Plant Germplasm Registration Notice*

The Plant Germplasm Registration Committee of ICAR in its XXXVIIth meeting held on October 23th, 2017 at the ICAR-National Bureau of Plant Genetic Resources, New Delhi approved the registration of following 64 germplasm lines out of 87 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. TNAU 60S (IC0622805; INGR17028), a TGMS Line of Rice (*Oryza sativa)*

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The use of male sterility is a prerequisite for commercial exploitation of heterosis since rice is a self-pollinating crop. Following the landmark finding of rice genotypes reversibly turn male fertile to male sterile and *vice versa* with changes in environmental factors, such as temperature and/or day length during critical phases of plant growth, the concept of two-line breeding emerged as an alternative to the three-line approach (Yuan, 1997) in China. The main advantages of two-line heterosis breeding include the ability to use a wide range of genotypes as male parents, absence of negative effects associated with sterility-inducing cytoplasm and no need for maintainer lines. Higher temperature (> 30ºC) results in sterility while lower temperature (<23ºC) results in fertility. These characteristic features of TGMS ease out the hybrid seed production and subsequently it was demonstrated that the TGMS was more effective in increasing grain yield and seed production efficiency (Yuan, 1990). The prevailing wide range of temperature differences in Tamil Nadu favour both hybrid seed production and the maintenance of TGMS in different locations (Siddiq and Ali, 1999). Hence, this study was started and the new TGMS line TNAU 60S was identified as spontaneous mutant from the rice variety PMK 3 with desirable floral characteristics and stable sterility.This TGMS line has the duration of 125 days with semi dwarf plant type. The panicle exertion percentage is 76.9% with wide angle of glume opening which makes the line with higher out crossing potential highly amenable for commercial exploitation. The grain quality of the TGMS line is highly preferable. TNAU 60 S has been used in hybridization and many heterotic hybrids were developed. TNAU 60 S is found promising for the characters stable pollen sterility, panicle exsertion, angle of glume opening and it can be successfully utilized for the development of two line hybrids for hybrid rice breeding.

Seed production potential in the TGMS lines during fertility reversion phase can be enhanced by growing them under medium hill regions of Gudalur (1500m MSL) in Nilgiris district (Aarasakesary *et al.*, 2015). At Gudalur, the temperature range during the month of July and August was less than 20ºC. The appropriate sowing date of TGMS lines was fixed during June-July in such a way that the critical stages of panicle development would be exposed to the required temperature.The individual lines were maintained under isolation and genetically pure seeds were produced at Gudalur. The TGMS line TNAU 60S was evaluated at different locations for their stability in sterility and it was proved that under high temperature (Coimbatore) it expressed 100% sterility and at low temperature it produced more than 90% seed set at Gudalur (Manonmani *et al*., 2016). This line with wider pollen sterility period under plains can be very well exploited for developing two line rice hybrids during the period of December to April. The same lines can be easily seed multiplied at Gudalur during July to November. Thus TGMS system has great potential for revolutionizing hybrid rice production through

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simple, less expensive and more efficient seed production technology.

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2. CSR 53 (Bulk 18) (IC0619320; INGR17029), a Rice (*Oryza sativa*) Germplasm with Tolerance to Salinity Stresses up to ECe 10.0dS/m

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Soil salinity negatively affects agricultural production worldwide. Globally, more than 800 million hectares of land globally 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 (both saline and alkaline) and 2.96 million ha affected by saline soils. Genetic improvement of salt tolerance in rice appears to be economically feasible and a promising strategy for maintaining stable rice production globally. The line CSR 53 (Bulk 18) was developed for saline areas where ECe is up to 10.0 dS/m from the cross CSR23/CSR27 through bulk breeding method at the Division of Crop Improvement, Central Soil Salinity Research Institute, Karnal, Haryana.

Morpho-agronomic characteristics: This is a medium duration, semi dwarf culture, with green foliage, erect flag leaf, compact panicle, medium slender grains and complete panicle exertion. During 2012, CSR 53 (Bulk 18) showed superiority yield advantage of 16.4%, 17.86%, 73.68, 50.02, 198.66% and 17.44% over CSR 44 (Qualifying line 1), NDRK 50032 (Qualifying line 2), RP Bio 4919-363-5 (Qualifying line 3), CSR 36 (National check), Local Check, Jaya (Yield check) and CSR 23, respectively under high salinity condition in Karnal district of Haryana. During 2013, CSR 53 (Bulk 18) showed superiority yield advantage of 27.94 %, 25.63%, 29.24 % and 133.17% over CSR 36 (National check), Local check, CSR 23 (National check) and Jaya(Yield check), respectively across salt affected locations of Karnal, Rohtak and Panipat in Haryana and Gangavathi in Karnataka. During 2014, CSR 53 (Bulk 18) showed superiority yield advantage of 14.39%, 13.36%, 13.88% and 104.92% CSR 36 (National check), Local check, CSR 23 (National check) and Jaya (Yield check), respectively across salt affected locations of Karnal and Panipat in Haryana.

The line CSR 53 (Bulk 18)was found superior in yield over CSR 36 (National check), Local check, Jaya (Yield check) and CSR 23 (National check) by 37.76%, 32.03% 145.58% and 19.86%, respectively across the three years (2012, 2013 and 2014) in salt affected locations of Haryana (Karnal, Rohtak and Panipat) and Karnakata (Gangavathi).

Associated characters and cultivation practices: CSR 53 (Bulk 18) is saline tolerant high yielding, medium slender grained variety and moderately resistant/tolerant to major insect pests and diseases such as stem borer, leaf folder, case worm, blue beetle, WBPH, leaf blast and brown spot. It is also less responsive to higher doses of nitrogen. The yield reduction and yield gain respectively at lower and higher doses of fertilizers are less in Bulk 18 indicating its high nutrient use efficiency. It has high milling recovery (79.9%) and head rice recovery (66.2%), medium slender grains, good cooking quality with medium alkali spreading value (4.7), intermediate amylose content (24.0%) and medium gel consistency (30.7mm).

The performance of CSR 53 (Bulk 18) was consistently high under salinity for three successive years in Haryana and Karnataka. It showed yield superiority over national check (CSR 36), local check (CSR 23) and yield check (Jaya). This Germplasm could be used in future breeding programmes aiming at development of high yielding salt tolerant rice varieties for saline soils.

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3. HSRBW-2 (IC0623528; INGR17030), a Wheat (*Triticum aestivum* L.) Germplasm with High Tolerance to Head Scab

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Head scab of wheat caused by *Fusarium* species is a destructive disease of humid and semi humid wheat growing areas of the world and is generally characterized by bleaching of the wheat spike, shrivelled kernels and accumulation of mycotoxins, which may cause various ailments in humans and animals. In India, this diseasewas reported from Arunachal Pradesh, Wellington and Tamil Nadu (Chaudhary *et al.,* 1991). The yield losses up to 21.6% were recorded in wheat variety PBW 222 in Punjab (Kaur *et al.,* 2000). Under the new trade policies, wheat quality will be of paramount importance as this disease may hinder exports. Keeping this in view, breeding program was designed to introgress head scab resistance from resistant parent Sumai#3 to high yielding, but susceptible genotypes HD 2967, PBW 502 and DPW 621-50 following the back cross pedigree method.

Genotype HSRBW-2 was developed from the cross Sumai #3/HD2967 following a back cross pedigree breeding approach to introgress resistance. Selections were practised in the segregating generations for spring growth habit as Sumai#3 is of facultative winter habit, since in India only spring types are grown and preferred by the farmers.

Morpho-agronomic characteristics: The head scab donor parent Sumai #3 and susceptible parental line HD 2967 along with derived lines were evaluated consecutively for three years under artificial conditions. The genotype HSRBW-2 showing high level of resistance to the head scab over three years was identified (Table 1) as depicted from the average spikelet infection score of 3 over three years of evaluation under artificial conditions.

Table 1. Evaluation of genotypes for head scab resistance under artificial conditions in polyhouse at ICAR- IIWBR, Karnal.

Genotype	Pedigree	% Average spikelet infection			Highest Score	Average score
		2013-14	2014-15	2015-16		
Donor Parent	Sumai#3	3	2	4	4	3
Recipient Parent	HD 2967	66	68	65	68	66
HSRBW-2	Sumai#3/*2HD 2967	3	2	2	3	3

Table 2. Mean performance of HSRBW-2 and parents for agronomic characteristics during 2015-16

Genotypes	Days to heading	Days to maturity	Plant height	Thousand grains weight
HSRBW-2	83	129	92	38
Sumai#3	92	143	105	35
HD 2967	80	129	92	39

Associated characters and cultivation practices: HSRBW-2 takes about 83 days to flowering and in total 129 days from seed to seed (Table 2). This genotype is having a height of 92 cm and thousand grains weight of about 38 g. The high level of head scab resistance in HSRBW-2 plus spring background makes it a potential donor for use in hybridization programmes targeted to improving head scab resistance in future wheat genotypes.

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4. HSRDW-2 (IC0623529; INGR17031), a Durum Wheat (*Triticum durum* L.) Genotype Highly Tolerant to Head Scab

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Fusarium head blight is a destructive disease in all the wheat growing areas of the world where the climate is humid and semi humid. Typical symptoms of head blight are bleaching of the wheat spike, shrivelled kernels and accumulation of mycotoxins which may cause adverse effects on health. This disease is of economic importance, as it may affect exports since *Fusarium* spp. are known to produce mycotoxins in grains under the WTO regulation regime (Saharan *et al.,* 2007). During 2005, due to continuous rain in March in Punjab, head scab appeared in a severe form on durum variety PDW 274 in Gurdaspur area (Bagga and Saharan, 2005) and is becoming a problem in NEPZ and NWPZ as none of the released bread or durum wheat variety is resistant to head scab. A modified backcross pedigree approach was used to introgress head scab resistance from donor parent Sumai#3 to susceptible but high yielding genotype PDW 291. Selections were practised in the segregating generations and fixed genotypes from this cross were evaluated for head scab resistance under artificial conditions. This genotype, in the tetraploid background, may be used for transferring head scab tolerance in durum improvement.

Morpho-agronomic characteristics: The durum wheat genotype HSRDW-2 showing high level of resistance to the head scab over three years was identified under artificial screening for the disease. HSRDW-2 showed high level of resistance as depicted from the average spikelet infection score of 3 over three years of evaluation under artificial conditions (Table 1). The infection score in this genotype is equivalent to that of donor Sumai#3.

Table 1. Evaluation of genotypes for head scab resistance under artificial polyhouse conditions at Karnal.

Genotype	Pedigree	% Average spikelet infection			Highest spikelet infection Score	Average spikelet infection
		2013-14	2014-15	2015-16		
Donor Parent	Sumai#3	3	2	4	4	3
Recipient Parent	PDW 291	72	79	75	79	75
HSRDW-2	Sumai#3/*2PDW 291	2	3	3	3	3

Table2. Mean performance of proposed stocks and checks for Agronomic characteristics during 2015-16.

Traits	Entry	Donor parent	Recipient parent
	HSRDW - 2	Sumai # 3	PDW 291
Days to heading	88	92	87
Days to maturity	134	143	137
Plant height (cm)	85	105	86
1000-grains weight (g)	43	35	42

Associated characters and cultivation practices: HSRDW-2 flowers in about 88 days and takes about 134 days from seed to seed (Table 2). This genotype is having a height of 85cm and thousand grains weight of about 43g. The high level of head scab resistance in HSRDW-2 in a spring background makes it a potential donor for use in hybridization programmes targeted to improving head scab resistance in future durum wheat genotypes.

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5. HI 8751 (IC0623451; INGR17032), a Wheat (*Triticum turgidum* ssp. *durum*) Germplasm with Resistance to Stem Leaf and Stripe Rusts, Karnal Bunt and Flag Smut

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Diseases like stem, leaf and stripe rusts, flag smut and Karnal bunt cause severe yield losses in durum wheat production. Karnal bunt is a major problem as far as wheat exports are concerned. In view of their continued evolution, broadening of genetic base for host resistance is necessary in order to minimize the losses caused by these pathogens.

HI 8751 (HD 4685/HI 8634),durum wheat genotype was identified to be resistant to stem, leaf and stripe rusts, Karnal bunt and flag smut in multi-location testing *viz*., Plant Pathological Screening Nursery (PPSN), Elite PPSN and Multiple Disease Screening Nursery (MDSN) from 2012 to 2016 (Table 1). It showed high levels of adult-plant resistance to most prevalent and virulent

Table 1. Field responses of HI 8751 to stem, leaf and stripe rusts of wheat

Year of testing	Trials	Stem rust		Leaf rust				Stripe rust	
		South		South		North		North	
		HS	ACI	HS	ACI	HS	ACI	HS	ACI
2012-13	NIVT 5B	20MR	3.0	5MR	0.4	30S	9.3	20MS	3.6
2013-14	AVT I	20S	4.1	20MR	2.3	10MR	1.6	20S	5.3
2014-15	EPPSN	20S	10.6	20MR	2.6	5S	1.2	5MS	1.8
2015-16	MDSN	10MS	2.8	5S	1.3	0	0.0	20MS	4.8

(HS-Highest score, ACI–Average Co-efficient of Infection)
Source: AICW&BIP – Crop Protection Reports (2012-16)

Table 2. Adult-plant responses in Advance Varietal Trial I of HI 8751 to specific pathotypes of stem leaf and stripe rusts of wheat (2013-14).

Stem rust pathotypes				Leaf rust pathotypes			Stripe rust pathotypes	
40A		117-6		77-5		104-2	46S119	78S84
Indore	Pune	Indore	Pune	Delhi	Ludhiana	Delhi	Ludhiana	Ludhiana
5MR	10MR	10S	10MR	TR	0	5R	20MS	40MS

Table 3. Seedling responses of HI 8751 to individual pathotypes of stem, leaf and stripe rusts (2013-14).

Stem rust pathotypes													
11	11A	24A	34-1	40A	40-1	40-3	117-1	117-2	117-3	117-5	117-6	184	295
R	R	MS	R	R	R	R	S	R	R	R	MS	MX	R

Leaf rust pathotypes																								
11	12	12-2	12-3	12-5	12-7	12-9	77	77-1	77-2	77-5	77-7	77-8	77-9	77-10	77A-1	104-2	104-3	104-4	104B	106	107-1	162-1	162-3	162A
R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	S	R	R	R	R	R	R	R	R

Stripe rust pathotypes													
78S84	46S119	K	T	P	31	38A	L	14A	I	A	20A	N	13
MR	R	MS	R	MX	S	R	MS	S	R	R	R	R	R

Table 4. Disease scores of Flag smut and Karnal bunt

Year of testing	Trial	Flag smut (%)		Karnal bunt (%)							
		HS	Avg	Jammu	Hissar	Delhi	Dhaulakuan	Ludhiana	Karnal	HS	Avg
2012-13	NIVT 5B	-	-	-	-	-	0.0	3.5	-	**3.5**	**1.7**
2013-14	AVT I	**0.0**	**0.0**	4.2	0.0	13.0	0.5	0.5	0.0	**13.0**	**3.0**
2015-16	MDSN	**0.0**	**0.0**	-	-	-	-	-	-	**1.0**	-

pathotypes like 77-5 and 104-2 of leaf rust, 40A and 117-6 of stem rust, and 46S119 and 78S84 of stripe rust in isolated nurseries (Table 2). It showed seedling resistance to the leaf rust pathotypes and to most of the stem and stripe rusts pathotypes tested (Table 3). It also showed resistance to other diseases like flag smut and Karnal bunt (Table 4). Hence, it can be used as potential resistance donor to breed varieties against these multiple pathogens as it is often difficult to find multiple disease resistance in a single genotype.

