to its tall in stature. The present identified palm has a highest yield (181.70 kg), more number of bunches (20.50) and less height increment (18 cm) in comparison to other progenies by taking moving average (Yield: 98.13 kg, No. of bunches: 13.38, Height increment: 32.48 cm) of the same cross. The mesocarp content of this accession also more (72.20%) when compared with the standard duras.

The utilization of high-yielding genetic base as a planting material has been proven to be the most efficient and sustainable means of increasing the yield output of existing oil palm genetic base (Arolu *et al.*, 2017). This genetic stock recorded highest yield and short stature compared with other progenies. However, it can be used as a mother parent for the development of high yielding and dwarf oil palm hybrids.

The uniqueness and novelty of this accession of *Elaeis guineensis* Jacq. is confirmed on the basis of its yielding behavior and dwarf stature which are a desirable trait to the farmers. Fruit form of this palm is also confirmed through molecular markers. This accession can further be used for oil palm improvement programmes. The seeds of the accession (Palm number: 33) obtained from the institute exotic germplasm block in research farm of ICAR-Indian Institute of Oil Palm Research, Pedavegi, Andhra Pradesh.

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44. Palm No.72 (IC0635048; INGR20044), a Dura Type Oil Palm (*Elaeis guineensis*) Germplasm with Medium Height Increment.

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Till date there is no source of more number of bunches and medium height dura mother palms in India. Productivity and harvesting are the two major gaps in oil palm production in India. After eight years of palm age it is very difficult to harvest bunches manually by climbing palm due to its tall in stature. The present identified palm having more number of bunches (22.00) with medium height increment (30 cm) in comparison to other progenies by taking moving average (No. of bunches: 15.40, Height increment: 31.56 cm) of the same cross. The details morphological traits are given in Table 1.

The utilization of high-yielding genetic base as a planting material has been proven to be the most efficient and sustainable means of increasing the yield output of existing oil palm genetic base (Arolu *et al.,* 2017). This genetic stock recorded highest yield and short stature compared with other progenies. However, it can be used as a mother parent for the development of high yielding and dwarf oil palm hybrids.

The uniqueness and novelty of this accession of *Elaeis guineensis* Jacq. is confirmed on the basis of its yielding behavior and dwarf stature which are a desirable traits to the farmers. This accession can further be used for oil palm improvement programmes. The seeds of the accession (Palm number: 72) obtained from the institute exotic germplasm block in research farm of ICAR-Indian Institute of Oil Palm Research, Pedavegi, Andhra Pradesh.

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45. Palm No. 542 (IC635049; INGR20045), a Sterile Dura Type Oil Palm (*Elaeis guineensis*) Germplasm with Virescence.

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The sterility in dura is may be due to crossing over and recombination of genes. The problem of gene flow is particularly important to the genetic improvement of perennial crop like oil palm. By using female sterile lines there is a possibility to create sterile hybrid plants to control gene flow. The ovule of female sterile plants is aborted but the phenotype of most of the plant is otherwise normal. The inflorescence and flowers of sterile plants are normal and had a high pollen fertility.

Development of superior variety by accumulation of beneficial alleles from vast plant genetic resources is a major challenge. Fertility in the oil palm is shown to be controlled by a single gene which is linked to the gene controlling fruit form. The sterile dura's are very rare and can be used as a male parent in selected crosses.

Sterile female plants sometimes can be used to identify regulatory genes that influence ovule and female gametophyte development. These regulatory genes are involved in nucellar and integument cell development (Balasubramanian and Schneitz, 2002).

The uniqueness and novelty of this genetic stock of *Elaeis guineensis* Jacq. is confirmed on the basis of its fruit form and its 100% sterility as well through molecular markers.

This accession can further be used for oil palm improvement programmes. This accession (Palm number: 542) obtained from the institute field gene bank in research farm of ICAR-Indian Institute of Oil Palm Research, Pedavegi, Andhra Pradesh.

Research on female sterility in plants can have several applications. The selection against sterility for seed production improvement could be made easier. Female-sterile plants could be used as pollen parents for hybrid seed production.

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46. Palm No. 482 (IC635050; INGR20046), a Sterile Dura Type Oil Palm (*Elaeis guineensis*) Germplasm with Broad Leaf Sheath.

Anitha Pedapati[1]*, RK Mathur[1], G Ravichandran[1], K Suresh[1], P Murugesan[2], K Sunil Kumar[2], Kalyanbabu B[1], HP Bhagya[1] and G Somasundaram[1]
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Wild traits are the reservoir of many useful genes/ alleles which can be used to survive climate extremes. Wild traits have very high level of resistance/tolerance to various stresses. Due to climate change, several areas are now becoming unsuitable for cultivation of traditional crops. To cope with this situation, there is a need to breed new crop cultivars with a broad genetic base capable of withstanding frequent climatic fluctuations and wider adaptability due to adapted gene complex.

The sterility in dura is may be due to crossing over and recombination of genes. The problem of gene flow is particularly important to the genetic improvement of perennial crop like oil palm. By using female sterile lines there is a possibility to create sterile hybrid plants to control gene flow. The ovule of female sterile plants is aborted but the phenotype of most of the plant is otherwise normal. The inflorescence and flowers of sterile plants are normal and had a high pollen fertility.

Fertility in the oil palm is shown to be controlled by a single gene which is linked to the gene controlling fruit form. The sterile dura's are very rare and can be used as a male parent in selected crosses. Sterile female plants sometimes can be used to identify regulatory genes that influence ovule and female gametophyte development. These regulatory genes are involved in nucellar and integument cell development, 2002).

The uniqueness and novelty of this genetic stock of *Elaeis guineensis* Jacq. is confirmed on the basis of its fruit form, broad leaf sheath and its 100 % sterility. This accession can further be used for oil palm improvement programmes. This accession (Palm number: 482) obtained from the institute field gene bank in research farm of ICAR-Indian Institute of Oil Palm Research, Pedavegi, Andhra Pradesh. Research on female sterility in plants can have several applications. The selection against sterility for seed production improvement could be made easier (Rosellini *et al.*, 1998). Female-sterile plants could be used as pollen parents for hybrid seed production.

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47. IC0610027-20 (IC0610027; INGR20047), a Pisifera Oil Palm (*Elaeis guineensis*) Germplasm with 98.5% Sterility. Nigrescence Fruit Form.

Bhagya HP[1]*, RK Mathur[1], P Murugesan[2], K Sunil Kumar[2], Ravichandran G[1], Ramajayam D[3], Goutham Mandal[4], AGK Reddy[5], Kalyanbabu B[1] and Anitha P[1]

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Oil palm is very important crop for fulfils the edible oil requirement of our country. As compared to other annual oil yielding crop this is giving more oil yield (5-6 t/ha). Oil palm breeding programme mainly depending male (sterile pisifera) and female parent (fertile dura) for hybrid seed production. Commercial material for farmer cultivation is tenera, this can be obtained by crossing of fertile Dura and sterile pisifera. Pisifera population is rare and in that also getting sterile pisifera is very scarce. Male parent (Sterile pisifera) should be having 100% sterility. In breeding programme dwarf dura material as female parent is already available but we are not having sterile pisifera. Pisifera palms available are usually with more trunk girth, high vegetative growth and less fruit set or no fruit set. But this palm will be having more sterility (98.55%). So this pisifera with high sterility needed in breeding programme as a male parent and this pollen can be used for hybrid seed production of oil palm.

Trait description (Accession: IC0610027-20)

Traits	2016-17	2017-18	2018-19	Average
Number of bunches per year	8	10	7	8.33
FFB yield (kg/palm/year)	117.21	147.30	106.65	123.72
Bunch weight (kg)	18.25	14.37	10.64	15.38
Total number of fruits	1200	1405	1035	1275.66
Number of sterile fruits	1181	1399	1011	860
Sterility %	98.41	99.57	97.68	98.55

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48. IC0610024-47 (IC0610024; INGR20048), a Parthenocarpic Pisifera Oil Palm (*Elaeis guineensis*) with Good Fruit Set (68.62%).

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Oil palm (*Elaeis guineensis* Jacq.) is monocious crop, male and female inflorescence will be bearing separately on the same palm. Oil palm is cross pollinated crop and it is mainly pollinated by weevil (*Elaeidobius kamerunicus*) and if pollinator is not available, poor fruit set or no fruit set can be happened. Parthenocarpy is the natural or artificially induced production of fruit without fertilization of ovules, which makes the fruit seedless. In oil palm parthenocarpy is not common. In oil palm induced parthenocarpy was done and it was given poor fruit set. Identified palm is natural parthenocarpic and fruit set is good and this palm can be directly used in breeding programme and If this palm performs better in yield and oil content, directly this palm can be multiplied clonally used for commercial plantation. So this will reduce the problem of pollination. Where ever pollinator is a problem or pollinator not able survive in that areas this material will be useful. Cultivated variety of oil palm is Tenera and this is having high mesocarp, less shell and kernel. Our main objective is to get a more oil from the mesocarp for edible purpose and this will be obtained from this fruit and here no kernel and shell. Here we are having an advantage of whole fruit can be processed for oil extraction and will be getting more oil to bunch ratio as compared to normal fruits and Parthenocarpic pisifera palms could be use in molecular breeding programme aim to develop linkage mapping and further evaluation.

Trait description

Traits	2016-17	2017-18	2018-19	Average (2016-19)
Number of bunches per year	14	26	8	16
FFB yield (kg/palm/year)	111.66	220.23	77.19	136.36
Bunch weight (kg)	9	10.42	7.22	8.88
Total number of fruits	632	788	805	741.66
Number of Parthenocarpic fruits	347	578	625	516.66
Sterile fruits	285	210	180	225
Parthenocarpic fruit set %	54.90	73.35	77.63	68.62

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49. NRCGCS 636 (HOS-89) (IC635044; INGR20049), a Groundnut (*Arachis hypogaea*) Germplasm with High Oil Content (56%).

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Groundnut (*Arachis hypogaea* L.) is an improtant oilseed crop worldwide. About 47.09 million tonnes of peanut are produced from 27.94 million hectares worldwide (FAOSTAT 2017). In general, oil content in groundnut varied from 48% to 53%. It is estimated that 1% increase in the seed oil content increases the groundnut processer's benefit by 7% (Liao, 2003), indicating greater impact of oil content trait for farmers and traders. Hence, breeding groundnut for enhanced oil content is a major objective worldwide.

A high oil content (53%) breeding line ICGV 06100 was crossed with Sunoleic 95R in 2011 and 104 advanced lines were developed using SSD method. Of which four lines were found with very high oil content (~55%). Oil content of these lines was confirmed over five seasons. Oil content was estimated using both Soxhlet method and Gas Chromatography. Of which a very high oil content breeding line, NRCGCS-636 was characterized for morpho-physiological and yield traits.

NRCGCS-636 is a Spanish bunch, very high oil content groundnut germplasm developed at ICAR-Directorate of Groundnut Research, Junagadh, Gujarat. It was bred from a cross between ICGV 06100 × Sunoleic95R using pedigree selections. It has moderate plant height, alternate branching and small dark green ovate leaves. It bears compound inflorescence with yellow coloured standard petal and takes about 24 days after sowing for 50% flowering in kharif season. It yielded 154 g of pod/m2 with ~35% Harvest Index, ~68% shelling out-turn and ~38 g of 100-kernel weight. Kernels of NRCGCS-636 are monochrome with rose colour testa. NRCGCS-636 is tolerant to Rust (scored 1 in 1-9 scale) and susceptible to Late leaf spot disease (scored 7 in 1-9 scale). Oil content of NRCGCS-636 over five years varied from 55% to 58% with a mean of 57%. NRCGCS-636 matures in 115 days after sowing during kharif season. NRCGCS-636 can be grown directly as very high oil content genotype or used as donor in future breeding program.

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50. NRCGCS-635 (HOS-30) (IC635045; INGR20050), a Groundnut (*Arachis hypogaea*) Germplasm with High Oil (56%).

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A high oil content (53%) breeding line ICGV 06100 was crossed with Sunoleic95R in 2011 and 104 advanced lines were developed using SSD method. Of which four lines were found with very high oil content (~55%). Oil content of these lines was confirmed over five seasons. Oil content was estimated using both Soxhlet method and Gas Chromatography. Of which a very high oil content breeding line, NRCGCS-635 was characterized for morpho-physiological and yield traits.

NRCGCS-635 is a Spanish bunch, very high oil content groundnut germplasm developed at ICAR-Directorate of Groundnut Research, Junagadh, Gujarat. It was bred from a cross between ICGV 06100 × Sunoleic95R using pedigree selections. It has moderate plant height, alternate branching and small dark green ovate leaves. It bears compound inflorescence with yellow coloured standard petal and takes about 25 days after sowing for 50% flowering in kharif season.

It yielded 150 g of pod/m^2 with ~36% Harvest Index, ~67% shelling out-turn and ~40 g of 100-kernel weight. Kernels of NRCGCS-635 are monochrome with rose colour testa. NRCGCS-635 is tolerant to Rust (scored 1 in 1-9 scale) and susceptible to Late leaf spot disease (scored 7 in 1-9 scale). Oil content of NRCGCS-635 over five years varied from 55% to 58% with a mean of 56%. NRCGCS-635 matures in 120 days after sowing during kharif season. NRCGCS-635 can be grown directly as very high oil content genotype or used as donor in future breeding program.

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51. ACC. No. 52 (IC632088; INGR20051), a Cumin (*Cuminum cyminum*) Germplasm with White Flower and Compact Plant Type.

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Cumin with white flower is unique character, generally all cultivated, released varieties and genetic stock are having pink flowers. Seed Spices Research Station, S.D. Agricultural University, Jagudan, Gujarat has explored cumin with white flower. Cumin with pink flower is having anthocynanin pigmentation in their flower.

52. 52. Acc. No. 53 (IC632089; INGR20052), a Cumin (*Cuminum cyminum*) Germplasm with Hairy Seed and Spreading Plant Type

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Hairiness on seeds of cumin is rare occurrence; moreover, it is heritable character. Hairy cumin is maintained at Seed Spices Research Station, S.D. Agricultural University, Jagudan, Gujarat. In the past, hairy cumin was considered as a weed but after continuous selection now it is germplasm. To study various agronomical advantages for commercial cumin cultivation, this was identified and maintained.

According to morphological description, hairiness found on seeds till maturity, and after harvesting it will disappear which does not affect quality of cumin seed.

53. Jor Lab L-11 (IC635431; INGR20053), a Lemon Grass (*Cymbopogan flexuosus*) Germplasm Rich in Methyl Isoeugenol (48%) and Myrcene (39%) in Essential Oil.

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Cymbopogon flexuosus L of the family Poaceae is a highly valued grass known throughout the world for its aromatic properties. It belongs to the family Poaceae and consists of 140 species, of which 45 species reported from India and tropical Asia (Lal *et al.*, 2016). The essential oil from this species is widely used in flavours, fragrances, perfumery, soaps and detergents owing to its lemon like odour (Dutta *et al.*, 2017, Ganjewala 2009). The compounds present in C. flexuosus essential oil viz- citral, geraniol, geranyl acetate, methyl eugenol, citronellol, beta-myrcene, methyl iso-eugenol, limonene, piperitone, citronellal, alpha-terpineole, pinene etc are known to posses insecticidal, antibacterial, antifungal and insect repellent properties and recently gained importance for its biological and pharmacological applications (Lal *et al.*, 2018, Ganjewala 2009, Baruah *et al.*, 2017). Besides citral rich there are some species which contains geraniol (*Cymbopogon martini),* elemicin (*Cymbopogon khasianus, Lal et al., 2018*), and methyl eugenol (*Cymbopogon khasianus)* as their main component. The objective of the study is to identify novel myrcene and methyl iso-eugenol rich variety of lemongrass available in North East India. Myrcene has an earthy, spicy, clove fragrance commonly used in culinary and perfume industry while methyl iso-eugenol has typical sweet-warm, spicy-clove, woody, floral odour mostly used in perfume industries. In the present study total 230 lemongrass accessions collected from different regions of North East India were planted in Randomized Block Design (RBD) with three replications at experimental farm CSIR-NEIST, Jorhat, during the year 2014. Morphological and essential oil quality data were recorded during the year 2015-16 and 2016-17 and based on two years selection trial data a high myrcene and methyl iso-eugenol rich line was identified and named as Jor Lab L-11. The identified line was planted along with two checked variety at four locations during the year 2017-18. The average essential oil yield of Jor Lab L-11 for multilocation trial was 0.58% and contains 48% and 39% myrcene and methyl iso-eugenol as major component in the essential oil respectively (Table 1). Myrcene and methyl iso-eugenol percentage, essential oil percentage, tillers/plant were significantly higher as compared to check varieties. Besides these, the essential oil of Jor Lab L-11 also contain limonene, elemicin, β-pinene, α –pinene, citronellol, neryl acetate, linalool, geranyl acetate, methyl eugenol, geraniol, citral b, citronellal, citral a, α–terpineol and nerol as minor compounds.

Table 1. Average multilocation trial data of Jor Lab L-11 planted in four different locations (Jorhat, Imphal, Pasighat, Lakhimijan) of North East India during 2017-18

Variety	Plant height (cm)	Tillers/plant	Herbage yield/ tons/ha/yr	Essential oil % v/w	Myrcene %	Methyl isoeugenol%	Major oil constituent
Jor Lab L-11	109.25	48.5	20.68	0.58	48	39	Myrcene, Methyl iso-eugenol
RRLJM-622(Check-1)	109	43	19.21	0.42	12	20	Myrcene, Methyl iso-eugenol
Jor Lab L-2 (Check-2)	118	38.25	21.25	0.38	2.3	0.67	Citral

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54. Jor Lab AC-1 (IC635433; INGR20054), a Sweet flag (*Achorus calmus*) Germplasm with Essential Oil Yield more than 1.2% on Dry Weight Basis. Cis Asarone is more than 80% of the Essential Oil.

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Acorus calamus L. (sweet flag) is an aromatic medicinal plant, generally found in the temperate and subtropical regions of the world (Nigam *et al.*, 1990). It is abundantly found in the northern temperate and subtropical regions of Europe, North America and East Asia (Nigam *et al.*, 1990). It is used in various commercial and pharmaceutical industries for its medicinal and aromatic properties; and used since ages in traditional medicines (Van *et al.*, 1997, Lal *et al.*, 2016). The essential oils obtained from the rhizome are used medicinally, as flavourings in alcoholic beverages, as fragrant essences in perfumes and sacred oils, and for insecticidal properties (Mazza, 1985). The aim of the present study was to identify a high essential oil yielding variety of A. calamus. In this study, forty germplasm were collected from different parts of India and planted in RBD during the year 2014. All agronomical and oil quality data were recorded. The major compound in the essential oil was β-asarone (Table 1). After evaluation of two season data, a high essential oil genotype was identified and was named as "Jor Lab AC-01". The newly identified line is superior to the check variety as the yield of essential

Table 1. **GC/MS data of components present in the essential oil of *Acorus calamus* (Jor Lab AC-1)**

S.No.	Compound name	RT	Area (%)
1	methyl 2-methylbutyrate	03.22	0.05
2	ocimene	05.77	0.17
3	camphene	06.24	0.01
4	*l*-linalool	06.49	0.14
5	terpineol	07.05	0.09
6	*α*-citronellol	08.13	0.04
7	nerol	09.01	0.05
8	linalyl acetate	10.39	0.03
9	neric acid	10.40	0.04
10	2-methoxy-3-allylphenol	11.95	1.91
11	calarene	12.18	2.41
12	*α*-maaliene	13.20	0.22
13	methyl isoeugenol	13.67	1.51
14	sulcatol	14.16	0.03
15	germacrene-*D*	14.85	0.17
16	epiglobulol	15.35	0.12
17	euasarone	15.64	1.90
18	spathulenol	15.79	0.14
19	*cis*-asarone	16.53	80.42
20	dieoicedren-1-oxide	16.89	1.52
21	isolongifolenone	16.89	0.13
22	acorenone	18.51	0.45
23	*iso*-calamendiol	18.93	0.75
24	paroxetine	20.82	0.25

oil is much higher (1.20%) in comparison to the check variety (0.62%). Moreover, in this new line, in addition to high essential oil yield, the total dry rhizome yield/tones/ha/year (2.18) is much higher as compared to the check variety (1.89) (Table 2). Data recorded from the five locations across Northeast India gave satisfactory and stable results. High essential oil varieties have wide range of use across several industries like pharmaceutical, perfumery, cosmetic and many others (Lal *et al.*., 2018). As the market demand is increasing for high essential oil yielding varieties day by day along with the market price of essential oils, farmers will be benefitted by selling the essential oil of this high yielding variety and cultivation of this crop seems to be a profitable venture.

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Table 2. **Average morphological and oil constituent of *A. calamus* with check variety at five different locations in the year 2017-18**

Variety	Location	Plant height (cm)	No. of tillers/ plant	No. of leaf/ plant	No. of primary rhizome	Dry rhizome recovery	Fresh rhizome yield/tones/ha	Essential Oil%	Essential oil yield tonnes/ ha/season	Total dry rhizome yield/tones/ ha/season
Jor Lab AC-1		88	8	12	1	32	6.80	1.20	2.63	2.18
Check variety (CIM-Balya)		92	10	11	1	31	5.60	0.62	1.19	1.89

55. Jor Lab B-2 (IC635434; INGR20055), a Annato (*Bixa orellana*) Germplasm with Bixin Content More than 1.1%. Normal Range of Bixin Content is 0.3 to 1.3% in the Germplasm.

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Bixa orellana commonly known as Sinduri plant is a natural source of bixin. This perennial, rapidly growing tree is of great agro-industrial interest as the seeds of the plant are rich in carotenoid content, mainly bixin which is a source of natural dye (Madrid *et al.*, 2006; Franco *et al.*, 2008). Annatto colorants have several uses due to which it is a popular agro-industrial crop (Franco, 2007). it is used extensively in food industry, particularly in cheese and dairy products cereal-derived products, sweets, beverages, sauces, sausages and meat products (Barcelos *et al.*, 2012; Giriwono *et al.*, 2013; Pierpaoli, 2013; Vilar, 2014; Kang *et al.*, 2010; Galindo-Cuspinera *et al.*, 2003; Shibata, 2008; Matuo *et al.*, 2013). In this experiment a total of 52 genotypes were collected and planted in the CSIR-NEIST Experimental farm during 2008. After screening five-year data all the genotypes were screened for agronomical, qualitative and quantitative characters out of which 5 genotypes were selected for high bixin content and high seed yield and were planted again in RBD during 2013. After study of six years from the studied genotype the genotype 2 was found the best variety of Bixa orellena possessing high bixin content. The genotype 2 has an average plant height of 209 cm, average number of branch per plant is 23 and the average plant diameter is 70 cm. The average number of capsule per clump is 12.75; the average capsule clump per plant is 58, and the average number of seeds per capsule is 32.50. Among the studied varieties the genotype 2 was found to have an average yield of 554.50 gm of bixin yield per plant and the average bixin content was found 1.1%. While the average yield of bixin content per plant of the check variety was found 541.00 gm and the bixin content of the check variety was found 0.60%. The genotype was named as 'Jor Lab B-2'. Till date none of the variety of *B. orellena* has been reported to have high bixin content. Cultivation of this variety will be much beneficial economically as it has a high bixin content which is a source of natural dye that has various applications in numerous fields. Presently there is no variety of *Bixa orellena*, so the identified variety is novel as it has high bixin content and higher yield than the check variety.