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6. QBP 12-11 (IC0624127; INGR17033), a Wheat (*Triticum aestivum*) Germplasm with Low Hardness Index (Soft Endosperm)

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The milling and baking industry of India is rapidly expanding and is valued at ~Rs 69 billion. Biscuits occupy an important place in the bakery industry of India. In fact, India is the third largest producer of biscuits next to USA and China. However, the flour used in India for local production of biscuits is generally an "all purpose flour' and not specific to the production of a particular end-product. Thus, such a flour is not entirely suitable for biscuit making and as a result, chemicals/ improvers are required to be added to the flour during baking. Exporting nations such as Australia, Canada, USA etc. have lessened their dependence on the use of such chemicals and have made genetic improvement in the quality of their flour. Biscuits in these countries are made from flour that is derived from wheat grains that are soft in texture. Texture of the grain (endosperm) is determined by the hardness index it produces on crushing. Lower the grain hardness index (GHI), softer the grain. However, in India all commercially used varieties are hard grained. Therefore, genetic improvement to produce soft grained wheat suited for biscuit quality is a priority for wheat quality breeders. So far, one genetic stock namely QLD 28 having soft grain (GHI=27) has been registered with NBPGR. ICAR-IARI have developed a new strain QBP12-11(Wbll1*2/Kkts*2/3/T. dicocconPI272533/Ae.squarrosa (458)//Cmh81a.1261/ Vee#10-7) with much higher grain softness than QLD 28. This line is a selection of a CIMMYT entry and was evaluated in the Quality Component Screening Nursery (QCSN) conducted by IIWBR and its cooperators at 12 locations for three consecutive years (2012-13, 2013-14 and 2014-15) by IIWBR cooperators all over India. QBP 12-11 recorded lowest GHI (17.7) among bread wheat genotypes in all the three years. Since molecular markers for grain softness are available, QBP 12-11 stock can be used as a donor for marker based transfer of grain softness in new elite materials to develop soft grained genotypes suitable for biscuit quality breeding.

7. HI KK 10 (NP4 + *Lr*13) (IC0624491; INGR17034), a Wheat (*Triticum aestivum*) Germplasm Carrying *Lr*13 as Locally Adapted Differential for Indian Pathotypes of Wheat Leaf Rust (*Puccina triticina*)

and

8. HI KK 11 (NP4 + *Lr*18) (IC0624492; INGR17035), a Wheat (*Triticum aestivum*) Germplasm Carrying *Lr*18 as Locally Adapted Differential for Indian Pathotypes of Wheat Leaf Rust (*Puccina triticina*)

and

9. HI KK 12 (NP4 + *Lr*19) (IC0624493; INGR17036), a Wheat (*Triticum aestivum*) Germplasm Carrying *Lr*19 as Locally Adapted Differential for Indian Pathotypes of Wheat Leaf Rust (*Puccina triticina*)

and

10. HI KK 13 (NP4 + *Lr*26) (IC0624494; INGR17037), a Wheat (*Triticum aestivum*) Germplasm Carrying *Lr*26 as Locally Adapted Differential for Indian Pathotypes of Wheat Leaf Rust (*Puccina triticina*)

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Leaf rust caused by *Puccinia triticina* Eriks. (*Pt*) is most common among three rust diseases of wheat (*Triticum aestivum* L.). Leaf rust differentials being used in India consist of sets 0, A and B (Nayar *et al*., 2001). Majority of the leaf rust differentials in set 'A' and most varieties in set 'B' are winter types, which require a long photoperiod for flowering. Hence, maintenance of these differentials is difficult, particularly in the plains of India due to their long duration and often there is either seed set failure or production of shriveled grain. Hence, need was felt for developing near-isogenic *Lr* lines in the background of a locally adapted variety. NP 4 was selected as a background parent which is not known to carry any *Lr* gene or suppressor factor (Kaushal *et al.*, 1982) for leaf rust resistance, and being early maturing, slow rusting, lodging-tolerant, non-shattering, heat and drought tolerant, and bold seeded variety. Hence, a backcross programme was initiated in 1997-98 for transferring the *Lr* genes in NP4 background.

NP4 lines carrying *Lr1, Lr2a, Lr2c, Lr3a, Lr9, Lr10, Lr15, Lr17a* and *Lr20* genes singly have already been registered with ICAR-NBPGR. They are: HI KK1 (NP4+*Lr1*, INGR 16024), HI KK2 (NP4+*Lr2a*, INGR 16025), HI KK3 (NP4+*Lr2c*, INGR16026), HI KK4 (NP4+*Lr3a*, INGR 16027), HI KK5 (NP4+*Lr9*,INGR16028), HI KK6 (NP4+*Lr10*,INGR16029), HI KK7 (NP4+*Lr15*, INGR 16030), HI KK8 (NP4+*Lr17a*, INGR16031), and HI KK9 (NP4+*Lr20*, INGR 16032).

Thatcher backcross lines carrying the target *Lr* genes *viz*., *Lr13, Lr18, Lr19* and *Lr26* were used as donors. A total of six backcrosses were done in succession followed by selection and testing which was completed in 2015-16. Intense selection was made during each generation for NP 4 plant type (awnless spikes and pubescent glumes) coupled with resistance phenotype of the target gene. The latter was identified in the field through syringe inoculation after 30-35 days of sowing with aqueous suspension of the uredospores of an avirulent pathotype. Leaf rust pathotype (pt) 12-2 (1R5) was used for selecting resistant plants carrying singly the gene(s) *Lr26*; pt 12-5 (29R45) for *Lr13* and *Lr19*; and pt 108-1 (57R27) for *Lr18*.

The lines developed were seedling tested with several avirulent pathotypes for confirming homozygosity for target *Lr* gene (DR. Knott, Pers. comm.). Close

Table 1. Comparison of seedling infection types (at 16-20^0 C) to selected avirulent leaf rust pathotypes of the newly developed near-isogenic lines (HI KK 10-13) with the corresponding donor *Lr* lines (RL Nos.) and the recurrent parent NP 4

Wheat genotypes	Seedling infection type[1]	Avirulent leaf rust pathotypes used for testing
HI KK 10 (NP4+*Lr13*)	0;	11, 12, 16-1, 63, 106
RL 4031 (Tc+*Lr13*)	0;	
NP 4	33+	
HI KK 11 (NP4+*Lr18*)	0;2$^+$	12, 12-4, 77A-1, 106, 162A
RL 6009 (Tc+*Lr18*)	0;2$^+$	
NP 4	33$^+$	
HI KK 12 (NP4+*Lr19*)	;1	10,12-1,16-1,104-2,106,107
RL 6040 (Tc+*Lr19*)	;1	
NP 4	3$^+$	
HI KK 13 (NP4+*Lr26*)	0;	10, 11, 12-4, 12-8, 16-1, 17, 63, 77, 77A-1, 106, 108, 162A
RL 6078 (Tc+*Lr26*)	0;	
NP 4	3$^+$	

[1]As described by Roelfs *et al.* (1992)

similarity between seedling infection types of the newly developed backcross lines and the corresponding donor lines confirmed successful transfer of the target *Lr* genes in NP 4 background (Table 1).

Homozygous resistant lines carrying singly four genes *viz*., *Lr13*, *Lr18*, *Lr19* and *Lr26* have been developed. These near-isogenic lines having early maturity and other desired agronomic traits of NP4 are easy to maintain under Indian conditions, and hence, should be widely useful for virulence analysis and genetic studies.

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11. HI 8765 (IC0624495; INGR17038), a Wheat (*Triticum turgidum*) Germplasm with Resistance to Stem, Leaf and Stripe Rusts, Karnal Bunt & Flag Smut. High Yield Potential

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HI 8765 (HI 8504/CPAN 6206//HI 8627), durum wheat genotype was identified to be resistant to stem, leaf and stripe rusts, Karnal bunt and flag smut in multi-location testing *viz*., Plant Pathological Screening Nursery (PPSN), Elite PPSN and Multiple Disease Screening Nursery (MDSN) from 2013 to 2017 (Table 1). It showed high levels of adult-plant resistance to most prevalent and virulent pathotypes like 77-5 and 104-2 of leaf rust, 40A and 117-6 of stem rust, and 46S119 and 78S84 of stripe rust in isolated nurseries (Table-2). It showed seedling resistance to most of the prevalent and virulent pathotypes of stem and leaf rusts like race 40-group of stem rust and races 77-group and 12-group of leaf rust. Even though, it showed seedling susceptibility to stripe rust pathotypes, it has shown high levels of field resistance (Adult plant resistance) (Table 3). It also showed resistance to other diseases like flag smut and Karnal bunt (Table 4). HI 8765 showed significant superiority in grain yield of 38.1% in NIVT and on par in AVT-I in comparison to zonal check variety AKDW 2997-16 in Peninsular Zone (Table 5).As the availability of multiple disease resistant high yielding genotypes is rare, HI 8765 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 8765 to stem, leaf and stripe rusts of wheat

Year of testing	Trial	Stem rust		Leaf rust				Stripe rust	
		South		South		North		North	
		HS	ACI	HS	ACI	HS	ACI	HS	ACI
2013-14	NIVT 5B	10MS	2.9	10S	4.9	10S	2.2	10MS	2.0
2014-15	AVT I	40MR	3.1	5S	1.9	5MS	0.5	40S	4.9
2015-16	EPPSN	10MR	1.0	20S	6.0	10MR	0.7	0	0
2016-17	MDSN	20MS	8.3	20MR	2.1	TR	0.1	10S-20MS	5.5

(HS-Highest Score, ACI-Average Coefficient of Infection); Source : AICW&BIP Crop Protection Reports (2013-17)

Table 2. Adult-plant responses in Advance Varietal Trial I of HI 8765 to specific pathotypes of stem, leaf and stripe rusts of wheat (2014-15)

Stem rust pathotypes					Leaf rust pathotypes					Stripe rust pathotypes			
40A			117-6		77-5			104-2		46S119		78S84	
Indore	Pune	Power kheda	Indore	Pune	Delhi	Ludhiana	Power kheda	Delhi	Ludhiana	Ludhiana	Delhi	Ludhiana	Delhi
20RMR	20MR	TR	5S	30MS	20R	0	0	10R	0	10S	TR	0	40S

Table 3. Seedling responses of HI 8765 to individual pathotypes of stem, leaf and stripe rusts (2014-15)

Stem rust pathotypes

11	11A	15-1	21	21A-2	24A	34-1	40A	40-2	40-3	122	117-1	117-3	117-4	117-5	117-6	184	184-1	295
R	R	R	R	R	MS	R	R	R	R	R	MR	MR	R	R	MS	S	R	MS

Leaf rust pathotypes

11	12	12-2	12-3	12-5	12-7	12-9	16-1	77	77-1	77-2	77-5	77-7	77-8	77-9	77-10	77-12	77A-1	104-2	104-3	104-4	104B	106	107-1	108-1	162-1	162-3	162A
R	R	R	R	R	R	R	MS	R	R	R	R	R	R	R	R	R	R	S	R	S	R	R	R	R	MS	R	R

Stripe rust pathotypes

78S84	46S119	K	T	P	38A	L	14A	I	A	20A	N
S	S	S	MS	S	R	MS	R	S	R	R	R

Table 4. Disease scores of Flag smut and Karnal bunt

Year of testing	Trial	Flag smut (%)						Karnal bunt (%)								
		Ludhiana	Hissar	Durgapura	Karnal	HS	Avg	Jammu	Hissar	Delhi	Dhaula-kuan	Ludhiana	Karnal	Pant nagar	HS	Avg
2013-14	NIVT 5B	-	-	-	-	-	-	-	-	-	0.0	1.0	-		1.0	0.5
2014-15	AVT I	0	0	0	1.2	**1.2**	**0.4**	8.4	0.0	13.2	1.6	0.0	0.0	0.6	**13.2**	**3.4**
2016-17	MDSN	-	-	-	-	**10.0**	**3.3**	-	-	-	-	-	-		0.0	0.0

Table 5. Grain yield (q/ha) of HI 8765, compared to zonal check variety AKDW 2997-16

Year of testing	Trial	No. of locations	HI 8765	AKDW 2997-16	CD
2013-14	NIVT 5B	2	21.4 (38.1)	15.5	2.8
2014-15	AVT I	4	17.0 (NS)	18.2	2.1

Note: Value in parenthesis is percentage increase over check variety, NS : Non-significant

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12. LBPY 11-2 (IC0624496; INGR17039), an Early Maturing Wheat (*Triticum aestivum*) Germplasm with Bold Seed for Warmer Areas of India

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Wheat is an important staple food crop grown over range of environments and grain yield is adversely affected in hot dry environments in Central and Peninsular India. It is reported that heat stress adversely affects grain yield, biomass, maturity duration and grain size in wheat (Balla *et al*., 2014). Genotypes having high thousand grain weight (TGW) are considered better for improving yield as it has a strong positive correlation with grain size. Accordingly, LBPY 11-2 was developed (cross NL297/BL2022) and identified as an early maturing bold seeded genotype possessing bold grains.

Morpho-agronomic characteristics: LBPY 11-2 had high 1000-grain weight (49.3g) over three years (2012-15) in Yield Component Screening Nursery (YCSN) and also possessed more grains/spike and tillers/meter and thus was promoted from YCSN to National Genetic Stock Nursery (NGSN). Further its performance across locations (Dharwad, Niphad, Akola and Pune) in peninsular zone and central zone (Indore, Bilaspur, Vijapur, Junagadh, Jabalpur, Powarkheda, Sagar, Kota and Bhavnagar) under NGSN (2015-16), established 10 days advantage in flowering and maturity duration as compared to the best check Sonalika.

Associated characters and cultivation practices: The mean performance of the LBPY 11-2 under NGSN across zones revealed its superiority for combination of traits like; early flowering, early maturity, medium plant height, high tillers/meter, spike length and 1000-grain kernel weight, established its usefulness as potential donor for earliness and high grain weight (50g) across warmer regions of India.

Table 1. Performance of LBPY 11-2 in central and peninsular zone for different traits.

Trait	Central Zone		Peninsular Zone	
	Entry	Check	Entry	Check
	LBPY 11-2	Sonalika	LBPY 11-2	Sonalika
Days to maturity	**105**	110	**100**	110
1000 grain weight (g)	**50**	42	**50**	37

Table 2. Overall performance of LBPY 11-2 for agronomic & quality traits in NGSN during 2015-16.