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56. Jor Lab L-15 (IC635702; INGR20056), a Lemon Grass (*Cymbopogon khasianus*) Germplasm with High Geraniol Content (83%) in Essential Oil.

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Cymbopogon species, which belongs to the family Poaceae, is an important genus of medicinal and aromatic plants. *C. khasianus* is a perennial crop which grows by vegetative propagation (Lal *et al.*, 2018; Dutta *et al.*, 2017). It is commonly found in Khasi Hills, Jaintia Hills, Naga Hills and lower Assam of NE India (Dutta *et al.*, 2016). The essential oil of this species is rich in various valuable chemical compounds, which are useful for industrial and commercial purposes (Dutta *et al.*, 2016, Lal *et al.*, 2016, Baruah *et al.*, 2017). In this present study, a total of 425 germplasm of *Cymbopogon* species which were collected from different regions of India, and was analyzed for its agronomical, essential oil yield and quality data, for two year 2014-15 and 2015-16. To identify the constituents, extraction of essential oil was done using hydro-distillation and GC/MS analysis. The major constituent was geraniol (Table 1). On the basis of two consecutive year data, a geraniol rich line was identified and the results were confirmed by planting as multi-location trial, along with the standard check (IIMJ (CK) – 10) during the year 2016-17 and 2017-18. The average essential oil yield of the newly developed variety in the five different locations was 0.54% and average geranial content of the multi-location trial was 83%; which is much higher as compared to the check variety that showed essential oil yield of 0.40% and geraniol content of 46.8% This selected germplasm also showed better agronomical traits in comparison to the check variety (Table 2).. This new identified line was named as "Jor Lab L –15". The high essential oil yielding varieties meet the needs of various pharmaceutical, cosmetics and food industries, across the world (Lal *et al*., 2018). Therefore it can be concluded that the farmers would be benefited by adopting this superior variety having high geraniol content. The societal status of the farmers will become better, as they can sell the essential oil at higher rates. This in turn will help in raising the economic status of the farmers as well as the whole society.

Table 1. GC/MS analysis of the compounds identified in the essential oil of Jor Lab L-15

Compound Name	Retention time	Area%
O- cymene	8.445	0.23
2- Carene	9.565	0.12
D-limonene	10.683	0.14
trans-β-Ocimene	11.071	3.70
1,3,6-Octatriene	11.502	1.87
4-Nonanone	12.550	0.13
Linalool	13.728	0.39
γ-Terpinene	14.660	1.17
3-Carene	15.463	0.56
p-Mentha-1,5-dien-8-ol	16.707	0.11
α-Phellandrene	17.983	0.32
γ-Terpinene	18.540	0.33
Citral	20.049	0.24
Geraniol	20.826	83.58
Citral	21.396	0.59
β-myrcene	26.310	4.74
trans-Isoeugenol	28.966	0.14
Copaene	31.668	0.16
Hedycaryol	32.997	0.10
Elemicin	33.317	1.00
3-Carene	33.456	0.37

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Table 2. Average agronomical and essential oil data of multi-location trials, along with check variety for two years (2016-17 and 2017-18)

Plant variety	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Tiller/ plant	Herbage yield (tons/ha/year)	Essential Oil%	Essential oil yield/ha/year	Major oil constituent (% geraniol)
Jor Lab L-15	109.00	86.00	1.10	56.00	22.8	0.54	12.31	83.00
IIMJ (CK) - 10	79.00	84.00	0.78	76.00	16.8	0.37	6.74	46.8

57. CSIR-IHBT-VJ-08 (IC0630605; INGR20057), a Tagar (Indian_Valeriana) (*Valeriana jatamansi*) Germplasm with High Essential Oil Content: 0.331% (3.31 g/kg).

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Valeriana jatamansi Jones is popularly known as Indian valerian, Mushkbala (Kashmiri/ Hindi), Sugandhwala or Tagar (Sanskrit) and is a native plant of Himalayan origin. Valeriana jatamansi, a perennial medicinal herb, is now endangered and at the edge of becoming extinct in India (Mahajan and Pal, 2016). It is therefore a pressing need to conserve and maintain this species in their natural habitat. The species is extensively utilized for its roots and rhizomes which contain essential oil. In order to improve productivity and essential oil content of the roots, a breeding programme has been undertaken to identify promising selection for commercial cultivation.

Using progeny selection approach nine accessions of Indian valerian were initially shortlisted based on root biomass accumulation and essential oil content over two years. The progeny plants of these nine accessions were evaluated in multi-location trials for root biomass and essential oil content at four locations in mid- and high-altitude regions over a period of two years along with check variety 'Himbala'. Overall, CSIR-IHBT-VJ-08 performed better than check at all the four locations with high essential oil content of 0.331% (3.31g/kg). The genotype CSIR-IHBT-VJ-08 was developed at CSIR-Institute of Himalayan Bioresource Technology, Palampur, Himachal Pradesh (Latitude: 32.0934° N, Longitude: 76.5439° E and at an altitude of 1300m amsl).

Morpho-agronomic characteristics: The characteristic features of CSIR-IHBT-VJ-08 are large leaf size with slightly serrated margins and pointed apex. The selection CSIR-IHBT-VJ-08 is vigorous in growth and has a potential to be utilized as aromatic plant on commercial basis for high essential oil content.

Associated characters and cultivation Practices: *Valeriana jatamansi*, a perennial medicinal herb of the Valerianaceae family, is widely found in the temperate zone of the western Himalaya at an altitude of 1300–3300 m amsl. In India, the species is now endangered and at the edge of becoming extinct (Nayar and Sastry, 1998) due to over-exploitation from its natural habitat to meet the burgeoning demand and there is need to cultivate the plant species for production of essential oil.

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Table 1. Essential oil content (g/kg) in Indian valerian accessions CSIR-IHBT-VJ-08 in comparison to check

Plant No.	Essential oil content (g/kg)				
	Palampur	Mukteshwar	Kukumseri	Ribling	Mean
CSIR-IHBT-VJ-08	3.81	3.66	3.59	4.12	3.80
Himbala (check)	3.02	2.88	2.82	3.19	2.98

58. TNGsy-55-Mettupalayam Local 4 (IC0630558; INGR20058), a Gymnema (*Gymnema sylvestre*) Germplasm with Elliptic Leaf Shape and Obtuse Base.

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Gymnema sylvestre is one of the important medicinal plants that holds a unique position among the sweetness modifying materials of natural origin. Various poly herbal formulations with *Gymnema sylvestre* extract are being used for the treatment of Diabetes mellitus. Several clinical trials and experimental studies have indicated that the plant is an invaluable source of bioactive compounds for the treatment of diabetes. The plant is source of gymnemicacid. Gymnemic acids have been used as molecular targets in drug development. Besides having pharmacological importance, the gymnema extract possesses valuable dietary applications to combat diabetes. Although the plant has immense prospects in drug development, it faces threat of extinction due to continuous deforestration and indiscriminate collection.

Under natural habitat, considerable variations exist among the morphological traits in this species. However detailed information on the extent of variability is not available. At present no descriptors as well as varieties are available in Gymnema sylvestre. Identification of morphological marker will help for DUS descriptor development which is important for protecting IPR. Moreover, morphological marker will help for varietal identification.

Research at the Department of Medicinal and Aromatic Crops of Tamil Nadu Agricultural University, Coimbatore has led to the establishment of a germplasm of Gymnema comprising of sixty-six accessions collected from various parts of Tamil Nadu. At present no descriptors as well as varieties are available in *Gymnema sylvestre*. The characterization of germplasm was made based on the Kew Plant Glossary (Henk Beentje, 2010). Based on the characterization, variations were observed for leaf characters viz., leaf shape, leaf base leaf tip and leaf pubescence.

Morpho-agronomic characteristics: Leaf shape varied from ovate, elliptic and lanceolate. 24 % of the germplasm had ovate shaped leaves; 15% of the germplasm had elliptic shape and 12% had lanceolate shape. The shape in other entries ie 48% of the germplasm had shape which varied from ovate-elliptic, elliptic-ovate, ovate- lanceolate and ovate-oblanceolate. Of the varied leaf shapes observed, ovate is the most common and considered as reference or check. The accession TNGSy 33–IC-0630536 which is collected from Palani, Dindigul district of Tamil Nadu is the reference genotype which has ovate shaped leaves with round base and acute tip. Pubescence is present in the leaves. The accession TNGSy55-IC-0630558 is an elite genotype which has elliptic shape with obtuse base and acute tip. Pubescence is absent in the leaves. Compared to the reference genotype, the elite genotype TNGSy-55–IC-0630558 varied for leaf shape and leaf base and leaf pubescence.

Morphological, yield and quality traits: Observations on morphological and yield characters were recorded for the 66 accessions and the per seperformance of the genotypes ranged from 2.40-4.58 cmfor leaf length; 1.57-2.90 cm for leaf breadth; 0.47-1.37 cmfor petiole length and 1.07-2.74 cm for intermodal length. The per se performance for leaf dry weight ranged from 0.08 -0.75 kg and 0.48-1.54 % for gymnemagenin content. The elite genotype recorded leaf length 2.57 cm; leaf breadth-2.17 cm; petiole length-1.14 cm; intermodal length-1.69 cm and leaf dry weight of 0.26 kg/plant with gymnemagenin content of 1.07%.

Associated characters and cultivation practices: Pubescence was absent in leaves present in midrib, petiole and stem. Commercial propagation is done through cuttings; Planting season: June to August; Spacing: 1 × 1m; Training: Being a climber, support has to be provided for training the vine; Intercultural operations: Based on the prevailing climate and intensity of weeds, weeding has to be carried out; Plant Protection: Need based control measures has to be followed; Harvesting: One year after planting.

Table 1. Characteristics features of elite genotype TNGSy-55–IC-0630558

Particulars	
Leaf shape	Elliptic
Leaf base	Obtuse
Leaf tip	Acute
Leaf pubescence	Absent
Mid rib pubescence	Present
Leaf length (cm)	2.57 cm
Leaf breadth(cm)	2.17 cm
Petiole length (cm)	1.14 cm
Internodal length (cm)	1.69 cm
Leaf dry weight (kg/plant)	0.26 kg/plant
Gymnemagenin content (%)	1.07%

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59. CSIR-IHBT-DH-04 (IC635704; INGR20059), a White Dragonhead (*Dracocephalum heterophyllum*) with High Biomass Yield 3.11 kg/plot (6 sqm). Essential Oil Content 0.22%.