Trait	Genotype	Checks	
	LBPY 11-2	Sonalika	HD 2967
Days to heading	73	75	84
Days to maturity	119	121	124
1000 grain wt. (g)	46	40	37
Spike length (cm)	12	9	11
Protein content	11.7	10.7	10.7
Grain iron concentration (ppm)	39.2	36.4	34.7
Grain zinc concentration (ppm)	40.8	37.2	33.6

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13. FLW31 (IC0624500; INGR17040), a Wheat (*Triticum aestivum*) Germplasm with Resistance to Black and Brown and Rusts Ug99 Pathotypes. Carries *Sr*24/ Lr24 and Unutilized *Sr*43 in Good Agronomic Background

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Rusts are important diseases of wheat (*Triticum aestivum* L.) throughout the world. The preferred way of controlling these pathogens is through the use of resistant varieties. There are several genes that can express resistance to these diseases. However, changes in pathogen virulence can render them less useful for use in breeding new varieites (Bhardwaj et al., 2016). The emergence of the Ug99 group of stem rust races (TTKSK, TTKSF, TTKST, TTTSK) which have defeated *Sr31* and many other stem rust resistance genes has reaffirmed the need to deploy diverse and effective resistance sources to safeguard wheat production (Pretorius *et al.*, 2000). Keeping in view the need to deploy diverse resistance gene against brown and black (including Ug99) rusts, the genotype FLW31 was developed through pedigree method from cross between HI1500(*Lr24/Sr24*) and exotic line KS10-2 C83.4(*Sr43*) backed by marker assisted selection. FLW31 having two gene based resistance would be useful in diversifying resistance for brown and black rusts in all wheat growing zones of India.

Seedling and adult plant resistance response against most virulent and prevalent pathotypes under controlled conditions showed that F LW31 is resistant to black and brown rusts (Table 1). FLW31 carries *Sr43* and *Lr24/Sr24* genes for resistance to wheat rusts. *Sr43* also confers resistance to Ug99 virulences of stem rust (Singh *et al*., 2015).

Plants of FLW31 have moderate waxiness on leaf sheaths and peduncles. It has average plant height of 105cm and matures in about 155 days under Shimla Conditions. Its grains are reddish-amber coloured, semi hard and thousand-grain weight of 41.6g.

Table 1. Seedling response of FLW31 for brown and black rust pathotypes under artificial controlled conditions

Pathotypes	Black rust						Brown rust			
	34-1	40A	40-1	40-3	117-1	117-6	12-5	77-2	77-5	104-2
Reaction	0;	0;	0;	;	;	;	0;	;1	;1	;1

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14. FLW32 (IC0624501; INGR17041), a Wheat (*Triticum aestivum*) Germplasm with Resistance to Black Rust Including Ug99 Pathotypes; It Carries Unexploited *Sr*26 in the Background of Raj3765

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Wheat black or stem rust (*Puccinia graminis* f. sp. *tritici*), is highly variable and devastating pathogen. It evolves quickly to evolve new pathotypes/races, rendering resistant wheat varieties susceptible and pose a serious threat to wheat production in different parts of the world (Bhardwaj *et al.*, 2016). The new pathotype, designated as TTKSK and its variants, popularly known as Ug99, have the ability to overcome the resistance conferred by a majority of the stem rust resistance genes, including *Sr31* (Prasad *et al*., 2016). Keeping in view the need to deploy diverse resistance gene against FLW32 was developed from cross Raj3765/Eagle (*Sr26+Sr9g*). *Sr26* is known to confer long time black rust resistance in Australia. *Sr26* being in winter wheat background cannot be used directly in wheat breeding programme in India. *Sr26* has not been used in Indian wheat breeding programme. Therefore, *Sr26* was transferred into spring wheat variety Raj3765 using marker assisted backcross breeding and pedigree selection. FLW32 would be useful to wheat breeders in diversification of black rust resistance in Central and Peninsular zones of India.

FLW32 showed high resistance (0; to; 1) to black rust when evaluated against most virulent and predominant pathotypes under controlled condition (Table 1). It also showed resistance against Ug99 pathotypes of black rust when tested in Kenya in 2013.The adult plant reaction (APR) of FLW 32 to black rust showed resistant response. Two backcrosses followed by pedigree selection for resistance and yield attributes were undertaken to develop this stock. FLW32 provides complete resistance against stem rust pathotypes and adult plant resistance against brown rust also. Presence of *Sr26* in FLW32 has been confirmed through molecular marker. It also carries rust resistance genes *Lr10, Lr13, Sr2,* and *Sr9g*. Plants of FLW32 showed moderate waxiness on leaf sheaths, peduncles and glumes. FLW32 has an average plant height of 99 cm and takes 152 days to mature under Shimla conditions. The grains are amber coloured, semi hard with thousand-grain weight of 42.1g.

Table 1. Seedling response of FLW32 for brown rust pathotypes under artificial controlled conditions

Pathotypes	Black rust pathotypes							
	11	21-1	34-1	40A	40-1	40-3	117-1	117-6
Reaction	0;	0;	0;	0;	0;			;

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15. FLW33 (IC0624649; INGR17042), a Wheat (*Triticum aestivum*) Germplasm with Resistance to Black and Brown Rusts of Wheat; Resistant to Ug99 pathotypes; Carries *Sr*32, *Sr*24/*Lr*24 in Good Agronomic Background

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Rusts are economically the devastating diseases of wheat as they pose major threat to wheat production in most of the wheat growing areas of the world (Khan *et al*., 2017). Deployment of rust resistant wheat cultivars has been the most economical and environmentally friendly strategy to control rust diseases. However, changes in pathogen virulence can render them susceptible and not useful for breeding after some time (Bhardwaj *et al*., 2016). The emergence of the Ug99 group of stem rust races (TTKSK, TTKSF, TTKST, TTTSK) which has defeated *Sr31* and many other stem rust resistance genes has reaffirmed the need to deploy diverse and effective resistance sources to safeguard wheat production world over (Pretorius *et al*., 2000). Keeping in view the need to deploy diverse resistance gene against brown and black (including Ug99) rusts, the genotype FLW33 was developed from the cross HI1500/C77.19 (*Sr32*). Ug99 resistant C77.19 carrying *Sr32* is a winter wheat germplasm and cannot be used directly in Indian wheat breeding programme. FLW33 having unutilized Ug99 resistance gene Sr32, will add to the genetic diversity in wheat breeding programme for black rust prone areas of Peninsular and Southern Hill Zones of India.

FLW33 was found to be completely resistant to black and brown rusts when tested against most virulent pathotypes (Table 1). Black rust resistance is based on two resistance genes (*Sr24* and *Sr32*) each conferring complete resistance to field population of stem rust in India. It was also found resistant to Ug99 pathotypes of black rust when tested in Kenya in 2013. Presence of *Sr24/*

Lr24 and *Sr32* in FLW33 has been confirmed through robust molecular markers. FLW33 shows waxiness on leaf sheaths, flag leaves, peduncles and glumes. Average plant height is 93 cm and maturity duration is 145 days under Shimla conditions. Its grains are semi hard and reddish-amber having thousand-grain weight of 41.4g.

Table 1. Seedling response of FLW33 for brown and black rust pathotypes under artificial controlled conditions

Pathotypes	Black rust pathotypes						Brown rust pathotypes				
	11	34-1	40A	40-1	117-1	117-6	12-5	77-2	77-5	77-9	104-2
Reaction	0;	0;	0;	0;	;	;	0;	;1	;1	;1	;1

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16. DWRB173 (IC0624123; INGR17043), an Extra Early Heading Hooded Barley (*Hordeum vulgare*) Germplasm

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DWRB173 is early heading hooded barley genotype and highly desirable sources in breeding programmes, especially for rainfed areas and to alter the awns for better feeding ability for animals. The genotype DWRB173 is hooded barley, which was selected from ICARDA material (YAGAN/CAPUCHONA 20) for extra earliness and evaluated during *rabi*, 2014-15 to 2016-17 at karnal and during *rabi*, 2015-16 at Hisar (Table 1). The genotype showed spike emergence in nearly 53-55 days (Anonymous, 2017; Kumar *et al*., 2016) and details are given below-

Table 1. Heading (days) data of DWRB173 and checks

Location	Year	Genotype	Checks		
		DWRB173	DWRB92	DWRB101	BH902
Karnal	2014-15	54	89	90	88
Karnal	2015-16	55	85	87	89
Karnal	2016-17	54	89	88	91
Hisar	2015-16	53	84	85	87
	Mean	54	87	87	89
% advantage		-	38	38	39

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17. DWRB175 (IC0624124; INGR17044), an Extra Dwarf Barley (*Hordeum vulgare*) Germplasm

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Barley is very important coarse cereal for feed, food and malt purposes but heavily prone to lodging and resultantly facing higher yield losses. The genotype DWRB175 is two-row barley genotype, selected from segregating exotic ICARDA material (NACKTA/HJA A33//FNC1) for short plant height (Anonymous, 2017). After selection the genotype DWRB175 was further purified and observed with extra dwarf plant height during *rabi*, 2014-15, 2015-16 and 2016-17 and found promising with mean plant height of 60.8 cm (Table 1). The genotype DWRB175 will be highly useful genetic resource for barley breeders for shortening plant height and to check the lodging up to a greater extent. The details are given below-

Table 1. Plant height (cm) of DWRB175 and checks

Location	Year	Plant height (cm)		
		DWRB175 (Hulless)	BH902 (Check)	NDB 943 (Hulless Check)
Karnal	2014-15	61.5	96.0	105.0
Karnal	2015-16	60.0	94.0	104.0
Karnal	2016-17	60.5	94.0	102.0
Hisar	2015-16	61.0	95.0	104.0
	Mean	60.8	94.8	103.8
% advantage		-	35.9	41.4

References

Anonymous (2017). Annual report 2016-17, ICAR-IIWBR, *Eds*: L Kumar, K Venkatesh, HM Mamrutha, R Sendhil, V Gupta, Rinki, A Jha and GP Singh. ICAR-IIWBR, Karnal, India. P. 152.

18. DWRB176 (IC0624125; INGR17045), a Barley (*Hordeum vulgare*) Germplasm with Long Spikes with More Number of Grains and Resistance to Stripe Rust

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The genotype DWRB176 is highly desirable genetic resource for long two-row spikes, high number of grains with high 1000 grain weight of 55g (48-62 g). The genotype was developed by pedigree method at ICAR-IIWBR, Karnal. The genotype DWRB176 (BK1509-DWRB62/DWRB73) is unique for two rowed long spikes (12.5-13 cm) and possess more number of grains per spike (34-36) in comparison to the malt barley checks viz. DWRUB52 (8.5-9.5 cm and 24-26 grains), RD2849 (8.5-9.5 cm and 24-26 grains), DWRB101 (8-9 cm and 22-24 grains) and DWRB123 (8.5-10.0 cm and 24-26 grains), respectively (Table 1, Anonymous, 2017a).

In addition, DWRB176 is also desirable for stripe rust (*Puccinia striiformis* f. sp. *hordei*) resistance and was confirmed under artificial epiphytotics in coordinated multi-location initial barley disease screening nursery (IBDSN-2015-16) and in Elite barley disease screening nursery (EBDSN-2016-17) (Anonymous, 2016; Anonymous, 2017b). In seedling resistance test (SRT) DWRB176 also showed resistant reactions for the barley stripe rust races viz. 24, Q, G, 57 and MS reactions for the race M.

Table 1. Spike length of DWRB176 and checks

Year	Location	DWRB176 (BK1509)	Checks			
			DWRUB 52	DWRB 101	DWRB 123	RD 2849
2014-15	Karnal	13.2	9.0	8.7	10.0	8.5
2015-16	Karnal	12.7	8.5	9.0	9.0	9.5
2015-16	Hisar	12.8	8.9	8.3	8.4	9.0
2016-17	Karnal	13.1	9.5	9.5	10.2	10.0
	Mean	13.0	9.0	8.9	9.4	9.3

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19. DWRB180 (IC0624126; INGR17046), a Barley (*Hordeum vulgare*) Germplasm with Resistance to Spot Blotch

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Spot blotch (*Bipolaris sorokiniana*) is a devastating disease in barley and nearly all the cultivars released are highly susceptible for spot blotch in India. The in-built resistance is always desirable over chemical control to save environment from hazardous effects of the fungicides and *vis-à-vis* to enhance profitability of small and marginal farmers. DWRB180 is six-row barley genotype, which showed resistance reactions for spot blotch under coordinated evaluation (*artificial inoculation*) in initial barley disease screening nursery (IBDSN) during 2016-17 (Table 1).

The genotype DWRB180 was selected from exotic material (P.STO/3/LBIRAN/UNA80//LIGNEE640/4/BLLU/5/PETUNIA1/6/M111) for morphological characters coupled with spot blotch resistance and evaluated at Karnal during *rabi*, 2014-15 to 2015-16. During *rabi*, 2016-17, the genotype was evaluated in IBDSN at the centres namely, Pantnagar, Varanasi, Kanpur and Faizabad and showed resistance for spot blotch (Anonymous, 2017).

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Table 1. Multi-location screening for spot blotch (artificial inoculations) of DWRB180 and checks

Year	Location	DWRB180 (BK1626)	Checks			Infector
			BH902 (NWPZ)	HUB113 (NEPZ)	BH959 (CZ)	
(2016-17)	Pantnagar	25	67	78	99	68
	Varanasi	24	68	89	89	89
	Kanpur	24	36	36	79	89
	Faizabad	24	57	57	79	78

20. GJG 0814 (IC0623452; INGR17047), a Chickpea (*Cicer arietinum*) Germplasm with Fusarium Wilt Resistance

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Introduction

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). As per survey conducted by Kumar and Bourai (2012), the yield loss was up to 72.16 per cent due to this disease. This genotype was found to be resistant in wilt sick plot at ICRISAT, Kanpur, Rahuri and Junagadh during different years (2009-10, 2012-13, 2013-14, 2015-16) of testing.

The line GJG 0814 (IC0623452; INGR17047), 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 (JG 315 × GCP 9605) × JG 315.

Morpho-agronomic characteristics of GJG 0814

Entry	Year	Yield (Kg/ha)	Maturity days	100 seed wt. (g)
GJG 0814	2010-11	1831 (8)	103 (7)	22.2 (8)
	2011-12	2007 (9)	112 (8)	19.1 (9)
	2012-13	2263 (9)	107 (8)	20.3 (9)
Mean		2033.7	107.3	20.5

(Source: AICRP report)

Associated characters and cultivation practices

Resistant to *Fusarium* wilt disease	Semi spreading growth habit
Medium maturity (107 days)	Single flower per peduncle
Average Yield (2034 Kg/ha)	Brown seed colour
Medium seed size (20.53 g/100 seeds)	Angular seed shape

Seed rate: 60 Kg/ha; Spacing: 45×10 cm; Fertilizer dose: 20:40:00 N:P:K

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21. DRMR MJA 35 (IC0622804; INGR17048), an Indian Mustard (*Brassica juncea*) Moricandia system based CMS line with Resistance to White Rust Disease

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White rust caused by *Albugo candida* (Pers. ex Lev.) Kuntze is one of the most devastating diseases of Crucifers and causes severe losses in Indian mustard (*Brassica juncea*). Symptoms of the disease may appear at vegetative stage itself and sustain even at flowering stage. Maximum damage is caused by stag head formation due to malformation of flowering buds directly causing the yield losses. Indian germplasm of *B. juncea* generally has been reported to have susceptibility against existing pathogen. Resistance to white rust has been shown to be governed by a single dominant gene. Development of hybrids has been a long sought goal to enhance the yield potential in *B. juncea*. Dominance of resistance over susceptibility will result in resistant phenotype of F1 hybrid even if one of the two parents carries resistant gene. Considering these facts, efforts were initiated to introgress white rust resistant gene(s) from exotic germplasm (ZEM 2) expressing resistance. Crosses between donor (ZEM 2) and susceptible parent HB 9916 were attempted during 2002-03. Resulting F_1 was backcrossed with recurrent parent HB 9916 till BC_3 was obtained. Subsequent two generations were advanced following pedigree method. Finally one resistant line with good agronomic base was selected and named as MJB 35. This selected resistant line was crossed with existing *moricandia* based cytoplasmic male sterile line MJA 5 as pollen parent. Accordingly, MJB 35 was converted to cytoplasmic male sterile line having resistance against white rust following backcross method. Consequent upon five backcrosses with MJB 35, cytoplasmic male sterile line DRMR MJA 35 was developed and inducted to AICRP-RM uniform disease nursery trial. The resultant white rust resistant CMS line DRMR MJA 35 was evaluated for disease reaction at five locations during 2012-13 and at six locations during 2013-14 along with resistant and susceptible checks; EC 399299 and Rohini, respectively. Observations on leaves were recorded at 75 days and 100 days and for staghead formation at flowering stage.

DRMR MJA 35 expressed resistance reaction at Hisar and Morena centres during both years. On the basis of mean performance for disease severity of total eight environments in two years, proposed strain DRMR MJA 35 (disease severity 8.1%) was at par with resistant check EC 399299 (7.0%) at 75 days stage and at 100 days stage. DRMR MJA 35 (disease severity 5.4%) showed better performance than resistant check EC 399299 (9.2%). Similarly, the performance of DRMR MJA 35 (0.3%) was better than resistant check (4.4%) for stag head formation at flowering stage. On the basis of above mentioned results, it is concluded that proposed strain DRMR MJA 35 has expressed resistant reaction against white rust. Two independent loci *viz*. AcB1-A4.1 & AcB1-A5.1, governing resistance to *Albugo candida* causing white rust in Indian mustard tagged in two east European lines, Heera and Donskaja, respectively by Panjabi-Massand *et al*. (2010) were validated in DRMR MJA 35. DRMR MJA 35 is the first *moricandia* based white rust resistant cytoplasmic male sterile line of Indian mustard The proposed line shall be useful in developing white rust resistant hybrid cultivar in Indian mustard.

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22. RG-2661 (IC0374272; INGR17049), a Castor (*Ricinus communis*) Germplasm with Resistance to Leafhopper (*Empoasca flavescens*)

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Leafhopper, *Empoasca flavescens* Fabr. (Hemiptera: Cicadellidae) is one of the major crop damaging insect pests in castor (*Ricinus communis* L.). It could cause yield loss to the extent of 22-89% (Lakshminarayana and Duraimurugan, 2014). Host-plant resistance is the most reliable, economical and eco-friendly measure to control leafhopper. Availability of resistant source is the prerequisite to breed resistant cultivars. In order to identify leafhopper resistant sources, several castor germplasm selections were screened against leafhopper across locations in multi-years under heavy insect pressure by taking up late August sowing using infester row method.

Morpho-agronomic characteristics: RG-2661 (IC0374272) has been developed from a semi-wild castor population (Semi-wild-2) collected from Maharashtra through progeny selection followed by pedigree breeding and inbreeding for 12 generations. It is a medium duration (57-67 days to flowering and 123-141 days to maturity), tall plant (104-134 cm) type with very big leaves and thick stem having 18-19 stem nodes; and possessing triple bloom nature.

Associated Characters and Cultivation Practices: RG-2661 was found to be stably resistant to leafhopper (0-1 hopper burn score on 0-4 scale) across locations over years when screened under heavy insect pressure for six years at Hyderabad and for four years at Palem and Yethapur locations while the susceptible checks, DPC-9 and DCH-177 had 4 hopper burn score on 0-4 scale. RG-2661 is identified as a valuable donor for leafhopper resistance to utilize in resistant breeding programmes. It can also serve as base material for developing mapping populations for tagging the gene (s) responsible for leafhopper resistance.

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23. NRCPB rapa 8 (IC374272) (IC0623820; INGR17050), a Yellow Sarson (*Brassica rapa*) Germplasm with Potential as a Parent for Resynthesis of *B.juncea*

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The resynthesis of *B. juncea* is a very cumbersome process involving *in vitro* ovary and embryo culture (Srivastava *et al*., 2004; Bansal*et al.,* 2009; Chatterjee *et al*., 2016) and special technical expertise and laboratory facilities (*in vivo* and *in vitro*), which may not be available with plant breeders. Although low frequency of hybrid seed recovery has been reported in interspecific crosses between *B. rapa* and *B. nigra*, the results are not consistent and depends on genotype combination, environmental conditions and so on (Prakash 1973).

NRCPB *rapa* 8 enables efficient resynthesis of *B. juncea* by bypassing the *in vitro* embryo rescue procedures.NRCPB *rapa* 8 when pollinated with different *B. nigra* genotypes, consistently yields high frequency (about 16 to 42.67 %) of hybrid seeds (amphihaploid). Therefore, it greatly simplifies resynthesis of *B. juncea* and increases the efficiency of hybrid recovery with all accessions of *B. nigra*. Further, this trait can be transferred to other *B. rapa* genotypes to extend the scope of resynthesis with other *B. rapa* accessions. Use of this accession would thus help in creating novel genetic variability in *B. juncea*, that could further be utilized in breeding improved varieties and hybrids.

The material was purified by selecting and intermating plants showing similar agronomic and morphological features from a yellow sarson seed sample which was collected from local market in Kolkata in 1996. Subsequently, uniform, homozygous line was developed by selfing a selected plant. This line is named as NRCPB *rapa* 8.

Morpho-agronomic characteristics and cultural practices: Important agronomic features of NRCPB *rapa* 8 are presented in Table 1. It is a self-compatible, yellow sarson genotype possessing tetralocular silique. It is comparable to other yellow sarson genotypes for reaction to major biotic and abiotic stresses and can be cultivated following standard agronomic practices recommended for other mustard varieties.

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Table 1. Morpho-agronomic characteristics of NRCPB *rapa* 8

Trait	Locule in silique	Days to flowering	Days to flower termination	Days to maturity	Plant height (cm)	No. of siliques on main raceme	No. of primary branches	No. of secondary branches	No. of seeds per silique	1000 seed weight (g)	Oil content (%)	Seed colour
Mean	4	48	70	128	133.9	35.12	16.94	29.78	36.33	3.56	39	Yellow

24. CS 15000-1-2-2-2-1 (IC0624502; INGR17051), an Indian mustard (*Brassica juncea*) Germplasm with High Tolerance to Salinity (ECe 12 dS/m) and Alkalinity (pH 9.4)

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Globally, 932.2 million hectare area is affected with salinity and sodicity stresses (Metternicht and Zinck, 2003), out of which, an area of nearly 6.73 million hectare is affected by these stresses in India (Singh *et al.*, 2014). Indian mustard [*Brassica juncea* (L.) Czern and Coss] is an important oil-seed crop in the world and is grown in more than 50 countries across the globe, which often experiences saline stress as it is grown extensively in the arid and semi-arid regions of the world. Salinity stresses contribute to yield losses and this low economic yield is related to the crop's susceptibility. There is a greater need to improve crop plants for salinity tolerance. Hence, it becomes necessary to develop salt tolerant genotypes in Indian mustard. One of the approaches is the characterization of the available germplasm for identification of tolerant genotypes that provides an initial germplasm base for breeding salt-tolerant crops. Consistent breeding efforts at ICAR-Central Soil Salinity Research Institute (ICAR-CSSRI), Karnal resulted in the development of an improved salt tolerant genotype CS15000-1-2-2-2-1 by crossing two salt tolerant genotypes CS 54 and CS 610-10-1-5 (CS 52: a highly salt tolerant variety; CS 610-10-1-5: a high yielding (Seed and oil) salt tolerant genotype, both developed at ICAR-Central Soil Salinity Research Institute, Karnal). Pedigree method was followed for selection and evaluation of germplasm in salt affected soils for high seed yield and tolerance to soil salinity conditions.

Morpho-agronomic characteristics: On the basis of three year (2013-14 to 2015-16) trials conducted for saline/alkaline conditions in AICRP on Rapeseed and Mustard CS15000-1-2-2-2-1 seed yield of 1840 kg/ha which was 17% and 19% higher than yields of two checks i.e. CS 54 (1566 kg/ha) and Kranti (1552 kg/ha), respectively. It also provided 13% to 16% higher oil yield (721 kg/ha) than Kranti (637 kg/ha) and CS 54 (620 kg/ha). This strain matures, on an average, in 134 days and takes 60 days to flower. The strain attains the height of approximately 171cm and produces high number of primary branches (6), secondary branches (8), main shoot length (70) and 1000 seed weight (5g) (Table 1).

Associated characters and cultivated practices: CS15000-1-2-2-2-1 also showed resistance to Alternaria blight under natural conditions compared to check Rohini, YSB-9 and RTM-314 and also AB severity in pods. Further, CS15000-1-2-2-2-1 also showed much lesser incidence of WR, PM, DM, Stag head and SR compared to check Rohini, EC399301, EC399299 and PHR-2. Under artificial conditions also, similar performance was recorded. Against mustard aphid, data of 26 trails showed lesser average aphid infestation index compared to checks Varuna and at par with CS 54, Kranti and Rohini. CS15000-1-2-2-2-1 responded favorably to the additional doses of fertilizer (NPK). Further 100% RDF was found suitable for this genotype. Looking to its seed and oil yields and disease resistance under high salt stress condition CS 15000-1-2-2-2-1 is being proposed for registration as a national genetic stock/ donor for the development of salt tolerant mustard genotypes to affected soils and water conditions (saline and alkaline) of *Rabi* season in the states of Haryana, Punjab and Uttar Pradesh.

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Table 1. Multi-location performance on important traits like yield and yield components [Locations: Salinity [Agra (ECiw 12 dS/m) Karnal (ECe 10.7 dS/m), Hisar (ECe 10.6 dS/m)]; Alkalinity: Karnal (pH 9.3) and Lucknow (pH 9.4)]

Parameters	Year of testing	Proposed genotype	Check 1	Check 2
		CS15000-1-2-2-2-1	CS 54 (NC)	Kranti (NC)
Mean Seed Yield (Kg/ha)	2012-13	2173	1861	1818
	2013-14	1732	1550	1502
	2014-15	1616	1288	1337
	Mean	1840	1566	1552
Per cent increase (+) or decrease (-) over checks	2012-13		+17	+20
	2013-14		+12	+15
	2014-15		+25	+21
	Mean		+17	+19
Mean Oil Yield (Kg/ha)	2012-13	844	723	706
	2013-14	677	639	683
	2014-15	641	498	523
	Mean	721	620	637
Per cent increase (+) or decrease (-) over checks	2012-13		+17	+20
	2013-14		+6	-1
	2014-15		+29	+23
	Mean		+16	+13
Plant height (cm)	2012-13	169.3	179.4	185.2
	2013-14	160.5	167.2	167.4
	2014-15	183.9	187.5	185.9
	Mean	171.2	178.0	179.5
Main shoot length (cm)	2012-13	71.1	57.2	69.1
	2013-14	64.8	62.4	58.1
	2014-15	74.5	76.3	74.8
	Mean	70.1	65.3	67.3
1000 Seed weight (g)	2012-13	4.8	4.9	4.4
	2013-14	5.2	5.0	4.2
	2014-15	5.1	4.9	4.2
	Mean	5.0	4.9	4.3

[Source – AICRP on R&M Annual Report 2013-14 (Page PB 80, Table 2.3.30a) and 2014-15 (Page PB 75, Table 2.3.33) and 2015-16 (Table 2.3.38a and 2.3.38b, PB 76).

25. Him Stevia (CSIR-IHBT-ST-01) (IC0624505; INGR17052), a Stevia (*Stevia rebaudiana*) Germplasm with Reb-A/Stevioside ratio=1.25; Rebaudioside-A content (%)=7.34; Stevioside content (%)=5.87

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Stevia rebaudiana, a perennial herb of the Asteraceae family, has been recognized worldwide for its excellent sweetening property. Leaves of stevia produce diterpene glycosides (stevioside and rebaudiosides), which are non-nutritive, non-toxic, high-potency sweeteners, 300 times sweeter than sucrose (Tanaka 1982) and substitutes for sugar (Rajasekaran *et al*., 2007). Rebaudioside-A is of particular interest among the glycosides produced in the leaves of stevia because of the most desirable flavour profile (DuBois 2000), while, stevioside is responsible for after taste bitterness. CSIR-IHBT, Palampur has developed a new clonal genotype of *S. rebaudiana* with higher content of rebaudioside-A and reduced content of stevioside for utilization of this source of natural sweeteners.

Morpho-agronomic characteristics: Chemical characterization of stevia genotype 'HIM STEVIA'

(CSIR-IHBT-ST-01) has a desirable glycoside profile, Rebaudioside-A (7.34%), Stevioside (5.87%) and Total glycoside content of 14.49% at Palampur conditions. Him Stevia has been selected based on higher proportion of Rebaudioside-A than stevioside (ratio of Rebaudioside-A to stevioside is ≥1), thereby making a desirable improvement in sweetness profile of the plant.

Associated characters and cultivation practices: The selection has a potential of yielding 3.68 t/ha of dry leaf yield during the second year of production and performed consistently and is vigorous in growth as evaluated in field trials over a period of two years at Palampur location and has excellent nursery performance with respect to rooting and early establishment. It has compact stature and dark green leaves.

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26. CSIR-IHBT-ST-02 (IC0624506; INGR17053), a Stevia (*Stevia rebaudiana*) Germplasm with Delayed flowering by 120 days. Prolonged Vegetative Phase with More number of harvests per year

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Stevia rebaudiana has been recognized worldwide for its excellent sweetening property. Leaves of stevia produce nine diterpene glycosides which are non-toxic, high-potency sweeteners. Stevia is a short-day plant that flowers from January to March in the southern hemisphere and from September to December in the northern hemisphere (Valio and Rocha 1977; Zaidan *et al*., 1980). Mutagenesis is a potential tool to broaden variability and to isolate desirable economic traits in a shorter period compared to conventional breeding procedures. CSIR-IHBT, Palampur has developed a new clonal mutant genotype of *S. rebaudiana* with delayed flowering trait through gamma irradiation which prolong the vegetative phase of the stevia crop.