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White dragonhead (*Dracocephalum heterophyllum*) is perennial, aromatic herb of high altitude region in Himalayas which has characteristic aroma in the aerial parts of the plant. The plant is native of Western Himalayas (Stappena *et al.*, 2015; Zeng *et al.*, 2010) and has been reported growing wild in the northern part of India, including Jammu and Kashmir, Himachal Pradesh, Uttarakhand and Sikkim at an altitude of 3000–5200 m amsl (Mahmood *et al.* 2005; Agarwal *et al.*, 2005). Leaf extract of white dragonhead is reported to be used in treating eye ailments like redness of eyes, irritation and conjunctivitis by the native people of Spiti valley in Himachal Pradesh and in Laddakh region of trans-Himalaya (Singh *et al.*,. 2008; Mahmood *et al.* 2005). Its essential oil has antiasthamatic, anticoughing and disinfectant properties. It is known to contain flavones and essential oil content (Zhang *et al.*, 2008). The essential oil of Dracocephalum heterophyllum contains mainly citronellol (74.2%) of total 40 compounds. Only small amounts of cis-rose oxide (2.2%), citronellyl acetate (1.7%) and trans-rose oxide (1.1%) contribute to the oil (Stappena *et al.* 2015).

In this context, with an aim to improve aerial biomass and essential oil content, breeding of white dragonhead was done using progeny selection approach. One hundred eighty-two accessions representing populations of diverse origin were screened for morphological traits viz., leaf lamina size, leaf number, number of branches and inflorescence length were measured at the time of flowering. Multivariate clustering approach was used to identify six accessions with significantly high values for all the parameters which were shortlisted by retaining their seeds. Progeny plants of these six breeding lines were evaluated in multi-location trials at four locations over two years along with 'Him surabh' variety of white dragonhead as the check variety. CSIR-IHBT-DH-04 performed better than the check variety with high biomass yield of 3.11 kg/plot

Morpho-agronomic characteristics: The characteristic features of CSIR-IHBT-DH-04 are large mature leaf size (leaf lamina length more than 6 cm and width more than 2.5 cm). The plants are vigorous in growth and flower in the months of June and July.

Associated characters and cultivation practices: Propagation of white dragonhead is through seed in the month of March-April.

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Table 1. Mean of two years for aerial biomass yield (kg/plot) of CSIR-IHBT-DH-04 in white dragonhead accessions in comparison to check

Plant No.	Aerial biomass (kg/plot)				
	Location-1	Location-2	Location-3	Location-4	Mean
CSIR-IHBT-DH-04	3.11	2.96	3.19	3.18	3.11
Him surabh (check)	2.75	2.64	2.62	2.78	2.69

60. 60. CSIR-IHBT-AM-02 (IC635705; INGR20060), a Wormwood (*Artemisia maritima*) Germplasm with High Biomass Yield 8.175 kg/plot (24sqm).

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Sea wormwood (*Artemisia maritima*; family Asteraceae) indigenous to high altitudes of western Himalayan region is an endangered perennial shrub with localized distribution and being highly habitat specific (Parihar *et al.*, 2012; Watson *et al.*, 2002; Mehrdad *et al.*, 2007). It is called Chhara, Jantunashava in sanskrit, Darmanah in urdu, Kirmaniova, Surabandi in Marathi, Chhuvaria-Jamoda in Gujarati. It has strong aroma. The essential oil is used as a deodorant, anthelmintic, antiseptic (Parihar *et al.*, 2010), antisplasmodic, carminative, vermifuge and has insecticidal properties (Kumar *et al.*, 2011). It is also used to cure arthritis (Nawchoo and Buth, 1995). Locally, people in Himalayas use the leaves of the plants for preparation of dhoop. The main compounds analyzed by simultaneous GC/MS and GC/FID were camphor and 1,8-cineole from *A. maritima* (Stappen, 2014). Aqueous methanol extract of *Artemisia maritima* (L.) at a dose of 500 mg/kg has been reported to exhibit hepatoprotective activity against acetaminophen and carbon tetrachloride-induced hepatic damage (Janbaz & Gilani, 1995). Plant has erect woody stems arising from the base with woody rootstock. Leaves are simple, sessile to sub-sessile 2 - 5 cm long, highly lacerate, alternate and obtuse. Capitulum is terminal with 0.3-0.4 cm diameter, ovoid-globose, involucral bracts (Bora and Sharma, 2011; Heywood and Humphries, 1997; Mucciarelli and Maffel, 2002; Polyakov and Shishkin, 1995; Anonymous, 2021).

In order to improve biomass production and essential oil, breeding of sea wormwood was undertaken using progeny selection approach. One hundred fifty accessions of diverse origin were screened for above ground biomass at the time of maturity and eight accessions with high biomass were shortlisted by retaining their seeds. The progeny plants of eight breeding lines were selected for further evaluation in multi-location trials at four locations over two years. Population mean of Artemisia breeding lines being evaluated was used as control. CSIR-IHBT-AM-02 is a selection from AU-11 (collection from Udaipur, Lahaul & Spiti, HP) which performed well with average biomass yield 8.175 kg/plot (24 sqm plot).

Morpho-agronomic characteristics: The characteristic features of CSIR-IHBT-AM-02 are plant height of approximately 70 cm and secondary branches more than 40. The plants are vigorous in growth and secondary branches attain a length of 60-65 cm.

Associated characters and cultivation practices: Artemisia maritima is a shrub with much branched stem up to 1m high. Leaves are whitish in colour. Artemisia maritima is found naturally in the Western Himalayas between altitude range of 2500m to 3500m. It can be grown in degraded poor dry soil pH range 6.0-7.6. under temperate conditions but requires adequate sunlight for growth.

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61. IIHR-12 (IC0630783; INGR20061), a Tuberose (*Polianthes tuberosa*) Germplasm. Open Pollinated Seedling Selection from Arka Shringar.

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Tuberose (*Polianthes tuberosa* L.) belongs to the family Asparagaceae is a tropical bulbous fragrant ornamental plant, native to Mexico (Trueblood, 1973). It occupies a prime position in Indian floriculture industry for loose flower, cut flower and floral concrete. Tuberose genetic stock IIHR-12 is derived from open pollinated seedling selection from Arka Shringar. It was developed at ICAR-Indian Institute of Horticultural Research (ICAR-IIHR), Bengaluru, Karnataka, India which is situated at an altitude of 930 meter above mean sea level and latitude 120 58´ North latitude, 780 45´ East longitude, respectively. The genetic stock IIHR-12 is unique for medium tall upright spike, attractive star shaped floret, compactly arranged on spike with shorter internodes.

Table 1. Morpho-agronomic description of tuberose genetic stock IIHR-12

Traits	Two years pooled data
Days to spike appearance	148.30
Days to opening of 1st floret	19.77
Spike Length (cm)	72.64
Rachis length (cm)	28.06
Number of florets per spike	42.53
Length of floret (cm)	6.02
Diameter of the floret (cm)	3.67
Bud length (cm)	6.06
Matured bud weight (g)	1.40
Single flower weight (g)	1.71
Flowering duration (days)	190.80
No. of spikes per clump	3.89
Weight of spike (g)	54.87
Internodal length (cm)	3.39
No. of matured bud in spike	5.31
Flower type	Single
Flower bud tinge	Pinkish tinge
Nature of spike	Straight
Colour/tinge of unopened bud	RHS Red Purple group 58 D
Colour of floet	RHS White group 155 C

Morpho-agronomic characteristics: IIHR-12 produces medium tall spike (72.64 cm), longest rachis (28.06 cm) with more number of matured bud on spike (5.31) and shorter intermodal length (3.39 cm)

Associated characters and cultivation practices: Tuberose require moderate climate with temperature ranging from 20-35 ºC. Tuberose is suited to a wide range of soils from loamy to sandy loam having a pH in the range of 6.5 to 7.5 with good aeration and drainage. It is a day neutral plant and full sunlight is essential for flowering. Tuberose is sensitive to water logging and hence proper drainage is essential. The medium size bulbs of 2.5 cm in diameter are planted on the sides of the ridges with a spacing of 30 × 30 cm at 2.5 cm depth during June-July. The genetic stock IIHR-12 is suitable for cut flower and flower arrangement.

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62. 62. IIHR15-7 (IC0632114; INGR20062), a Gerbera (*Gerbera jasmeonii*) Germplasm. Flower Form: Semi-Double. Flower Colour: NN155A, White Group.

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Gerbera, family Asteraceae, is one of the important cut-flowers grown for domestic and export markets. Gerbera grown under 870 ha with productivity of 21300 t/ha, and stands fourth most important cut flower in India. Highest production of gerbera comes from Uttarakand with 7.80 (000' MT), while share of Karnataka is 6.2 (000, MT) (Anon., 2017). The Gerbera germplasm IIHR15-7 was developed through half-sib method of breeding with IIHR9 as parent, at ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka (13º 58' N Latitude, 78oE Longitude and at an altitude of 890 meter above mean sea level), India. The germplasm IIHR15-7 along with its parent and commercial check was evaluated for flower quality traits under polyhouse in Completely Randomized Block Design, during 2016-17 to 2018-19. The germplasm IIHR15-7 is unique for its white flower colour (NN155A, White group) and semi-double flower form. It is suitable for cut-flower and flower arrangement purposes.

Morpho-agronomic characteristics: The Gerbera germplasm IIHR15-7 is having white flower (RHS colour chart, NN155A White group) with semi-double flower form. On an average, it produces 2.87 flowers per plant per month with flower stalk length (61.39 cm).

Associated characters and cultivated practices: The germplasm IIHR15-7 has average flower head diameter (11.89 cm), flower stalk diameter (5.79 mm) and vase life (7.74 days). The Gerbera is generally grown under polyhouse with shade net. It grows best in well drained loamy soil, rich in organic matter, having adequate moisture holding capacity with soil pH (5.5-6.5) and EC less than 1 dS/cm^2. The tissue cultured plug plants (4-5 leaves) to be planted on raised beds at a spacing of 40 cm between rows and 30 cm between plants accommodating 6-7 plants/m^2. The water requirement during the peak summer is 4-6 litres/m^2/day and 2 to 3 litres/m^2/day during the winter.

During bed preparation, a basal dose of FYM @ 20 kg/m^2, and first three months of planting apply 10:15:20 g NPK/m^2 and 15:10:30g NPK/month/m^2 from fourth month onwards (when flowering starts) in two splits at 15 days interval is good for establishment.

References

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Table 1. Morpho-agronomic description of Gerbera germplasm IIHR15-7 with parent and commercial check (pooled data of three years)

Genotype	Flower diameter (cm)	Flower stalk length (cm)	Flower stalk diameter (mm)	No. of flowers/ plant/ month	Vase life (days)	Flower colour (RHS colour chart)	Flower form
IIHR15-7	11.89	61.39	5.79	2.87	7.74	White group NN155A	Semi-double
IIHR9 (parent)	11.46	61.19	5.80	2.43	7.29	Red purple group 69A	Semi-double
Arka Ashwa (check)	11.86	61.10	6.64	2.56	7.42	Red purple group 68D	Semi-double
Susan (commercial check)	12.04	62.81	6.62	2.69	7.59	White group NN155C	Semi-double
SEm±	0.47	0.44	0.38	0.49	0.51	-	-
C.D. at 5%	NS	NS	NS	NS	NS	-	-

63. IIHR16-8 (IC0632115; INGR20063), a Gerbera (*Gerbera jasmeonii*) Germplasm with Flower Colour: 65A, Red Purple Group. Flower Form: Double

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Gerbera, family Asteraceae, is one of the important cut-flowers grown for domestic and export markets. Gerbera grown under 870 ha with productivity of 21300 t/ha, and stands fourth most important cut flower in India. Highest production of gerbera comes from Uttarakand with 7.80 (000' MT), while share of Karnataka is 6.2 (000, MT) (Anon., 2017). The Gerbera germplasm IIHR16-8 was developed through half-sib method of breeding with Arka Ashwa as parent, at ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka (13º 58' N Latitude, 78º E Longitude and at an altitude of 890 meter above mean sea level), India. The germplasm IIHR16-8 along with its parent and commercial check was evaluated for flower quality traits under polyhouse in Completely Randomized Block Design, during 2016-17 to 2018-19. The germplasm IIHR16-8 is unique for its flower colour (65A, Red Purple Group) and double flower form. It is suitable for cut-flower and flower arrangement purposes.