Morpho-agronomic characteristics: A clonal solid mutant genotype CSIR-IHBT-ST-02 for delayed flowering (prolonged vegetative phase) was identified in stevia population treated with 5kR gamma irradiation at CSIR-IHBT, Palampur. The mutant CSIR-IHBT-ST-02 forms flower buds during the 1st week of January instead of 1st week of September as in case of control (at least 120 days delayed flowering as compared to controlCanada-2-3-1) at Palampur location. The mutant trait is observed to be stable over the years (Fig. 1).

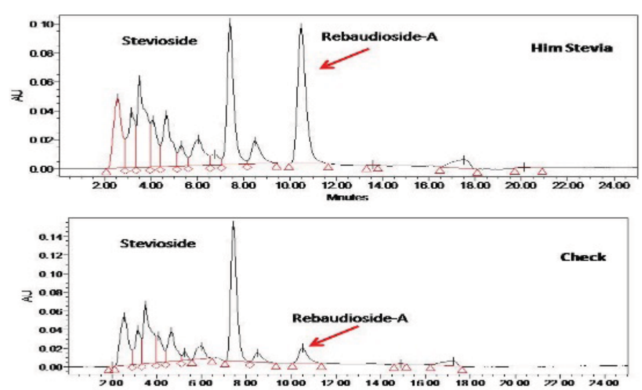

Fig. 1. Representative HPLC chromatogram of leaf samples of genotype 'Him Stevia' (CSIR-IHBT-ST-01) in comparison to check

The glycoside profile of the mutant genotype is given in Table 1.

Associated characters and cultivation practices: This delayed flowering trait in the mutant genotype CSIR-IHBT-ST-02 can prolong vegetative phase of the stevia crop which in turn increase number of harvests resulting in higher foliage yield which is the economic part of the plant.

Table 1. Flower bud initiation and Steviol glycoside profile of Mutant CSIR-IHBT-ST-02 at Palampur location

	Mutant CSIR-IHBT-ST-02			Check (Canada-2-3-1)		
Year	Flower bud initiation	Stevioside (%)	Rebaudioside-A (%)	Flower bud initiation	Stevioside (%)	Rebaudioside-A (%)
2009-10	2nd January	5.30	0.01	1st Sept	5.80	1.30
2010-11	5th January	7.40	0.10	6th Sept	6.70	1.80
2011-12	5th January	7.70	0.80	2nd Sept	6.70	2.00
2012-13	7th January	3.50	0.01	5th Sept	7.00	2.10
2013-14	6th January	8.60	0.10	5th Sept	6.60	2.40
Mean	5th January	6.50	0.20	4th Sept	6.56	1.92

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27. PG-IIIM-101 (IC0624503; INGR17054), a Rose-scented Geranium (*Pelargonium graveolens*) Germplasm with Higher Fresh Foliage, High Oil Content (0.14-0.18%), High Rhodinal Content (66-75%)

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Pelargonium graveolens L'Hér. (Rose-scented geranium; Family-Geraniaceae) is a high value aromatic crop which is cultivated for its essential oil obtained from distillation of above ground freshly harvested shoot/leaf biomass (Ravindra *et al*., 2004). The oil finds extensive use in aromatherapy, flavour and fragrance industry besides being used for the production of a commercial aroma chemical- rhodinol (a mixture of citronellol, geraniol and linalool) which has a wider use in fine grade perfumes (Rajeswara Rao *et al*., 1996, 2002). Rose-scented geranium is a sexually sterile crop due to genome complexity (2n=7x=77) (Lis-Balchin, 2003). Reproductive failure restricts its genetic improvement through conventional breeding methods. In absence of sexuality, we resorted to biotechnological interventions through tissue culture. We employed 'Bourbon' cultivar (Saxena *et al*., 2000; Ravindra *et al*., 2004) as a parental genetic stock for its improvement. Young leaf tissues of 'Bourbon' were used to induce callus formation and subsequently using appropriate plant growth regulators and cultural conditions, totipotentiality of dividing cells was used to regenerate complete plants. Since callus represents mass of proliferating cells which lose control over their growth and as a consequence genetic anomalies creep into the dividing cells. The whole process resulted in the development of deviant *in vitro* phenotypes which were successfully transferred under the field conditions for evaluation of different growth parameters, essential oil content and quality (GC-MS profiling). Among 176 somaclonal regenerants, the variety designated as PG-IIIM-101 was selected on the basis of higher oil content and quality essential oil profile. It was further evaluated at four muilti-locational sites for its stability and quality profile for two growing seasons. The study was conducted at CSIR-Indian Institute of Integrative Medicine, Jammu, India (32°44´ N longitude, 74°55´ E latitude, 304 m asl).

Morpho-agronomic characteristics: Rose-scented geranium is a multi-branched crop that grows 1-1.5 m in height and has a spread of about 1m. Its foliage is fragrant with broad lobed leaves. The lobes are dentate, pubescent with acute apices. The texture of leaves is shiny with cuticular wax.The variety developed (PG-IIIM-101) was evaluated at four locations namely Jammu (32.44° N, 74.55° E, 304 m asl), Pulwama, Kashmir (33.87° N, 74.89° E, 1650 m asl), Bhaderwah

(32.98° N, 75.71° E, 3110 m asl) and Rajouri (33.37° N, 74.31° E, 940 m asl) (J & K state) over two years. The comparative data of yields at different locations is provided in Table 1.

Associated characters and cultivated practices: The variety developed (PG-IIIM-101) is superior to parental genetic stock 'Bourbon' in terms of oil content (0.14-0.18%), essential oil profile (citronellol: 36.9-42.5%, linalool: 14.4-16.7%, geraniol: 15.6-19.9%, geranyl formate: 5.6-7.8%, γ-eudesmol: 1.3-1.9%) and fresh herb yield (1170-1430 g/plant). It shows wider range of adaptability as it can be grown as a short duration winter crop under sub-tropical Jammu conditions (November-April) and as a summer crop under temperate conditions of Kashmir and Bhaderwah (April-September). During cultivation experiments and muilti-locational trials, there was no incidence of any disease or insect-pest infestation. It grows in well drained, light to medium textured sandy loam soils having pH 5.0–8.5. It is cultivated vegetatively through terminal cuttings of 10-15cm long. A light irrigation at the time of planting is necessary for the establishment of cuttings. The crop is planted with inter-row spacing of 60 cm and intra row spacing of 70 cm. Decomposed farm yard manure (FYM) at the rate of 7-8 tonnes/ha is recommended before planting the crop. During growing season 2-3 irrigations are required. The crop matures in 160-170 days and the optimum stage of harvest in relation to essential oil quality and quantity is coincident with flowering stage. Fresh biomass is steam distilled for 2-3 hours using 1-2 kg/cm^2 steam pressure. The oil is stored in air tight aluminium or amber-coloured glass containers, capped tightly and kept in cool and dark place.

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Table 1. Comparative multilocational evaluation of yield and yield components of Rose-scented geranium (PG-IIIM-101) in comaprison to parental genetic stock*

Location/ Coordinates	Plant height (cm)	Plant spread (cm)	No. of branches/ plant	Herbage yield/ plant (g)	Oil content (%)	Herbage yield/ ha (Tonne)	Oil yield/ha (kg)
CSIR-IIIM (Jammu) 32. 44° N, 74. 55' E, 304 m asl	120-150 x̄ 135.70; SD ±18.38	95-105 x̄ 100.30; SD 6.36	31-39 x̄ 36.60; SD ±2.83	1170-1430 x̄ 1320.57; SD ±77.66	0.14-0.18 x̄ 0.15; SD ±0.015	35-36 (31-32)	40-42 (28-30)
	*105-125 x̄ 118.18; SD ±11.31	87-100 x̄ 98.80; SD 4.94	24-33 x̄ 28.09; SD ±5.65	1120-1280 x̄ 1183.18; SD ±48.08	0.10-0.12 x̄ 0.11; SD ±0.009		
Pulwama (Kashmir) 33.87° N, 74.89° E, 1650 m asl	107-142 x̄ 126.50; SD ±14.85	92-100 x̄ 96.40; SD 4.24	32-36 x̄ 33.80; SD ±0.70	1130-1340 x̄ 1234.00; SD ±74.44	0.14-0.16 x̄ 0.15; SD ±0.009	33-34 (31-32)	39-40 (32-33)
	98-118 x̄ 108.00; SD 9.19	89-104 x̄ 94.70; SD 4.23	31-35 x̄ 33.10; SD ±0.69	1110-1220 x̄ 1158.20; SD ±378.96	0.10-0.12 x̄ 0.11; SD ±0.007		
Bhaderwah 32.98° N, 75.71° E, 3110 m asl	93-122 x̄ 108.60; SD 14.85	80-98 x̄ 94.00; SD 9.19	31-35 x̄ 33.40; SD ±1.41	1045-1260 x̄ 11769.50; SD ±80.84	0.13-0.18 x̄ 0.15; SD ±0.017	31-32 (28-29)	38-39 (25-26)
	85-112 x̄ 109.00; SD 12.72	76-93 x̄ 84.00; SD 4.24	26-32 x̄ 28.60; SD ±2.12	980-1120 x̄ 1049.30; SD ±40.69	0.10-0.12 x̄ 0.11; SD ±0.008		
**BGSBU Campus (Rajouri) 33.37° N, 74.31° E, 940 m asl	63-78 x̄ 71.20; SD 8.48	72-83 x̄ 79.30; SD 5.65	18-25 x̄ 22.10; SD ±4.24	690-810 x̄ 748.00; SD ±41.85	0.08-0.10 x̄ 0.09; SD ±0.008	20-21 (17-18)	14-15 (11-12)
	60-72 x̄ 67.20; SD 3.53	65-76 x̄ 69.80; SD 6.36	18-23 x̄ 19.71; SD ±0.71	540-780 x̄ 649.00; SD ±74.94	0.07-0.09 x̄ 0.08; SD ±0.007		

*Data shown for parental genetic stock 'Bourbon' as control.

**BGSBU Campus, Rajouri is not recommended for commercial cutivation of Rose-scented geranium (PG-IIIM-101) due to its poor performance.

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28. DPO-9 (IC0623443; INGR17055), an Extended Bract Mutant of Isabgol (*Plantago ovata*)

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Isabgol is a wonderful bulking fiber for constipation besides it is used for treatment of diarrhea, constipation, and hemorrhoids. India is the sole exporter of this crop in the world market and earns considerable foreign exchange every year. It is also an excellent source of dietary fiber and has hypocholaesterolemic activity and is widely accepted as food additive in several processed materials like cookies, ice-cream, bread, and others (Trautwein *et al.,* 2000). It is being cultivated in arid and semi-arid regions of Gujarat, Rajasthan and parts of Madhya Pradesh as rainfed *rabi* crop (November to March) with supplementary irrigations and harvested at 110-120 days after sowing. Being an introduced crop from Mediterranean region, the genetic variability available in this crop is low and collection from foreign countries is becoming very difficult due to strict IPR regime. Hence, the additional variability has to be obtained either through mutation or by inter-varietal/inter-specific crosses. Even to develop the DUS guidelines, the number of descriptors available is very low. It is always desirable to have morphological characters that are easily identifiable before the flower opening/anthesis. Such markers will not only help in identifying the true to type plant and its maintenance, it also useful as development of high yielding varieties with distinct morphological characters. In this direction DMAPR has developed DOP 9, an isabgol mutant with a distinct morphological maker, extended bract.

Single plant with extended bract was identified and isolated in M_2 generation of DES treated Isabgol cultivar GI-2. It was self pollinated and advanced to next generation. In M_3 generation, it was bred true. It was advanced for few more generations and its extended bract marker trait was confirmed in the M_4 to M_7 generations. The distinct characters of DPO 14 in comparison with its parent GI-2 is presented in the Table 1.

DOP 9 mutant will be useful in many ways: i) it can be used as marker character for DUS guidelines, ii) as it is a qualitative trait, it can be used to study the inheritance pattern of extended bract, and iii) it can also used to develop high yielding varieties with this important marker that can be identified during pre-flowering stage to produce genetically pure seeds.

Table 1. Morphological description of Isabgol mutant DPO 9 as compared to its parent GI-2 (As per DUS guidelines of Isabgol)

Characteristics	DPO 9	GI-2 (Parent)
Leaf: Colour	Green	Green
Leaf: Pubescence	Medium	Medium
Leaf : Breadth (cm)	Medium (1.00 to 1.40)	Medium (1.00 to 1.40)
Plant: Growth habit	Drooping (Caespitose)	Drooping (Caespitose)
Plant: Height (cm)	Medium(35-50)	Medium(35-50)
Plant: Number of branches	Medium (5-15)	Medium (5-15)
Spike: Arrangements	Compact	Compact
Spike : Peduncle	Unbranched	Unbranched
Anther: Appearance	Normal	Normal
Peduncle: Axis	Partially filled	Partially filled
Spike: Flower arrangement	Compressed	Compressed
Spike: Length (cm)	Medium (3-7)	Medium (3-7)
Spike: Number	Medium (50-100)	Medium (50-100)
Spike: Number of seed bearing spikes	Medium (50-100)	Medium (50-100)
1000 seed weight (g)	Medium (1.6-1.8 g)	Medium (1.6-1.8 g)
Flower: Bract	Extended	Normal

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29. DWS-37 (IC0623444; INGR17056), an Ashwagandha (*Withania somnifera*) Germplasm with Revolute Rolled Leaves

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Ashwagandha is an erect, evergreen, perennial shrub belongs to the family *Solanaceace*. Ashwagandha native to Indian sub-continent is also known as 'Indian ashwagandha' and the roots are compared with Chinese ginseng (*Panax ginseng*) roots for their restorative properties. Breeding efforts in India has led to development of high yielding varieties viz., JA20, JA134, JA100 from Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya (RSVKVV), Mandsaur, Madhya Pradesh, India, AWS-1 from Anand Agricultural University (AAU), Anand, Gujarat and Rakshita and Poshita from the CISR-Central Institute for Medicinal and Aromatic Plants (CIMAP), Lucknow, India. Pure lines form an important genetic resource for improvement of yield and quality. All the varieties are havening normal leaves, where no rolling of leaf lamina has been observed. For the first time, DWS-37, a pure line selection with revolute leaf rolling (leaf lamina rolled downwards or towards the abaxial surface) was identified at the Directorate of Medicinal and Aromatic Plants Research, Anand, Gujarat (Table 1). A single plant selection with revolute leaf rolling phenotype as against the normal (no rolling) was selected during 2007 from open pollinated natural population of ashwagandha variety, JA 134 and was advanced through plant-to-row progeny by repeated selfing every year and a pure line (DWS 37) with revolute (rolled downwards or towards the abaxial surface) leaves was obtained. DWS 37 is stable, uniform and distinct and hence, may be used as an important allelic source to unravel genetics of leaf rolling in Ashwagandha. Further, this trait can be used as DUS character for identification of elite germplasm lines and cultivars. As the trait can be easily identified during the vegetative stage, it helps in early generation selection of some of important quantitive traits.