Morpho-agronomic characteristics: The Gerbera germplasm IIHR16-8 is having red-purple flower colour (RHS colour chart, 65A Red Purple Group) with double flower form. On an average, it produces 2.85 flowers per plant per month with flower stalk length (65.64 cm).

Associated characters and cultivation practices: The germplasm IIHR16-8 has average flower head diameter (12.89 cm), flower stalk diameter (5.77 mm) and vase life (7.00 days). The Gerbera is generally grown under polyhouse with shade net. It grows best in well drained loamy soil, rich in organic matter, having adequate moisture holding capacity with soil pH (5.5-6.5) and EC less than 1 dS/ cm^2. The tissue cultured plug plants (4-5 leaves) to be planted on raised beds at a spacing of 40 cm between rows and 30 cm between plants accommodating 6-7 plants/m^2. The water requirement during the peak summer is 4-6 litres/m^2/day and 2 to 3 litres/m^2/day during the winter.

During bed preparation, a basal dose of FYM @ 20 kg/m^2, and first three months of planting apply 10:15:20 g NPK/m^2 and 15:10:30g NPK/month/m^2 from fourth month onwards (when flowering starts) in two splits at 15 days' interval is good for establishment.

References

Anonymous (2017) Area and production statistics of horticultural crops. National Horticulture Board, New Delhi.

Table 1. Morpho-agronomic description of Gerbera germplasm IIHR16-8 with parent and commercial check (pooled data of three years)

Genotype	Flower diameter (cm)	Flower stalk length (cm)	Flower stalk diameter (mm)	No. of flowers/ plant/ month	Vase life (days)	Flower colour (RHS colour chart)	Flower form
IIHR16-8	12.89	65.64	5.77	2.85	7.00	Red purple group 65A	Double
Arka Ashwa (parent and check)	11.86	61.10	6.64	2.56	7.42	Red purple group 68D	Semi-double
Bismark (commercial check)	12.12	62.93	6.21	2.73	7.26	Red group 45B	Semi-double
SEm±	0.50	0.47	0.43	0.41	0.52	-	-
C.D. at 5%	NS	NS	NS	NS	NS	-	-

64. CSIR-IHBT-Gr-29-1 (IC0630599; INGR20064), a Gerbera (*Gerbera jasmeonii*) Germplasm with Double Flower Shape and Red Flower Colour.

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Gerbera (*Gerbera jamesonii* Bolus ex. Hooker F.) is an important cut-flower with extensive demand throughout the world due to its numerous shapes, colours and extended vase-life. It belongs to family Asteraceae and ranks fifth among the top ten cut flowers in the global market. Apart from its use in beds, borders, pots and rock gardens, it also has considerable export potential (Tija, 2001). It is a perennial plant which can be grown under wide range of climatic conditions. Based on its floral biology, gerbera is an out-cross in breeding behaviour and clonal propagation through tissue culture has resulted in development of large number of gerbera cultivars. New variations in gerbera can be developed through hybridization program involving diverse parents which will widen the range of floral variations and facilitate selection of desirable genotypes that can be clonally multiplied through vegetative propagation. With an objective to develop unique selections of gerbera, hybridization program was undertaken involving elite and diverse parental lines differing for flower color (Singh *et al.*, 2013), shapes and size at CSIR-Institute of Himalayan Bioresource Technology, Palampur, Himachal Pradesh, India (Singh *et al.*, 2009 & 2011).

F1 seeds of gerbera developed through manual crossing among selected parental lines were used for establishment of in vitro gerbera cultures. Germination of seeds was done on MS basal medium and the shoots obtained from seeds were cultured on MS media supplemented with different doses of growth regulators for shoot proliferation. maximum micro-shoot formation, number of leaves and leaf size were obtained in MS medium supplemented with 1 mg/L BAP + 0.03mg/L IBA + 0.025 mg/L NAA. Root induction was achieved by using half strength MS medium supplemented with 0.4 mg/L IBA. Primary hardening of rooted plantlets was done in trays filled with moist sand which was maintained under growth room conditions for about 15 days. Hardened plantlets were subsequently transferred to soil in sleeves for further hardening under nursery conditions. Morphological characterization of gerbera F1 genotypes with respect to floral traits was done under polyhouse conditions and evaluated for agronomic performance in comparison to parents over a period of four years. On the basis of mean performance of gerbera hybrids compared to respective parents, gerbera selection CSIR-IHBT-Gr-29-1 was found promising having double flower shape of standard size (flower diameter of 10.28 cm) and is red in color. The genotype CSIR-IHBT-Gr-29-1 has been developed at CSIR-Institute of Himalayan Bioresource Technology, Palampur, Himachal Pradesh (Latitude: 32.0934° N, Longitude: 76.5439° E and at an altitude of 1300m amsl).

Morpho-agronomic characteristics: CSIR-IHBT-Gr-29-1 was found promising having double flower shape of standard size (flower diameter of 10.28 cm) and is red in color.

Associated characters and cultivation practices: Commercially, gerbera is grown under controlled environmental conditions. Day temperature of 22o-25oC and night temperature of 12-16oC is ideal for growth and flower production. (Aswath *et al.*, 2015)

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65. No. 18 (IC635707; INGR20065), a Lily (*Lilium* sp.) Germplasm with Multiple Shoots/Sprouting, 100% Flowering and Larger Bud Size. Low Juvenile Period. No Vernalization Requirement.

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Lilium is an important ornamental bulbous crop worldwide. It is grown almost throughout the year in India. In India, bulbs of Lilium sourced from Holland, are planted for production of cut flower. At present, commercial cultivation of lilium is centered in and around Himachal Pradesh, Uttrakhand, J&K, Bangaloru and Haryana, from where flowers are being sent to local and international market. Commercially, lilium is propagated vegetatively through scaling, which usually takes 2-3 years to reach the flowering size bulb. Propagation of lilium through seeds took 5-6 years to start flowering. A short juvenile period and early flowering are the most important traits in lily breeding. Hence, introgression of precocious flowering traits from the species (Lilium formosanum) is the only method to minimize the juvenile period and produce flowering plants from smaller bulb in a short period of time (McRae, 1998 and Hiramastsu *et al.*, 2002).

Generally, for early sprouting and flowering, lilium bulbs require a cold treatment at 2-7 ºC for 6-8 weeks. Hence, low juvenility and precocious flowering are advantageous specially to reduce the cost of bulb storage, production of flowers from small bulbs and advance the breeding cycle. However, the contribution of indigenous hybrids/varieties in lilium is negligible and the bulbs are imported every time from the Netherlands (Dhiman *et al.*, 2014). Development of indigenous hybrids in flower crop like lilium is the need of the hour. It will not only save revenues spent in import of their bulbs but will also create several employments in India. Development of indigenous low juvenility line with no vernalization requirements holds the key for indigenous bulb production. The lilium line, No.18 is one indigenously developed breeding line with low juvenile period and ability to flower precociously, no vernalization requirement and multiple sprouting of flower stalk. This white flower coloured pure breeding line selected from a cross between *Lilium formosanum* Wallace × *Lilium longiflorum*.

Morpho-agronomic characteristics: This is one of the first Low juvenile line with precocious flowering ability. This line took 335 days to flowering from seed sowing. This line has white coloured trumpet shaped flower, bearing 2-3 flowers from seed with mild fragrance and good flower size. This line produced 1.2 shoots per bulb was at par with female parental line. The bulb has no vernalization requirement and re-sprouting under open as well as protected conditions.

Table 1. Salient growth and flowering traits of No.18 seed propagated line over the parents

Traits	No. 18	*Lilium formosanum*	*Lilium Longiflorum*
Days to bud formation (days)	299.9	279.13	343.0
Number of leaves/plant	57.3	27.13	26.0
Days to flowering (days)	335.6	300.3	385.0
Leaf length (cm)	12.6	8.33	11.0
Leaf width (cm)	1.9	2.08	2.8
Bud length (cm)	14.2	10.73	12.2
No. of shoots /plant	1.2	1.3	1.0
Flower size (cm^2)	11.0	9.62	8.5
% age first year flowering	100.0	65.0	35.0
Vernalization requirement	No	No	Yes (2 ºC for 6-8 weeks)

Associated characters and cultivation practices: The line No.18 belongs to the Lilium and flower during the month of July-August. This line has white coloured trumpet shaped side facing flowers with mild fragrance. Because of low juvenile period and precocious flowering, multiple sprouting and no vernalization requirement of bulbs, this line can be used in hybrid development programme.

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66. IIHRG-7 (IC620379; INGR20066), a Gladiolus (*Gladiolus hybridus* Hort) Germplasm with Variegated Florets on the Spike. Floret Colour [Red-Purple (65.B) having Red-Purple (62.A) Streaks with Red-Purple (67.B) Splash].

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Gladiolus is one of the most important bulbous flowering plant commercially grown for cut flowers, garden display and floral arrangements. It belongs to the family Iridaceae. The gladiolus hybrid selection IIHRG-7 is derived from a cross Meera × Picardy followed by selection and it was developed at ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka (13o 58' N Latitude, 78oE Longitude and at an altitude of 890 meter above mean sea level), India. The hybrid selection IIHRG-7 is unique for its floret colour [Red-Purple (65.B) having Red-Purple (62.A) streaks with Red-Purple (67.B) splash] and spike with variegated florets.

Morpho-agronomic characteristics: The plants are tall (142.06 cm) and on an average produces florets in 72.25 days. Its average spike length is 123.11 cm and rachis length (46.77 cm) which bears 12.66 florets per spike. On an average, it also produces 1.43 number of marketable spikes per corm, 1.46 number of corm and 26.63 number of cormels per mother corm.

Associated characters and cultivation practices: In and around Bengaluru, planting of gladiolus corms during the June, October and November months found to be the best considering the quality of the spike. Planting can be done during August to November in plains of northern India and March-April in hilly regions.

Gladiolus is generally planted in ridges and furrows system of planting with varying distance of 30 cm × 20 cm, 30 cm × 15 cm and 30 cm x 10 cm between rows and plants within the rows depending on size of the corms and the variety. For getting good quality of flowers, healthy corms of above 3 cm diameter should be selected and treated with Carbendizim (2 g/Litre) and Captan (2 g/Litre) for 20 minutes.

Table 1. Morpho-agronomic description of Gladiolus hybrid Selection IIHRG-7

Character	IIHRG-7
Days to spike emergence	63.95
Days to flower	72.25
Plant height (cm)	142.06
Spike length (cm)	123.11
Rachis length (cm)	46.77
Floret diameter (cm)	10.66
No. of florets per spike	12.66
Florets remain open at a time	5.55
Total spikes per corm (No.)	1.66
Marketable spikes per corm (No.)	1.43
Flowering duration (Days)	9.61
Corms produced per corm (No.)	1.46
Cormels produced per corm (No.)	26.63
Diameter of corm (cm)	6.75
Diameter of cormel (cm)	1.17
Weight of corm (g)	72.44
Weight of cormel (g)	0.57
Vase life (Days)	9.33
Spike weight (g)	78.33
Floret Type	Open-faced
Floret texture	Medium
Floret structure	Wavy
Floret placement	Good
Floret colour	Red-Purple (65.B) having Red-Purple (62.A) streaks with Red-Purple (67.B) splash

Apply 10 tons FYM per hectare if soil organic carbon levels are 0.5% to 0.75%. The dose of manure and fertilizer depends upon the soil health and nutrients content. In gladiolus, the major nutrient requirement is 250 kg N, 50 kg P_2O_5 and 200 kg K_2O per ha based on nutrient removal pattern of different cultivars raised from corms as planting material. Half dose of phosphorus and potash are applied at the time of land preparation as basal dose. Remaining half dose of phosphorus and potash is top-dressed at 3-leaf stage of the crop along with half dose of Nitrogen fertilizer. Remaining half dose of Nitrogen is applied at 6-leaf stage to get quality flowering. At the time of top dressing, earthing up to be done. The residual leaf biomass and other waste biomass can be ploughed back.