Table 1. Morphological description of ashwagandha DWS-37 a revolute leaf rolling genetic stock

Characteristics	JA 134 (Parent)	DWS-37
Plant height	Medium (60-80 cm)	Tall (90 cm)
Stem types	Erect	Semi-Errect
Number of branches from base	A few	A few
Branch position	Acrocaulous	Acrocaulous
Branch arrangement	Less diverge	medium
Leaf orientation (Transverse posture)	Geniculate	Straight
Leaf orientation (longituditional)	Conduplicate	Straight
Leaf colour (Young leaves)	Green	Light green
Lamina length (cm)	Medium	Medium
Lamina width (cm)	Narrow	Medium
Leaf shape	Elliptic	Elliptic
Leaf base	Attenuate	Oblique
Leaf margin	Undulate; medium wavy	Undulate; medium wavy
Leaf apex	Obtuse	Acute
Leaf rolling	Normal (no rolling)	Revolte (leaf lamina rolled downwards or towards the abaxial surface)
Lamina abaxial surface	Less hairy	Less hairy
Lamina adaxial surface	Less hairy	Less hairy
Petiole	Less hairy	Glaborous
Midrib surface	Less hairy	Less hairy
Stem internodes length	Short	Short
Stem surface	Less hairy	Medium hairy
Flower: pedicel length	Short	Short
Flower: corolla colour	Pale yellow	Pale yellow
Berry colour	Yellow	Yellow
No. of berries/plant	Medium	Medium
No. primary roots	Medium (4-6)	More (more than 7)
Root length (cm)	15-25	15-20
Withanolide-A content	Low (0.390 mg g^{-1} dry weight)	Low (0.259 mg g^{-1} dry weight)

Table 4. Quality profile of roots of DWS-37 and JA-134 during 2014-15

Acc.	Replications	Withaferin-A (ug/mg)	12-deoxy-withastramanolide (ug/mg)	Withanolide-A (ug/mg)
DWS-37	R1	1.847	0.240	0.260
	R2	1.685	0.234	0.258
	R3	1.668	0.230	0.260
	Mean	1.733	0.235	0.259
	Stdev.	0.099	0.005	0.001
JA-134	R1	0.057	0.206	0.394
	R2	0.070	0.205	0.388
	R3	0.075	0.207	0.389
	Mean	0.067	0.206	0.390
	Stdev.	0.009	0.001	0.004

30. DWS-127 (IC0623445; INGR17057), an Ashwagandha (*Withania somnifera*) Germplasm with Yellow Young Leaves

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Ashwagandha (*Withania somnifera* (L.) Dunal) (*Solanaceae*) is an important medicinal plant widely used as an antioxidant, adaptogen, aphrodisiac, anti-inflammatory agent and recently proved to combat against ulcers, arthritis, venom toxins and cancer like diseases. Four varieties *viz.*, JA 20, JA 134 RAV 100 and AWS-1) have been released and being cultivated by farmers. All varieties are having normal green colour leaves. For the first time, a selection with yellow young leaves (DWS-127) was identified at the Directorate of Medicinal and Aromatic Plants Research, Anand, Gujarat. DWS-127 bears yellow young leaves as against normal green leaves. DWS-127 bears yellow young leaves turn to normal green leaves up on leaf maturity (Table 1). A single plant selection with yellow colour young leaves as against the normal green leaves was selected from open pollinated natural population of ashwagandha variety, JA 134 during 2007 and was advanced through plant-to-row progeny by repeated selfing every year and a pure line (DWS 127) with yellow young leaves was obtained. DWS-127 is stable, uniform and distinct and hence, may be used as an important allelic source to unravel genetics of leaf color in Ashwagandha. Further, this trait can be used as DUS character for identification of elite germplasm lines and cultivars. DWS-127 may be useful to study epigenetics of chlorophyll biosynthesis in plants.

Table 1. Morphological description of ashwagandha DWS-127 a yellow young leaf pure line observed during 2014-15 at ICAR-DMAPR, Anand

Characteristics	JA 134 (Parent)	DWS-127
Plant height	Medium (60-80 cm)	Medium (60cm)
Stem types	Erect	Erect
Number of branches from base	A few	A few
Branch position	Acrocaulous	Acrocaulous
Branch arrangement	Less diverge	Less diverge
Leaf orientation (Transverse posture)	Geniculate	Geniculate
Leaf orientation	Conduplicate	Conduplicate
Leaf color (Young leaves)	Green	Yellow
Leaf color (Mature leaves)	Green	Green
Lamina length (cm)	Medium	Medium
Lamina width (cm)	Narrow	Narrow
Leaf shape	Elliptic	Elliptic
Leaf base	Attenuate	Attenuate
Leaf margin	Undulate; medium wavy	Undulate; medium wavy
Leaf apex	Obtuse	Obtuse
Lamina abaxial surface	Less hairy	Less hairy
Lamina adaxial surface	Less hairy	Less hairy
Petiole length	Less hairy	Less hairy
Midrib surface	Less hairy	Less hairy
Stem internodes length	Short	Short
Stem surface	Less hairy	Less hairy
Flower: pedicel length	Short	Short
Flower: corolla colour	Pale yellow	Pale yellow
Berry colour	Yellow	Yellow
No. of berries/plant	Medium	Medium

31. IIHR Musa Hybrid (Cal4X M.r) (IC0395101; INGR17058), a Banana (*Musa spp.*) Inter-specific Hybrid with Intermediate Characters, Flowers (Inflorescence) Bright & Semi Erect. Intermediate Height with Broad Leaves (can be used for leaf production)

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Bananas have evolved in nature by inter-specific hybridization (Simmonds 1962) and mutations combined with development of parthenocarpy and seedless nature. Hence they are difficult to breed, but continuous efforts by the breeders has helped in identifying the desirable hybrids in countries like Honduras, France, Nigeria, Uganda, Brazil etc. It is important to develop intermediate diploid hybrids with desirable characters which can help in further breeding. We at IIHR are involved in developing mapping populations which can help in functional genomics studies under NPTC. *Musa acuminata* ssp. *burmannica* (Calcutta-4) of section Eumusa, is a breeders favorite wild species which is resistance to black leaf streak and sigatoka leaf spot, several races of Fusarium wilt and partially resistant to *Radopholus similis* and other nematodes. Morphologically this subspecies has waxless foliage, light brown markings on the pseudostem and compact pendulous bunch with purple bracts (Promusa website). It is known to be male and female fertile. *Musa rubra* of section Rhodochlamys (Cheesman, 1947) is a dwarf plant highly sensitive to availability of water and humidity normally found in North Eastern Hilly regions of India which produces erect bunch with attractive orange bracts the fruits are very small full of seeds. It is generally referred as ornamental banana. Both species have basic chromosome number of n=11. A cross was made between Calcutta-4 (female parent) and *M.rubra* (pollen parent).

Morpho-agronomic characteristics: The proposed hybrid will be useful as a genetic stock in the breeding programs as a source of dwarf genes as it is showing intermediate chracteristics. It can be grown in all banana growing areas.

Associated characteristics and cultivation practices: Interestingly the hybrids are dwarf, have green broad foliage like the female parent Calcutta-4 and bright orange semi erect inflorescence like resembling *Musa rubra*. Hybrids can be used for leaf purpose as well as ornamental purpose. The hybrid nature was confirmed by molecular analysis.

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Table 1. Morphological characters among parent and hybrid of IIHR *Musa* hybrid (*Musa acuminata* ssp. *burmannica* (Calcutta-4) X *M.rubra*)

F_1/parents	Plant height(M)	Girth (Cm)	No. suckers	No. Leaves	Leaf Length (Cm)	Leaf Breadth (Cm)	Bunch Length (Cm)	Bunch type	No. Hands	No. Fingers
P1-Calcutta4 (Female)	1.43	11.0	5	3	144.0	56 .0	18.4	Horizontal (Deep Purple)	4 .0	54
P2-*M. r.* (Male)	0.44	2.0	1	4	66.0	20.0	7.0	Erect (Bright Orange)	2.0	15
F1 Hybrid	1.14	7.42	5.5	5.25	98.8	30.2	12.63	Semi- erect (Orange)	4.25	48.58

32. IIHR2-47 (IC0623437; INGR17059), a Chrysanthemum (*Dendranthema grandifloruim*) Germplasm with Flower Colour: 77.B, Purple Group, Fan 2. Stellate Ray Florets (Cylindrical shape)

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Chrysanthemum is one of the most important flowering plant commercially grown for cut flowers, garden display, floral arrangements and pot culture. It belongs to the family Asteraceae. The selection IIHR2-47 is derived from cv. Pink Cloud through half-sib selection and it was developed at ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka (13^o 58' N Latitude, 78^{o}E Longitude and at an altitude of 890 meter above mean sea level), India. IIHR2-47 is unique for flower colour (77.B, Purple group, Fan 2) and Stellate ray florets (cylindrical shape).

Morpho-agronomic characteristics: Plants are tall (51.75 cm), semi-spreading (48.27 cm) and takes 82.56 days for flower bud appearance. It produces average 17.03 branches and 78.77 flowers per plant. Its flower diameter is 4.77 cm and flowering duration 31.87 days. It has vase life of 5.97 days (Table 1).

Associated characters and cultivation practices: Chrysanthemum is commercially propagated through terminal cuttings and suckers. It grows well in sandy loam soil rich in organic matter and nutrients with pH of 6.5 to 7.2. Healthy uniform rooted cuttings are planted at spacing of 30 cm x 30 cm during March-April under Bangalore condition. Pinching of terminal growing portion is practiced after 30 to 40 days of transplanting. In general, recommended dose of fertilizer is 8-10 tones of farmyard manure, 50 kg N, 160 kg P_2O_5 and 80 kg K_2O per hectare as basal dose (Janakiram and Rao, 2004). The crop is to be irrigated once or twice in a week depending upon the soil and weather conditions. The major insect pests of chrysanthemum are caterpillar, mealy bug, leaf miner and thrips.

Table 1. Morpho-agronomic description of chrysanthemum half-sib selection IIHR2-47

Trait Description	Pooled data of three years
Plant height (cm)	51.75
Number of branches per plant	17.03
Plant spread (cm)	48.27
Days taken to first bud appearance	82.56
Number of flowers per plant	78.77
Diameter of flower head (cm)	4.77
Average weight of single spray (g)	35.98
Duration of flowering (day)	31.87
Vase life (day)	5.97
Flower colour (R.H.S. colour chart)	77.B, Purple group, Fan 2
Type of flower	Stellate (cylindrical ray florets)

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Janikiram T and TM Rao (2004) Chrysanthemum. Technical Bulletin 26. Director, IIHR, Hesaraghatta, Bangalore. pp. 7.

33. IIHR5-23 (IC0623438; INGR17060), a Chrysanthemum (*Dendranthema grandifloruim*) Germplasm with Flower Colour: 162.D, Gray Yellow Group, Fan 4. Stellate Ray Florets (Cylindrical shape)

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Chrysanthemum is one of the most important flowering plant commercially grown for cut flowers, garden display, floral arrangements and pot culture. It belongs to the family Asteraceae. The selection IIHR5-23 is derived from cv. Red Stone through half-sib selection and it was developed at ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka (13^{o}58´ N Latitude, 78^o E Longitude and at an altitude of 890 meter above mean sea level), India. IIHR 5-23 is unique for flower colour (162.D, Gray yellow group, Fan 4) and Stellate ray florets (Cylindrical shape)

Morpho-agronomic characteristics: Plants are medium (41.02 cm), erect (20.33 cm) and takes 48.00days for flower bud appearance. It produces average 12.78 branches and 80.39 flowers per plant. Its flower diameter is 4.02 cm and flowering duration 22.29 days. It has vase life of 4.92 days (Table 1).

Associated characters and cultivation practices: Chrysanthemum is commercially propagated through terminal cuttings and suckers. It grows well in sandy loam soil rich in organic matter and nutrients with pH of 6.5 to 7.2. Healthy uniform rooted cuttings are planted at spacing of 30 cm x 30 cm during March-April under Bangalore condition. Pinching of terminal growing portion is practiced after 30 to 40 days of transplanting. In general, recommended dose of fertilizer is 8-10 tones of farmyard manure, 50 kg N, 160 kg P_2O_5 and 80 kg K_2O per hectare as basal dose. The crop is to be irrigated once or twice in a week depending upon the soil and weather conditions. The major insect pests of chrysanthemum are caterpillar, mealy bug, leaf miner and thrips.

Table 1. Morpho-agronomic description of chrysanthemum half-sib selection IIHR5-23

Trait Description	Pooled data of three years
Plant height (cm)	41.02
Number of branches per plant	12.78
Plant spread (cm)	20.33
Days taken to first bud appearance	48.00
Number of flowers per plant	80.39
Diameter of flower head (cm)	4.02
Average weight of single spray (g)	28.42
Duration of flowering (day)	22.29
Vase life (day)	4.92
Flower colour (R.H.S. colour chart)	162.D, Grayed-yellow group, Fan 4
Type of flower	Stellate (cylindrical ray florets)

References

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34. VMT 5-1 (IC0623450; INGR17061), a Meiotic Tetraploid (MT) Potato (*Solanum tuberosum*) with 2× Genome from Semi-Cultivated Species *S. verrucosum* and other 2× from Cultivated Potato cv. K. Lalima. Highly Resistant to Late Blight. Performs Well Under Short & Long Day Conditions

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Pre-breeding strategy was employed at Central Potato Research Institute, Shimla for transferring late blight resistance from diploid, resistant, wild/ semi-cultivated *Solanum spp.* into cultivated potato cultivars through production of meiotic tetraploids (MTs) by unilateral sexual polyploidization (USP) scheme. The MTs (VMT-series) were developed following hybridization between resistant diploid Verrucosum Derived Selections (VDS clones) and susceptible tetraploid commercial cultivars. The MTs were screened for field resistance to late blight by detached leaf method following challenge inoculation with complex races of *P. infestans* in the lab and under natural field conditions at Kufri and Modipuram (Kaushik *et al*., 2008). Based on agronomic performance and late blight resistance, promising MTs including VMT 5-1 were used as parental lines in the late blight breeding programme. VMT 5-1 is one diverse tetraploid parent with fertile pollens and is being exploited in the hybridization. VMT 5-1 is one of the parents in three F_1C_3 clones viz., SM/11-77, SM/11-79 and SM/11-109 possessing high late blight resistance.

Before multi-location trials, VMT 5-1 was evaluated for 4 years at Kufri for total tuber yield and late blight resistance. The hybrid consistently out-yielded all the controls for total and marketable tuber yields at 100 days crop duration. The hybrid possesses consistently high level of resistance against late blight over the years.