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67. IIHRG-11 (IC620380; INGR20067), a Gladiolus (*Gladiolus hybridus* Hort) Germplasm for Resistant to Fusarium Wilt Disease. Floret Colour [Red (41.C) having Red (41.A) Margin. Blotch Red (46.B) with Yellow (13.C) border].

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Gladiolus is one of the most important bulbous flowering plant commercially grown for cut flowers, garden display and floral arrangements. It belongs to the family Iridaceae. The gladiolus hybrid selection IIHRG-11 is derived from the cross Gold Medal 412 × Poonam followed by selection and it was developed at ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka (13º58' N Latitude, 78º E Longitude and at an altitude of 890 meter above mean sea level), India. The hybrid selection IIHRG-11 is unique for its floret colour [Red (41 ºC) having Red (41ºA) margin. Blotch Red (46.B) with yellow (13 ºC) border] and resistant to Fusarium wilt disease.

Morpho-agronomic characteristics: The plants are tall (120.72 cm) and on an average produces florets in 76.65 days. Its average spike length is 95.18 cm and rachis length (48.81 cm) which bears 17.54 florets per spike. On an average, it also produces 1.70 number of marketable spikes per corm, 1.91 number of corms and 10.14 number of cormels per mother corm.

Associated characters and cultivation practices: In and around Bengaluru, planting of gladiolus corms during the June, October and November months found to be the best considering the quality of the spike. Planting can be done during August to November in plains of northern India and March-April in hilly regions.

Gladiolus is generally planted in ridges and furrows system of planting with varying distance of 30 cm × 20 cm, 30 cm × 15 cm and 30 cm × 10 cm between rows and plants within the rows depending on size of the corms and the variety. For getting good quality of flowers, healthy corms of above 3 cm diameter should

Table 1. Morpho-agronomic description of Gladiolus hybrid Selection IIHRG-11

Character	IIHRG-11
Days to spike emergence	66.66
Days to flower	76.65
Plant height (cm)	120.72
Spike length (cm)	95.18
Rachis length (cm)	48.81
Floret diameter (cm)	9.46
No. of florets per spike	17.54
Florets remain open at a time	6.86
Total spikes per corm (No.)	1.92
Marketable spikes per corm (No.)	1.70
Flowering duration (Days)	11.70
Corms produced per corm (No.)	1.91
Cormels produced per corm (No.)	10.14
Diameter of corm (cm)	6.64
Diameter of cormel (cm)	1.53
Weight of corm (g)	64.44
Weight of cormel (g)	1.08
Vase life (Days)	7.12
Spike weight (g)	73.15
Floret Type	Open-faced
Floret texture	Thick
Floret structure	Slightly ruffled
Floret placement	Double row
Floret colour	Red (41.C) having Red (41.A) margin. Blotch Red (46.B) with yellow (13.C) border

be selected and treated with Carbendizim (2 g/Litre) and Captan (2 g/Litre) for 20 minutes.

Apply 10 tons FYM per hectare if soil organic carbon levels are 0.5% to 0.75%. The dose of manure and fertilizer depends upon the soil health and nutrients content. In gladiolus, the major nutrient requirement is 250 kg N, 50 kg P2O5 and 200 kg K2O per ha based on nutrient removal pattern of different cultivars raised from corms as planting material. Half dose of phosphorus and potash are applied at the time of land preparation as basal dose. Remaining half dose of phosphorus and potash is top-dressed at 3-leaf stage of the crop along with half dose of Nitrogen fertilizer. Remaining half dose of Nitrogen is applied at 6-leaf stage to get quality flowering. At the time of top dressing, earthing up to be done. The residual leaf biomass and other waste biomass can be ploughed back.

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68. Co 13001 (IC635051; INGR20068), a Sugarcane (*Saccharum* sp.) Germplasm with High Sucrose at 240 days. Short Duration Clone (Maturing @ 240 days). Sucrose % 19.40.

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Sugarcane cultivation in the Southern states of India is in declining trend on account of continued monsoon failures and dip in water table. Similarly, sugar factories record low sugar recovery. This situation has necessitated development of short duration sugarcane varieties which can mature in 240 months instead of the normal maturity time of 360 days. Germplasm sources to serve as parents in breeding for earliness are needed to breed suitable varieties which can be harvested in 8-9 months as a way to tide over the harsh summer months in places where water is a scarce input. The identified germplasm Co 13001 is a typical short duration clone with a juice sucrose of 19.40 % at 240 days, which is a rare feature in sugarcane.

Co 13001 was developed through crossing two proven parents Co 740 x CoT 8201 and was selected from the ground nursery when it was assigned the number 2007-228. Based on its better performance of juice sucrose and on par performance of cane yield this clone was promoted to Pre Zonal Varietal trial where it was tested in the name 2011-17 and was elevated to Co cane status in 2013 as Co 13001 at ICAR Sugarcane Breeding Institute, Coimbatore. The clone recorded a remarkable performance for juice quality with sucrose of 19.40 % at 240 days, and fitted very well as a short duration maturing clones satisfying the norm of a minimum of 18% sucrose at 240 days. The juice sucrose content increased to 20.39% at 300 days and combined with yield levels on par with the standards, showing its merit as a potential clone for sugar richness.

Encouraged by its high early accumulation potential, Co 13001 was included in the multilocation trials in different sugar factory areas of Tamil Nadu along with 19 other elite clones with maturity ranging from 240 to 360 days, with an objective of enhancing sugar productivity in Tamil Nadu. The programme was started during 2016 through Institute- Industry Participatory Approach with the collaboration of South India Sugar Mills Association (SISMA), Chennai, Tamil Nadu. The trials were conducted during 2017-19 for two plant and one ratoon crops.

The superiority of the clones was assessed by comparing its performance in relation to a germplasm material registered for earliness (based on sucrose at 240 days) with ICAR NBPGR viz 2007-291, also known as Co 16001 and with the popular ruling variety of Peninsular zone of India viz Co 86032. Co 13001 was superior at five test locations viz., at ICAR-Sugarcane Breeding Institute, Coimbatore, Bannari Amman Sugars Ltd., Alathukombai, EID Parry (India) Ltd., Nellikuppam, Kothari Sugars and Chemicals Ltd., Sathamangalam and Sakthi Sugars Ltd., Sivaganga in first plant crop trials (2017-18) and second plant crop trial during 2018-19. Co 13001 performed better than Co 16001 at 240 days in both plant crops (2017-18 and 2018-19) and registered an improvement of 4.82% over Co 16001 and 5.21%

over Co 86032 (Hemaprabha *et al.* 2019). Hence Co 13001 qualified as a clone with short duration maturity. Genetic gain for juice sucrose content can be achieved byselecting parents like Co 13001 in breeding programme on account of the high heritability of the character. Number of such high parents with extra-earliness is very limited in sugarcane and hence this clone owes potential as a new source for developing short duration maturity genotypes. Co 13001 regularly flowers early in the crossing season (October-November) to facilitate its utilization in breeding programmes

Reference

Hemaprabha G, C Appunu, K Mohanraj and Bakshi Ram (2019) Promising genetic stocks identified from multi location varietal trials of institute-industry collaborative programme in Tamil Nadu. *Journal of Sugarcane research* **9**: 184-186

69. Co 14016 (IC635052; INGR20069), a Sugarcane (*Saccharum* sp.) Germplasm for High Cane Population (Number of Millable Canes 1,07,670/ha). Donor for Ratoonability.

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Sugarcane farmers' acceptance of a sugarcane variety rests in its ratooning potential, as a good ratoon crop adds productivity and profitability with substantially less input costs. Hence f armers tend to take multiple ratoons and choose varieties according to their ratooning potential. Trait specific enhancement of the character necessitates identification of suitable parents to be used in hybridization programmes.

Co 14016 was developed through biparental mating between two proven parents namely Co 86032 and Co 86011. The clone was advanced from early generations through selection by virtue of its robust growth and more number of millable canes (NMC) and was promoted to the Pre Zonal varietal trial, where it was tested in the name 2012-17. In this trial conducted at ICAR Sugarcane Breeding Institute, Coimbatore, the clone exhibited excellent crop stand with high cane population and cane yield and was elevated to Co cane status as Co 14016. Its cane yield was 143.52 t/ha, sugar yield was 20.44 t/ha and sucrose content was 21.91% at 360 days of crop age.

The encouraging performance of 14016 in the station trials promoted its testing in All India Co-ordinated research trials of Peninsular zone as well as multilocation trials in different sugar factory areas of Tamil Nadu aimed at identifying promising varieties. The multilocation testing of this clone along with 19 other elite clones through Institute-Industry Participatory Approach with the collaboration of South India Sugar Mills Association (SISMA), Chennai, Tamil Nadu was conducted during 2017-19 for two plant and one ratoon crops. Co 14016 was remarkable for its cane yield and enhanced cane population in plant as well as ratoon crops with synchronous tillering.

The performance of Co 14016 in plant crop and its ratoon crop at four centres in Tamil Nadu is considered for assessing its yield and ratoonability potential. In the plant crop (2017-18) at four locations viz. Bannari Amman Sugars Ltd., Sathyamangalam, Dharani Sugars and Chemicals Ltd. Polur, EID Parry (India) Ltd., Nellikuppam and Rajshree Sugars and Chemicals Ltd., Mundiambakkam, mean cane yield of Co 14016 was 155.26 t/ha against 127.60 t/ha of the best standard and the ruling variety Co 86032, with an improvement of 21.67%. The high cane yield of Co 14016 was contributed mainly by increase in NMC of 1,07,670/ha in comparison with 84,620/ha of Co 86032. NMC has been identified as an effective selection criterion for selecting better ratooning and high yielding clones in sugarcane under different environments and under abiotic stresses for its high genotypic coefficient of variation and high inter-environmental correlations. The high cane yield was translated to high sugar yield of 19.90 t/ha in Co 14016 over 16.76 t/ha in Co 86032 registering an improvement of 18.73% at these test locations. In the ratoon crop (2018-19), Co 14016 recorded a mean cane yield of 140.46 t/ha against 110.96 t/ha in Co 86032 with a remarkable improvement of 26.59% thus exhibiting high ratoonability potential (Hemaprabha *et al.*, 2019). In the ratoon crop as well, NMC was the main character for high cane yield with 1,21,640/ha, while Co 86032 recorded 92,590 canes/ha with a notable improvement of 31.39%. It could be seen that NMC in the ratoon crop registered 12.97% improvement over its plant crop. It is thus evident that Co 14016 has superior ratoonability combined with high cane yield and sugar yield. Hence this clone can be used as potential donor high NMC and ratoonability. The clone regularly flowers at Coimbatore conditions during October- November to facilitate breeding.