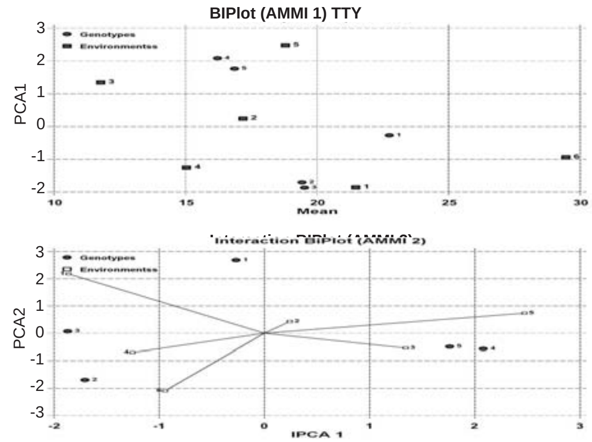

Fig. 1. Bi-plot (AMMI) for total tuber yield. Genotypes: 1:SM/00-42, 2:SM/00-120, 3: VMT 5-1 and controls viz., 4: K. Himalini, 5: K. Jyoti. Environments: 1:Hassan 2:Kufri 3: Ooty 4: Ooty (HSN) 5: Ranichauri 6: Srinagar.

Hybrid, VMT 5-1 had the 2nd highest stability and mean total tuber yield among evaluated genotypes in multi-location trials under AICRP (P) (Fig. 1). Besides, all the 3 late blight resistant hybrids, including VMT 5-1 had either higher or at par resistance to the best controls at Kufri, Ooty (ARS, Hassan), Pune, Ranichauri and Srinagar (AICRP-Potato Annual Report, 2015-16).

Till date, CPRI has developed and deployed 53 commercial cultivars suitable for growing under different eco-geographical locations. None of the present potato variety released by CPRI Shimla possesses widely diverse genes from *S. verrucossum*, therefore VMT 5-1 can serve as a boon in future breeding programmes for ensuring diversity and late blight resistance.

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35. Crd-6 (IC0623449; INGR17062), a Meiotic tetraploid, Somatic Male Fertile Hybrid potato (*Solanum tuberosum* (+) *S. cardiophyllum*) Carrying Resistance to Late Blight Introgressed from Wild Species *S. cardiophyllum*

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Solanum cardiophyllum Lindl. (PI 341233) (2n = 2x = 24, 1EBN) is a diploid wild potato species highly resistant to late blight, the most serious disease of potato. However, it poses a problem of sexual incompatibility with common potato. So to circumvent this problem, in this study, we developed interspecific potato somatic hybrids between cultivated *S. tuberosum* dihaploid C-13 and wild species *S. cardiophyllum* via protoplast fusion. Out of 26 regenerants, only 4 were confirmed as true somatic hybrids containing both parental genomes based on molecular markers and phenotypes. Somatic hybrids were identified by RAPD, ISSR, SSR, AFLP and cytoplasm (chloroplast and mitochondrial genomes) type molecular markers. Intermediate phenotypes of somatic hybrids were confirmed by leaf, flower and tuber traits. Late blight resistance of the hybrids was assessed by challenge inoculation of *P. infestans* under controlled conditions. Somatic hybrids were found tetraploid by FC analysis, exhibited high pollen stainability by acetocarmine staining and formed berries and viable seeds after crossing with a common potato variety. Somatic hybrids possessed diverse cytoplasm types (W/α, W/γ and T/β) as assessed by chloroplast and mitochondrial genome-specific markers. Further, cluster analysis generated based on the Jaccard's coefficient of molecular profiles generated by all above markers showed genetic distinctness in somatic hybrids and parents. Taken together, these interspecific somatic hybrids with diverse cytoplasm background have potential to employ in potato breeding programmes to widen the cultivated gene pool through conventional and molecular methods.

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36. MS/6-1947 (IC0623447; INGR17063), a Drought Tolerant Advanced Potato Hybrid (*Solanum tuberosum*) with Good Keeping Quality and High Tuber Yield

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Potato is a drought sensitive crop and the detrimental effects of water stress on potato tuber yield and other related traits are well known. Water deficit is responsible for decreased number of leaves, plant water potentials, leaf area, plant height, ground coverage and tuber number which ultimately culminate in to tuber yield reduction. Identification of drought tolerant genotypes for yield maintenance and breeding purposes is need of hour to increase drought tolerance of the potato crop, saving irrigation water and ensuring yield and food security in changing scenario of global climate and growing demand of water.

Morpho-agronomic characters: In initial investigation during winter crop season (2007-2008), segregating population of cross MS/82-638 x JX 576 were evaluated under reduced irrigation regimes (only three irrigations as against 5-6 irrigation during 90 days crop duration) and promising clones MS/6-1947 was identified for its better yielding ability under reduced water regime. The clone MS/6-1947 successfully passed through initial evaluation clonal generations. Subsequently in three advanced generation yield trials during 2009-2011 at Modipuram, the MS/6-1947 produced significantly higher total tuber yield than the best control Kufri Pukhraj by margin of 15% at 80 days (2009-10). The germplasm with 39 t/ha tuber yield showed yield advantage of 33%, 11% and 18% over controls Kufri Bahar (29 t/ha), Kufri Pukhraj (35 t/ha) and Kufri Sadabahar (33 t/ha) respectively at 75 days. At 90 days, the germplasm with 52 t/ha tuber yield exhibited yield advantage of 49%, 13% and 21 over controls Kufri Bahar (35 t/ha), Kufri Pukhraj (46 t/ha) and Kufri Sadabahar (43 t/ha) respectively.

Under drought tolerance trials (2010-2013) at Modipuram, MS/6-1947 outperformed under normal irrigation, mild deficit irrigation and severe drought conditions as compared to the best control Kufri Pukhraj as yield reduction was comparatively lower in MS/6-1947 under mild deficit and severe drought conditions. In this trial, MS/6-1947 produced significantly high marketable (29.7 t/ha, 19% higher) and total tuber (32.1 t/ha, 21% higher) yield than the best control Kufri Pukhraj (24.9 and 26.6 t/ha) under severe drought conditions. MS/6-1947 yielded 25% higher marketable and 22% higher total tuber yield under severe drought conditions in comparison to Kufri Bahar, the popular variety of the region having comparable tuber dry matter. The germplasm also possessed high drought tolerance index ie 1.02 and 0.79 under mild and severe drought respectively as compared to Kufri Pukhraj (0.85 and 0.58) and Kufri Bahar (0.79 and 0.51).

In drought tolerance trials (2012-2015) at Jodhpur, MS/6-1947 outperformed under normal irrigation and mild water deficit than best control Kufri Pukhraj as yield reduction was comparatively lower in MS/6-1947 under mild water deficit. In this trial, MS/6-1947 produced significantly high marketable (27.8 t/ha, 13% higher) and total tuber (29.4 t/ha, 4% higher) yield than the best control Kufri Pukhraj (24.6 and 28.3 t/ha) under mild water deficit. The MS/6-1947 yielded 73% higher marketable and 62% higher total tuber yield under mild water deficit in comparison to Kufri Surya, the heat tolerant variety. The germplasm also possessed high drought tolerance index (1.08) under mild drought as compared to control Kufri Pukhraj (1.00) and Kufri Surya (0.41) at Jodhpur.

Under early planting conditions (2010), MS/6-1947 with total tuber yield (18 t/ha) out yielded the controls like Kufri Pukhraj (14.72 t/ha) and heat tolerant variety Kufri Surya (12.85 t/ha).by margin of 23% and 41% respectively.

Associated characters and cultivation practices: The germplasm possessed good keeping quality and moderate level of late blight resistance. MS/6-1947 produces 9 to 10 medium sized attractive light white cream ovoid tubers with shallow eyes and cream flesh colour. Its tubers are easy to cook (15-20 minutes) and cooked/boiled potatoes are free from discolouration. It possesses pleasant flavour and mealy texture. The above results indicates that the germplasm MS/6-1947 can be good choice for integration in cereal based cropping sequences, for its exploitation as early/short duration crop and for attaining sustainable productivity in areas where water is limiting factor for raising the successful potato crop. This elite genetic stock can be well used in breeding progarmmes aiming high productivity under abiotic stress conditions.

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37. MS/8-1565 (IC0623448; INGR17064), a Purple Skin Coloured Advanced Potato Hybrid (*Solanum tuberosum*) with Very Good Keeping Quality and High Tuber Yield

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In India, mostly white/yellow skin or flesh coloured potatoes are preferred, however red skinned potatoes are liked in eastern part of India and Jammu & Kashmir. Coloured potato originates from the accumulation of pigments, i.e. carotenoids and anthocyanins (antioxidants). Coloured potatoes are liked by people to add colour and taste/interest to their meal.

Morpho-agronomic characters: The concerted breeding efforts at Central Potato Research Institute, led to development and identification of purple skin coloured germplasm MS/6-1565 from the segregating population of MS/89-1095 x CP3290 during 2007-08 rabi crop season. The germplasm successfully passed through initial clonal generations and based on consistence performance in advanced stage replicated trials, MS/8-1565 has been introduced in AICRP for multi-location testing. The germplasm is suitable for specialty sector and produced higher tuber yield (36.80 t/ha) than Kufri Arun (31.42 t/ha), Kufri Lalima (30.71 t/ha), Kufri Sindhuri (26.14 t/ha), Kufri Bahar (31.79 t/ha) at 75 days). Its yield advantage was 17%, 20%, 41% and 16% over Kufri Arun, Kufri Lalima, Kufri Sindhuri and Kufri Bahar, respectively. At 90 days, MS/8-1565 produced higher tuber yield (42.81 t/ha) than Kufri Lalima (39.64 t/ha), K Sindhuri (36.32 t/ha), Kufri Bahar (38.10 t/ha). Its advantage was of 8%, 18% and 12% than Kufri Lalima, Kufri Sindhuri and Kufri Bahar, respectively.

Associated characters and cultivation practices: It is medium maturing and produces attractive unique purple coloured ovoid tubers with shallow eyes and yellow flesh colour. MS/8-1565 possesses moderate 18-19% tuber dry matter, very good keeping quality and moderate resistance to late blight than Kufri Bahar at Modipuram. It has mealy texture, very good flavor & taste and free from discolouration after cooking. The germplasm is suitable for specialty sector due to its unique purple attractive purple ovoid shallow eyed tuber which leads to less peeling losses than Kufri Lalima and Kufri Sindhuri. The tubers of MS/8-1565, seldom exhibits external/internal defects and are not susceptible to skin damage at harvest. The new germplasm MS/8-1565 with unique purple skin colour will add to new colour in meal and develop increased interest of consumers for potatoes thereby expanding the promotion of potatoes. This elite genetic stock can be well used in breeding progarmmes for developing varieties with variable colour combinations having high nutritional values.

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38. MP/6-39 (IC0623446; INGR17065), an Advanced Potato Hybrid (*Solanum tuberosum*) for Processing with Excellent Keeping Quality and High Tuber Yield

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In India, out of total potato production, about 68% are utilized for table purpose, 7.5% for processing; 8.5% for seed and remaining 16% produce goes waste due to pre and post-harvest handling. Potato is a perishable commodity and its harvest time (Feb/March) in subtropical plains coincides with steep rise in temperature. Therefore, the potato has either to be consumed within a short period or is required to be shifted to the cold stores. Diversification of potato consumption was widely discussed as a tool for avoiding situation of potato over-production. High yielding varieties with multipurpose uses as table and processing purpose with ability to withstand under country store or ambient conditions for 60-75 days can be another tool to minimize the post-harvest losses. Breeding efforts in this direction led to identification of advanced stage hybrid MP/6-39 with high yield, excellent organoleptic, processing and keeping quality attributes. The hybrid derived from cross Kufri Himsona × Kufri Pukhraj during 2006 possesses moderate-high tuber dry matter with low reducing sugars and acceptable chip/fry colour.

Morpho-agronomic characters: Based on the mean performance in five states (Uttar Pradesh, Punjab, Gujarat, West Bengal and Madhya Pradesh), the hybrid MP/6-39 produced 28% higher processing grade (37 t/ha) and 22% total tuber yield (43 t/ha) than the best control Kufri Chipsona-3 (29 and 35 t/ha) at 90 days after planting. It produced 38% higher processing grade (37 t/ha) and 34% total tuber yield (43 t/ha) than the French fry control variety Kufri Frysona (27 and 32 t/ha) at 90 days after planting. The hybrid possessed 18-20% tuber dry matter content and its fry colour was in acceptable range (2.8) as compared to Kufri Chipsona-3 (2.7) and Kufri Frysona (2.5).

Associated characters and cultivation practices: The hybrid produces attractive white cream, ovoid tubers with shallow eyes and cream flesh. The hybrid possesses moderate resistance (AUDPC 290) to late blight as compared to most susceptible variety Kufri Bahar (AUDPC 750) during 2013-2015 at Modipuram. It has waxy texture, pleasant flavour and excellent organoleptic taste on boiling. Results on storage behaviour over three year (2014-16) revealed that advanced hybrid MP/6-39 have long dormancy period as it did not sprout even after 75 days of storage and also have minimum total weight loss (9.6%) as compared with Kufri Chipsona 3 (17%) and Kufri Frysona (11%). The produce of MP/6-39 can be exported to long distances owing to its long dormancy period and excellent keeping quality. The superior organoleptic and processing attributes of MP/6-39 makes the hybrid multi-purpose for use as table purpose in cooler regions and for chips/French fries in warmer region of the country. The multi-purpose advanced potato hybrid MP/6-39 can be helpful in expanding the potato production and its utilization in country.

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39. RP 5449-RIL-320 (IC0619226; INGR17066), a Novel Dual Donor Rice (*Oryza sativa*) with Resistance at Vegetative and Reproductive Stages to Brown Plant Hoppers (BPH) and White Backed Plant Hoppers (WBPH)

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At ICAR-Indian Institute of Rice Research, Hyderabad, a recombinant inbred line (F_9) *viz.*, RP 5449-RIL-320 was identified as a dual donor against planthoppers namely Brown planthopper (*Nilaparvata lugens* Stal) (BPH) and whitebacked planthopper (*Sogatella furcifera*) (WBPH), the most dreaded pests of rice. It possessed stable resistance during reproductive and vegetative stages. It was developed by crossing TN1 and Sinnasivappu, the susceptible and resistant parents to planthoppers respectively using single seed descent method of pedigree selection. A set of 250 RILs (F_9)were subjected to field screening at APRRI, Maruteru, the hot spot centre against planthoppers for 3 successive years 2012, 2013 and 2014. Simultaneously screened for 2 years (2013 and 14) in glass house for confirmation. In the first year (2012), a set of 30 RILs showed resistance when crop was affected by hopper-burn during flowering stage. RP 5449-RIL-320 could withstand high insect population of 495-600 WBPH and 35-40 BPH insects/hill during *kharif*, 2012; and 470-790 BPH and 10-15 WBPH insects/ hill during *rabi*, 2012 with a damage score (DS) of 3. (IIRR Annual report, 2012-13). In 2nd year (2013) during hopper-burn high infestation of 350-515 BPH and 80-130 WBPH insects/hill existed for a period of > 10 days during kharif, 2013 while 500-600 BPH and 5-10 WBPH insects/hill for about 20 days during *rabi* 2013. RP 5449-RIL-320showed consistent resistant reaction for both insects (DS: 4.5) (DRR newsletter, 2015). In third year (2014) also RP5449-RIL-320 recorded resistance (DS: 3) under hopper-burn in the presence of 390 to 450 BPH and 25 to 33 WBPH insects/hill during 2014, kharif and 500 to 600 BPH + 30 to 40 WBPH insects/ hill during 2014, *rabi*. The remaining RILs showed moderate resistance to susceptibe reaction.