Reference

Hemaprabha G, C Appunu, K Mohanraj and Bakshi Ram (2019) Promising genetic stocks identified from multi location varietal trials of institute-industry collaborative programme in Tamil Nadu. *Journal of Sugarcane Research,* **9**: 184-186

70. AS 04-2097 (IC635053; INGR20070), a Sugarcane (*Saccharum officinarum*) Germplasm Tolerant to Drought. Interspecific Hybrid with Broadened Genetic Base.

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Predictions of climate change have indicated an increased variability of rainfall in the next 40 years and an increased risk of high temperature and drought. Sugarcane production and productivity are significantly affected by abiotic stresses. Among the abiotic stresses, drought is an important stress which causes yield loss upto seventy percent (Zhao and Li, 2015). Hence development of varieties for drought tolerance becomes crucial in the current scenario of climate change. Saccharum spontaneum L. has been utilized in sugarcane breeding since 1912 due to its wider adaptability under biotic and abiotic conditions. The proposed genetic stock AS 04-2097 having drought tolerance and good vigour is an interspecific hybrid derived from a cross between sugarcane commercial cultivar (Co 8371) and the wild species *S. spontaneum* (SH 216, 2n=72). The clone distinguished in semi erect habit with curved canes, moderately thick internodes, prominent node swelling and lanceolate auricle.

Fifteen ISH/IGH hybrids with diverse genetic base were tested for climate resilience at four AICRP(S) centres both in tropical (Padegaon, Anakapalle) and subtropical (Karnal, Faridkot) regions with 2 standards for each region in replicated trials (Alpha design) during 2015-2016. Drought was imposed by withdrawing irrigation between 60 and 150 days after planting in all four centres. Data on cane yield, juice quality, physiological and agronomical traits contributing to drought tolerance were recorded. Percentage of increase/decrease due to imposition of drought for the characters was worked out. The entries which showed less than 15% reduction under drought were identified as tolerant clones.

Performance of AS 04-2097 under normal and drought conditions

Among the agronomic traits, AS 04-2097 showed less reduction for cane thickness, single cane weight and cane yield at 360 days at harvest under drought condition. Cane diameter showed 9.13% reduction with the mean value of 2.19 cm. Less reduction in single cane weight (3.0 %) was observed with mean cane weight of 1.0 kg/cane and 0.93 kg/cane under normal and drought conditions respectively. The complex character cane yield (90.48 t/h) had 13.08% of reduction under drought while the checks exhibited 17.21% reduction.

Table 1. Mean performance of AS 04-2097 under normal and drought conditions at 360 days

Clone	AS 04-2097			Checks*		
	Mean			Mean		
Traits	Normal	Drought	% Change	Normal	Drought	% Change
Cane Diameter (cm)	2.41	2.19	-9.13	2.75	2.28	-17.23
Single Cane weight (kg)	1.0	0.97	-3.0	1.14	0.98	-14.03
Cane yield t/h	104.1	90.48	-13.08	93.41	77.42	-17.21

*CoM 88121, 83 R 23, CoJ 88 (two locations), CoM 0265, CoA 06231, Co 98014 (two locations)

Considering cane yield and yield attributing parameters the clone AS 04-2097 was found to be one of the tolerant clones to drought. It shows 60% flowering hence readily can be utilized in hybridisation programme. The drought tolerant interspecific hybrid AS 04-2097 derived from the interspecific cross involving S. spontaneum with the cytotype 2n=72 is identified as a promising genetic stock for both to develop climate resilient varieties and to broaden the genetic base of modern sugarcane varieties.

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Zhao D and Y Li (2015) Climate Change and Sugarcane Production: Potential Impact and Mitigation Strategies. International Journal of Agronomy, ID 547386, http://dx.doi.org/10.1155/2015/547386.

71. CYM 08-922 (IC635054; INGR20071), a Sugarcane (*Saccharum* sp.) Germplasm with Drought Tolerance. Higher Relative Water Content and Lower Malondialdehyde Content under Drought. Second Backcross Progeny of the Cross involving Erianthus arundinaceus and *S. spontaneum* having the Cytoplasm of *E. arundinaneus*.

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Drought is one of the major abiotic stresses that influence sugarcane productivity in all sugarcane growing areas of tropical and subtropical zones in India. Traditionally Saccharum spontaneum has been the donor for many important traits in sugarcane. In recent years, considerable attention has been given to use *Erianthus* spp. which is identified as a valuable source for many traits such as ratoonability, tolerance to biotic and abiotic stresses and vigour. (Piperidis *et al.*, 2000). CYM 08-922 is a BC2 progeny of a novel intergeneric hybrid between Erianthus arundinaceus "IK 76-62" and Saccharum spontaneum "Iritty-2" which was developed at ICAR-Sugarcane Breeding Institute, Coimbatore during 2008. The clone was cytologically characterized using Genomic in situ hybridization (GISH) technique and had a total of 108 chromosomes, out of which 12 chromosomes were from *E. arundinaceus* and 96 chromosomes from Saccharum.

During 2015-17, a set of parental clones were evaluated for drought tolerance along with the susceptible check Co 775 in the field condition for cane yield, juice quality and physiological parameters. The results revealed that, the clone CYM 08-922 recorded the highest cane yield of 113.59 t/ha under drought condition and also recorded the highest Stress tolerance Index (STI) of 1.256. The clone 08-922 also recorded the highest relative water content (68.40%) and significantly lower malondialdehyde (MDA) content (97.34 µg/g) than the drought tolerant commercial varieties Co 86032 (158.78 µg/g) and CoM 0265 (134.23 µg/g) under severe water stress condition. Under glass house condition also the clone CYM 08-922 recorded significantly higher proline content and SOD activity. Among gas exchange parameters, photosynthetic rate and stomatal conductance were significantly higher in CYM 08-922. Based on the results, the clone CYM 08-922 with superior drought tolerance could be used as a potential parent for the breeding of drought-tolerant varieties in sugarcane.

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72. BER57 (IC635057; INGR20072), a Solanum (*Solanum berthaultii*) Germplasm Highly Resistant to Late Blight Disease. Diploid Wild Potato Species with Wider Genetic Base.

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The elite genetic stock BER57 was developed at ICAR-Central Potato Research Institute, Shimla by Clonal Selection method from several clones regenerated from true potato seed (TPS) of wild species (Solanum berthaultii, Accession no. PI265857). BER57 is an important genetic material for fusion parent in somatic hybridization and parental line in diploid breeding programme for introgression of very high resistance to late blight trait with wider genetic base into cultivated potato and also basic research studies on diploid potato breeding. Since potato is native to Lima, Peru (South America) and under the routine germplasm procurement programme of the institute, TPS of this wild species were obtained at the institute from the International gene bank the Potato Introduction Station, NRSP-6, Wisconsin (USA). This shows successful utilization of clonal selection method in development of elite genetic stock BER57 for high resistance to late blight over four seasons under controlled conditions by challenge inoculation. DNA fingerprinting of BER57 revealed SSR alleles (STU: 182, 184, 190, 193, 202 bp, and STIIKA: 188, 192, 195, 203, 218, 240, 243 bp) for genetic fidelity. A few DUS descriptors of BER57 are: purple lightsprout, semi-compact plant foliage, small plant height, green stem colour, intermediate leaf structure, small leaf length, narrow leaf width, ovate lanceolate leaf shape, white flower corolla, small flower size, yellow anther colour, normal anther cone, normal pistil, longer stylar length, late maturity, brown tuber skin colour, rough skin, long oblong tuber shape, shallow eye depth and yellow tuber flesh colour. This wild spcies BER57 with diverse genetic background, having very high resistance to late blight disease has potential to widen the gene pool of the cultivated potato.

73. PLD47 (IC635058; INGR20073), a Potato (*Solanum polyadenium*) Germplasm Highly Resistant to Late Blight Disease. Diploid Wild Potato Species with Wider Genetic Base.

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The elite genetic stock PLD47 was developed at ICAR-Central Potato Research Institute, Shimla by Clonal Selection method from several clones regenerated from true potato seed (TPS) of wild species (Solanum polyadenium, Accession no. CGN17747). PLD47 is an important genetic material for fusion parent in somatic hybridization and parental line in diploid breeding programme for introgression of very high resistance to late blight trait with wider genetic base into cultivated potato and also basic research studies on diploid potato breeding. Since potato is native to Lima, Peru (South America) and under the routine germplasm procurement programme of the institute, TPS of this wild species were obtained at the institute from the International gene bank of the Centre for Genetic Resources, the Netherlands (CGN). This shows successful utilization of clonal selection method in development of elite genetic stock PLD47 for high resistance to late blight over four seasons under controlled conditions by challenge inoculation. DNA fingerprinting of PLD47 revealed SSR alleles (STU: 147, 154, 160, 184, 193, 197, 202, 206, 209 bp, and STIIKA: 188, 192, 195, 203, 209, 214 bp) for genetic fidelity. A few DUS descriptors of PLD47 are: purple lightsprout, open plant foliage, small plant height, green stem colour, poorly developed wings, open leaf structure, large leaf length, medium leaf width, ovate lanceolate leaf shape, white flower corolla, small flower corolla size, yellow anther colour, normal anther cone, normal pistil, longer stylar length, late maturity, yellowish brown tuber skin colour, rough skin, ovoid tuber shape, shallow eye depth and yellow tuber flesh colour. This diploid wild species PLD47 with diverse genetic background having very high resistance to late blight disease has potential to widen the gene pool of the cultivated potato.

74. JAM07 (IC635059; INGR20074), a Potato (*Solanum jamesii*) Germplasm Highly Resistant to Late Blight Disease. Diploid Wild Potato Species with Wider Genetic Base.

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The elite genetic stock JAM07 was developed at ICAR-Central Potato Research Institute, Shimla by Clonal Selection method from several clones regenerated from true potato seed (TPS) of wild species (Solanum jamesii, Accession no. PI 498407). JAM07 is an important genetic material for fusion parent in somatic hybridization and parental line in diploid breeding programme for introgression of very high resistance to late blight trait with wider genetic base into cultivated potato and also basic research studies on diploid potato breeding. Since potato is native to Lima, Peru (South America) and under the routine germplasm procurement programme of the institute, TPS of this wild species were obtained at the institute from the International gene bank the Potato Introduction Station, NRSP-6, Wisconsin (USA). This shows successful utilization of clonal selection method in development of elite genetic stock JAM07 for high resistance to late blight over four seasons under controlled conditions by challenge inoculation. DNA fingerprinting of JAM07 revealed SSR alleles (STU: 171, 175, 178, 193, 202 bp, and STIIKA: 192, 195, 203, 209 bp) for genetic fidelity. A few DUS descriptors of JAM07 are: red-purple lightsprout, semi-compact plant foliage, small plant height, green stem colour, open leaf structure, small leaf length, narrow leaf width, narrow lanceolate leaf shape, white flower corolla, small flower corolla size, yellow anther colour, normal anther cone, normal pistil, longer stylar length, late maturity, brown tuber skin colour, rough skin, oblong tuber shape, shallow eye depth and white tuber flesh colour. This diploid wild species JAM07 with diverse genetic background having very high resistance to late blight disease has potential to widen the gene pool of the cultivated potato.

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75. CSR 59 (IC627947; INGR20075), a Rice (*Oryza sativa*) Germplasm Tolerant to Salinity Stresses upto ECe 10.0 dS/m with Long Bold Grain.

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A total of 800 million hectares of land are salt-affected, including both saline and alkaline soils, which are more than 6% of the world's total land area (FAO 2014). In India, 6.73 million ha are affected by salt and 3.77 million ha are affected by alkaline soils. Genetic improvement of salt tolerance in rice appears to be economically feasible and a promising strategy for maintaining stable rice production, globally. The rice (*Oryza sativa* L.) line, CSR 59 (IET 24547), a derivative of the cross CSR 27/CSR 11 at ICAR-CSSRI, Karnal. The line CSR 59 was developed for saline and alkaline areas where ECe ~ 10.0 dS/m. Of the two parents, CSR 27 is salinity (ECe~ 10.0 dS/m) and another parent CSR11 is tolerant to alkalinity (pH ~ 9.9) with high yield potential.

Morpho-agronomic characteristics: The line CSR 59 was developed from the cross CSR 27/CSR 11 for saline areas ECe = 10 dSm-1 (Krishnamurthy *et al.*, 2018). During 2014, CSR 59 showed superiority yield advantage of 8%, 94%, 10%, 7% and 8% over CSR 36 (National check), Jaya (Yield check), CSR 10, Local Check and CSR 23 respectively under high salinity condition in Panipat and Karnal district of Haryana (Directorate of Rice Research, 2015). During 2015, CSR 59 showed superiority yield advantage of 4%, 174 %, 26%,2% and 28 % over CSR 36 (National check), Jaya (Yield check), CSR 10, Local Check, and KR09003(Qualifying Variety IET 24538) respectively across salt affected locations of Panipat and Karnal in Haryana (Directorate of Rice Research, 2016). During 2016, CSR 59 showed superiority yield advantage of 66%, 722%, 42%, 61%, 75% and 39 over CSR 36 (National check), Jaya (Yield check), CSR 10, Local Check, CSR 23 and KR09003 (Qualifying Variety IET 24538), respectively across salt affected locations of Panipat and Karnal in Haryana (Directorate of Rice Research, 2017). The line CSR 59 was found superior in yield over CSR 36 (National check), Jaya (Yield check), CSR 10, Local Check, CSR 23 and KR09003 (Qualifying Variety IET 24538) by 19%, 185% 23%,17%, 12% and 18%, respectively across the three years (2014, 2015 and 2016) in salt affected locations of Haryana (Panipat and Karnal). The performance of CSR 59 was consistently high under salinity for three successive years in Haryana. It showed yield superiority over CSR 36 (National check), Jaya (Yield check), CSR 10, Local Check, CSR 23 and KR09003 (Qualifying Variety IET 24538).

Associated characters and cultivation practices: This line is medium duration (130-135 days), dwarf culture, with green foliage, long bold grains and complete panicle exertion. This line is moderately tolerant to stem borer, leaf folder and gall midge. This line is moderately tolerant to blast. The performance of CSR59 was consistently high across salinity stress locations for three successive years with other acceptable quality traits. This Germplasm can be used as a genetic stock for future breeding programmes aiming at development of high yielding salt tolerant rice varieties for saline and alkaline soils.

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76. CISG 20 (IC628575; INGR20076), Cotton (*Gossypium arboreum*) is a Spontaneous Mutant GMS Identified from Agronomically Adapted Line CISA 20. One among few GMS lines available in diploid. The line CISG20 (GMS) has Open Red Flower Facilitating Easy Crossing; Red Flower, Red Petal Spot and Red Plant Body.

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Cotton, also known as white gold is the leading commercial cash crop of the world. In India, cotton is grown in area of 12.3 million hectares with total production of 370 lakh bales (1 bale = 170 kg of lint) (ICAR-CICR Annual Report 2017-18). The majority of cotton area (more than 90%) is under G. hirsutum while <10% constitute the other three species (Mehetre, 2015). The identification and registration of first genetic male sterile line DS 5 in G. arboreum by Singh *et al.*, (1993) facilitated male sterility based seed production of intra-arboreum hybrids and their release. The new genetic male sterile line has been identified in the seed multiplication plot of CISG 20 at ICAR-Central Institute for Cotton Research, Regional Station, Sirsa. The GMS line CISG 20 is a spontaneous mutant identified from agronomically adapted line CISG 20 during 2008-09 crop season. It was maintained by sib mating.

Inheritance of male sterility: The male sterile plants were maintained through sib mating with male fertile plants and ratio of 3:1 was observed. The genetic study was performed by the test of goodness of fit to an expected segregation ratio by calculating the probability in Chi square test (Table 1). In F2 and BC1, the fertile-sterile plants ratio of 3:1 and 1:1 showed goodness of fit and non-significant confirming that a single-recessive gene is responsible for male sterility in line CISG 20.

Gene controlling male sterility: The male sterile plants of CISG 20 were crossed with heterozygous male fertile plants of DS 5 (GMS) line, an existing source of GMS in G. arboreum, having genetic constitution of aMs1 ams1 to ascertain whether the gene responsible for male sterility is the same or different as that of DS (GMS) which has ams1 ams1(Singh and Kumar, 1993). If the gene governing the male sterility in new source is same, then the test cross ratio among the male fertile and male sterile plants would have been 1:1, but the segregation was 3:1 ratio. Therefore, the genetic male sterility observed in the present study is governed by a single pair of alleles, which are different from the gene ams1 ams1 governing male sterility in DS5 (GMS) line. The gene for male sterility is designated as ams2 ams2 expressing completely male sterility condition and the heterozygous F1 (male fertile) is designated as aMs^2 ams^2.

Morpho agronomic characteristics: The line CISG 20 (GMS) has complete pigmentation i.e. red flower with red petal spot and red plant body which can be used as a marker trait for male sterility genotype identification and grow out test. The genetic male sterile line CISG 20 is pollen sterile throughout its reproduction stage, no pollen shedders are reported which rules out the selfed seed during hybrid seed production programme thus enhances the boll setting percentage (Patil *et al.*, 2018). The line has been observed as good general combiner. Associated characters and cultivation practices: The line CISG 20 (GMS) was evaluated for five years at ICAR-CICR, Regional Station, Sirsa having plant height of 140-150 cm with 5-7 monopodia/plant and 12-17

Table 1. Segregation pattern for male and fertility and sterility in F1, F2 and BC1 generation of GMS - CISG 20

Year	Generation	Ratio	Segregation observed		χ^2	P=0.05
			Fertile	Sterile		
2016-17	F_1	-	38	-	-	-
2017-18	F_1	-	43	-	-	-
2017-18	F_2	3:1	1128	398	1.011	0.31468
2018-19	F_2	3:1	1236	442	1.683	0.19457
2017-18	BC_1	1:1	211	183	1.990	0.15836
2018-19	BC_1	1:1	215	191	1.419	0.23361

sympodia/plant. Greenish red hairs are present on all over stem with dense gossypol glands on the underside of the leaf surface. The line showed a good yield potential of 88.6g seed cotton /plant with an average of 106 bolls/ plant, GOT (Ginning outtrun) of 36.4% with an lint index of 2.63. The line also showed tolerance against sucking pests and having a better adaptation under north western cotton belt of India.

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77. IPC 2010-121 (IC628574; INGR20077), a Desi Type Chickpea (*Cicer arietinum*) Breeding Line Resistant against Race-2 of *Fusarium oxysporum* f. sp. *ciceris*.

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Wilt disease caused by *Fusarium oxysporum* f. sp. *ciceris* (FOC) is a major biotic stress for chickpea crop leading to yield losses ranging from 10-40% worldwide (Nene *et al.*, 1984). It causes 100% loss under specific conditions (Jalali and Chand, 1992). Several elite breeding lines of chickpea were screened against Kanpur race (race 2) in wilt-sick plot of ICAR-Indian institute of Pulses Research, Kanpur. Among several desi type of chickpea lines, IPC 2010-121 was found resistant for four consecutive years. Disease development was very high with 100% mortality in susceptible check (cv. JG 62) and C-104 as late wilt check with WR 315 (JG 315) as resistant check. In each years of evaluation, wilt specific differentials were planted along with test genotypes for monitoring of the racial system (Haware and Nene 1982). Per cent Disease Incidence of Fusarium wilt in IPC 2010-121 was 6.35% (2014-15), 2.10% (2015-16), 6.65% (2016-17) and 7.50% (2017-18).

The parentage (Pedigree) of the line IPC 2010-121 is single cross (one way cross) of genotypes IPC 1997-7 and IPC 1995-1. The pedigree of the parentages used in the development of IPC 2010-121 includes IPC 1997-7 = ICCV 10 / BG 364 and IPC 1995-1= (Avrodhi/ PDG 83-34) / ICCV 95118. Pedigree breeding, accompanied with type selection was followed for the development of IPC 2010-121 at ICAR-Indian Institute of Pulses Research, Kanpur.

The identified genotype IPC 2010-121 is resistant to Race-2 of FOC (Sabale *et al.*, 2019). Therefore, this genotype will be useful for the chickpea breeder to include IPC 2010-121 as one of the parent in developing race specific resistant cultivars with high yield nature. Thereby, it prevents losses caused by the chickpea wilt disease.

Morpho-agronomic characteristics: The plant has semi erect type of architecture at maturity. It matures late (143 days) and has a medium seed size (Hundred Seed Weight=18.2 g). The genotype initiates flowering at 71 days after sowing while fifty per cent of the flowering reaches within 86 days after sowing. The pod initiation occurs at 91 days and fifty per cent podding reaches within 104 days after sowing. The plant height is about 65 cm. Number of pods per plant ranges from 64-80. Based on plot yield data, yield of IPC 2010-121 has been observed up to 3249 kg/ha.

Associated characters and cultivation practices: The genotype IPC 2010-121, thrive well under timely sown (first week of November) irrigated fields under Kanpur condition (East zone). Crop requires irrigation at 40-45days after sowing, pod initiation and seed setting or pod filling stages (if subjected to terminal heat/drought stress). This genotype is suitable for the development of resistant cultivars where race-2 is prevalent under irrigated condition.

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78. PM-81 (IC628568; INGR20078), a Sunflower (*Helianthus annuus*) Germplasm with Resistance to Powdery Mildew (PDS<10%).

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Sunflower (*Helianthus annuus* L.) is one of the important edible oilseed crops grown in the world after soybean and groundnut. The full potential of this crop is far from being exploited due to several abiotic and biotic stresses. The crop suffers from many fungal diseases, among them foliar disease takes a heavy toll by reducing the yield to considerable extent. Among the foliar diseases powdery mildew caused by the obligate parasite Golovinomyces orontii DC (formerly known as Erysiphe cichoracearum) is a potential destructive disease in recent years causing severe yield loss. Since decade, disease observed regularly during rabi-summer seasons and under severe conditions disease is found infecting the cotyledonary leaves up to ray florets.

Breeding efforts were initiated to develop powdery mildew resistant sunflower lines in Sunflower Scheme at Main Agricultural Research Station, Raichur during 2011-12. It was aimed to incorporate powdery mildew resistance in some of the elite lines of sunflower through intraspecific and interspecific crosses followed by selections to identify powdery mildew resistant lines. Sunflower line Powdery Mildew-81 (PM-81) was developed from an intraspecific cross between mono-head inbred (CMS-B) having good seed yield and a multi-head medium resistant line RCR-1947/1-1, followed by pedigree selection (Anon., 2016). The PM-81 has been found to be resistant for powdery mildew under artificial screening in greenhouse by spraying spore suspension culture prepared in 1% sucrose solution (Swetha 2016). Further the PM-81 was also screened in ICAR-Indian Institute of Oilseeds Research during 2017-18, wherein it recorded ‘score 0’ while susceptible check PS 2023 recorded ‘score 9’ on 0-9 scale (Anon., 2018). Several earlier reports are available for powdery mildew resistant line in wild relatives and pre-breed inter-specific crosses of sunflower (Reddy *et al.*, 2013). However, PM-81 is the first intra-specific cross derivative with cultivated background which can be directly used in line conversion and hybrid development.

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