For confirmation, the same set of 30 resistant RILs were screened in glass house in 2013 and 2014, *Kharif* and *Rabi* during early seedling stage. Separate screening experiments were conducted for BPH and WBPH reaction.

In glass house RP 5449-RIL-320 showed resistant reaction to both BPH (DS: 2.8 to 4) and WBPH (DS: 3 to 3.2) during 2013; BPH (DS: 3-3.5) and WBPH (DS: 3-3.6) during 2014. The resistant checks, Ptb 33 and MO1 for BPH and WBPH recorded mean damage scores of 3 and 2.9 respectively. It is a late duration culture (145 days) with intermediate plant height (118 cm), non lodging bearing short bold grains. It recorded good quality traits such as high head rice recovery (50%), intermediate desirable amylose content (24 %) and alkali spreading value (7).

Since RP5449-RIL-320 showed reproducible resistance to planthoppers over three years (2012, 2013 and 2014) in the field and 2 years (2013 and 14) in glasshouse, it could be utilized as a promising donor in the generation of resistant rice varieties against planthoppers.

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40. IET 24784 (RP 5866-Agami) (IC0619227; INGR17067), a Rice (*Oryza sativa*) Germplasm Rich in Zinc Micronutrient and Tolerant to Coastal Salinity

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Consumption of polished rice leads to micronutrient malnutrition due to Zinc deficiency. It inhibits growth, development and restricts normal functioning of immune system. Genetic enrichment of rice with Zinc is the most promising method compared to diverse diets, food fortification and supplementation approaches. IET 24784 (RP 5866-Agami), a selection from Agami possesses coastal saline tolerance (EC: 7 to 8) and enhanced Zn content (25.49µg/g).

Agami, a locally improved salt tolerant japonica cultivar of Egypt was introduced to ICAR-IIRR, Hyderabad through INGER nursery *viz*., 32nd International Rice Soil Stress Tolerant Nursery-Module 2, 2010. Within the population of Agami certain phenotypically superior plants possessing intermediate plant height (120 cm) and medium maturity (130 days) were selected and evaluated separately in progeny rows. The seed of one of the superior progenies was bulked and designated as RP 5866-Agami. It was found coastal saline tolerant (EC: 7 to 8; pH: 7.2 to 7.65) upon screening at Agricultural Research Station, Machilipatnam, a coastal saline centre of ANGRAU, AP during 2011, 2012 and 2013. It recorded 1.4 to 3.2 t/ha yield which is on par with coastal saline yield check, Indra (1.6 to 3.3 t/ha) during 2011 to 2013.

Incidentally RP 5866 -Agami was found to have high grain Zn content (>20 µg/g) and therefore tested in IVT- Biofortification trial during *Kharif*, 2014 bearing IET number 24784. It was evaluated along with 44 entries including 2 yield checks (IR64 and Samba Mahsuri) as well as 2 micronutrient checks (Chittimutyalu and Kalanamak) across the country in 17 locations spread over 12 states. Zinc content in polished rice was estimated by X-ray Fluorescence Spectrophotometer (XRF) at ICAR-IIRR, Hyderabad. IET 24784 displayed a mean grain yield of 2.8t/ha and high Zn content of 25.49µg/g in polished rice (10%) and 30.6 µg/g in brown rice and which is greater than that of micro nutrient checks, Kalanamak (18.29 µg/g) and chittimutyalu (21.49 µg/g) (ICAR-IIRR, Progress report, vol 1. 2014).

It displayed good cooking and eating quality parameters *ie.,* desirable amylose content (22.9 %), intermediate alkali spreading value (4) and soft gel consistency (63 mm); good physical quality traits like high head rice recovery (69.6%) and high milling outturn (71. 5%) (Padmavathi *et al.,* 2015). It possessed multiple resistance to three diseases namely blast (SI: 2.3), sheath rot (SI: 4.4) and RTD (SI: 5).

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41. CSR 47 (CSR 2K 232) (IC0639318; INGR17068), a Rice (*Oryza sativa*) Germplasm with Tolerance to Alkalinity Stresses up to pH 9.9

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Globally, more than 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 47 (CSR 2K 232) is a alkaline tolerant high yielding has been developed using Jaya and CSR 13 as parent through pedigree breeding method at the Division of Crop Improvement, Central Soil Salinity Research Institute, Karnal, Haryana. The line CSR 47 (IET 20328) was developed for alkaline areas where pH is up to 9.9. Of the two parents, CSR 13 is tolerant to alkalinity (pH ~9.9) and another parent Jaya has high yield potential. Hence, this culture combines the high yield from Jaya and tolerance from CSR 13 for alkalinity.

Morpho-agronomic characteristics: It possessed long bold grains and 95 days flowering duration. This is a semi dwarf culture, with green foliage, erect flag leaf, compact panicle and complete panicle exertion. This line has been evaluated through All India Coordinated Rice Improvement Programme (AICRP - Rice) IIRR, Hyderabad for three years (2011, 2012 and 2013) across five alkaline locations (pH up to 9.9) in Haryana (DRR 2012; DRR 2013; DRR 2014). Based on the data recorded during kharif 2011, 2012 & 2013, across the alkaline stress locations of Haryana. The line CSR 47 (IET 20328) was found superior in yield over the checks CSR 36 and Local check by 20 % and 20 %, respectively across the three years (2011, 2012 and 2013) in 5 salt affected locations of Haryana (Annual report, 2014-15).

Associated characters and cultivation practices: Based on screening in NSN1 and NSN2, IET 20328 showed moderately resistant/tolerant to major insect pests and diseases such as stem borer, leaf folder, case worm, blue beetle, leaf blast and brown spot. Quality parameters studied at IIRR, Hyderabad showed that IET 20328 has high head rice recovery (63.9 %), desirable alkali spreading value (5.0) and intermediate amylase content (23.7 %). CSR 47 (CSR 2K 232) is salt tolerant high yielding, long bold grained variety. The above values are indicative of excellent cooking quality of IET 20328.

The performance of CSR 47 (IET 20328) was consistently high under alkalinity for three successive years in Haryana. It showed yield superiority over national alkaline check and local check. Therefore, CSR 47 (IET 20328) was promising in the states of Haryana under alkalinity. This Germplasm can be used as a genetic stock for future breeding programmes aiming at development of high yielding salt tolerant rice varieties for alkaline soils.

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42. Salkathi (PB-289) AC-351181 (CSR 2K 232) (IC0256801; INGR17069), a Rice (*Oryza sativa*) Germplasm Resistant to Brown Plant Hopper

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The purified landrace 'Salkathi' showed resistance to brown plant hopper (BPH) consistently for last several years in All India Coordinated Rice Improvement Programme trials. Phenotyping of RILs against the BPH population at ICAR-NRRI, Cuttack, Odisha showed continuous skewed variation, suggesting the involvement of quantitative loci for resistance to BPH in Salkathi. Since no separate biotype was confirmed location-wise in India, this landrace was tested against different populations in different locations as mentioned in the Progress reports of the AICRIP.

Morpho-agronomic characteristics: The data on multilocation test were generated for four years through AICRIP, ICAR-IIRR, Hyderabad in which the said entry was showing promising results against BPH. In addition, it was also identified as a potential donor for having multiple resistance to several insect pests of rice.

Associated characteristics and cultivation practices: Salkathi was recommended for promotion to yield trial or for utilization in breeding programme for biotic stress like BPH resistance and also for resistance to multiple insect pests of rice. It was also recommended by the Institute Research Council (IRC) and Research Advisory Council (RAC) for registration as well as utilization in breeding programme. Basing on the recommendations, this donor has been utilized in making different cross combinations in breeding programmes of the ICAR-IRRI collaborative programmes and other rice research stations across the country. The breeding lines thus evolved were also showing highly resistant reaction against BPH.

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43. FLW18 (IC0621835; INGR17070), a Wheat (*Triticum aestivum)* Germplasm with Resistance to Brown Rust carrying Yr39+ in the background of PBW343

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Rusts are economically the most damaging diseases of wheat as they pose major threat to wheat production in most of the wheat growing areas of the world. The most effective and environmentally sound strategy to manage these diseases is through the deployment of resistant cultivars (Bhardwaj *et al*., 2016). Wheat cultivars become susceptible to new pathotypes of brown rust periodically (Prasad *et al*., 2017). At Regional Station ICAR-IIWBR, Shimla, FLW18 was developed from the cross PBW343/ *Lr39* (KS92WGRC15). Germplasm accession KS92WGRC15, donor of *Lr39* is in agronomically poor background as the line is derived from *Aegilops tauschii*. Therefore, the genetic stock FLW18 was developed in good agronomic background. FLW18 carrying *Lr39* and *Yr9*/*Lr26*/*Sr31*, which have been validated through molecular markers, provides resistance to all the brown and black rusts pathotypes reported in India.

FLW18 was found immune (0;) at seedling stage to all the pathotypes of brown rust under controlled and optimum conditions (Table1). The adult plant reaction (APR) of FLW 18 to brown and black rusts also showed resistant response. FLW18 has waxiness on leaf sheath, peduncle and glumes. It has average plant height of 89cm and matures in 122 days under Karnal conditions.

Its seeds are amber coloured with soft texture and has thousand-grain weight of 38.0 g.

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Table 1. Seedling response (2013-2016) of FLW18 to most virulent pathotypes of brown and black rusts

	Brown rust pathotypes								Black rust pathotypes			
Pathotype	12-5	77A	77-2	77-5	77-7	77-8	77-10	104-2	34-1	40A	40-1	117-6
Score	0;	0;	0;	0;	0;	0;	0;	0;	0;	2-	2-	2-

44. NRCSFR 09-3(IC0621475; INGR17071), a Sorghum (*Sorghum bicolor*) Germplasm with Improved Shoot Fly Resistance over the Elite Parent, 296B. Better level of Resistance to Grain Moulds compared to 296B. Derivative to Biparental Mating involving Two Shoot Fly Resistant Sources

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Sorghum shoot fly, *Atherigona soccata* Rondani is one of the major pests that destabilizes the performance of sorghum cultivars and ultimately reduces sorghum production in many parts of the world. It causes damage to the late sown crop in *kharif* and early sown crop in *rabi*. The seriousness of the shoot fly problem in sorghum, combined with the high costs and toxicity hazards of using chemical control, renders it necessary to develop new varieties or hybrids that possess resistance to this pest. In order to incorporate resistance into sorghum parental lines, intensive breeding efforts were initiated at IIMR, by crossing the elite parental lines with shoot fly resistant germplasm.

A series of crosses were made during 2003-2006 by using the elite parental lines and the shoot fly resistant sources from germplam such as IS 18551, IS 2312, IS 2122 and RSE 03. The F_2 population was sown by mid July, so that the plants are exposed to sufficient shoot fly pressure. From F_3 onwards, selections were made in the shoot fly nursery where high pest population is build up. The seed of the resistant F_6 progenies was multiplied and the genotypes were tested in multilocation under AICSIP.

NRCSFR 09-3 Is A Derivative Of The Biparental Mating Involving F_2s Of Two Crosses. The Parents Involved Are One Elite Parent 296B And Two Shoot Fly Resistant Sources From Germplasm, I.E. IS 2122 And IS 18551. It Has Much Better Level Of Shoot Fly Tolerance Compared To 296B, And Agronomically Better Compared To Both The Shoot Fly Resistant Sources. NRCSFR 09-3 Is Of Medium Height With Tan Background And Has Shoot Fly Resistance On Par With The Resistant Parent. For The Traits Contributing For Shoot Fly Resistance Such As Glossiness And Number Of Eggs Per Plant, NRCSFR 09-3 Was Found To Perform On Par With The Resistant Check, IS 18551 In AICSIP Trials. In The Pest And Disease Nursery Of AICSIP, NRCSFR 09-3 Has Recorded Better Level Of Resistance To Grain Moulds, An Important Disease During Kharif. Hence NRCSFR 09-3 Can Be Used As An Improved Source Of Resistance In The Shoot Fly Resistance Breeding Program.

Table 1. Performance of NRCSFR09-3 for shoot fly resistance in AICSIP trials over three years (10 environments)

Genotype	Pedigree	Shoot fly deadheart % at 28 DAE			
		2009	2010	2011	Av.
NRCSFR 09-3	{(296 B × IS 2122) × (296B × IS 18551)}	47.4	38.7	39.3	41.8
296 B		62.8	60.8	–	61.8
IS 18551		41.1	31.6	28.5	33.7
DJ 6514		82.6	79.2	80.8	80.9
CD 5%		11.0	8.9	14.5	
CV (%)		12.1	12.1	19.4	

NRCSFR 09-3 was evaluated in pest and disease nursery of AICSIP for three years during 2013 to 2015 and was found to perform well for shoot fly resistance traits, seedling glossiness and shoot fly eggs per plant (Table 2). In all the years, it showed less shoot fly deadheart percentage compared to the elite parent, 296B. In the pathology PDRN trials for two years, 2014 and 2015, it was found to have better level of tolerance to grain molds compared to its elite parent, 296B (Table 3).

Table 2. Performance of NRCSFR 09-3 for the traits associated with shoot fly resistance in the Pest and disease nursery (PDRN) of AICSIP during 2013-2015 (9 environments)

Genotype	Seedling glossiness (1-5 scale)				Shoot fly eggs/ 5 plants				Shoot fly DH% at 28 DAE			
	2013	2014	2015	Av	2013	2014	2015	Av	2013	2014	2015	Av.
NRCSFR 09-3	3.2	3.25	3.22	3.22	2.3	4.78	8.5	5.19	47.2	36.9	46.5	43.5
296 B	4.3	3.75	4.39	4.15	3.3	3.22	12.3	6.27	72.7	70.5	85.9	76.4
IS 18551	3.0	2.67	3.17	2.95	3.0	3.33	5.17	3.83	40.0	32.2	42.0	38.1
Swarna (sus check)	4.3	4.5	3.89	4.23	4.0	9.33	14.0	9.11	79.7	83.1	89.0	83.9
CD 5%	1.27	1.0	0.82	-	1.4	2.58	7.5	-	7.5	14	15.8	-
CV (%)	19.9	20.7	13.9	-	26	32.7	40.9	-	8.1	16	15.1	-

Table 3. Performance of NRCSFR 09-3 in the Pest and disease nursery (PDRN) of AICSIP Pathology during 2014-2015 (Four environments)

Genotype	Grain mold score-PGS*			Grain mold score-TGS**		
	2014	2015	Av	2014	2015	Av
NRCSFR 09-3	3.7	4.0	3.85	4.5	3.5	4.0
296 B	5.3	5.7	5.5	5.7	5.8	5.75
CD 5%	2.6	1.6	-	2.3	1.5	-
CV (%)	35.8	19.2	-	29.4	18.0	-

*PGS- Panicle grain mould score; **TGS-Threshed grain mould score

This line can be used as resistant source in the shoot fly resistance breeding program aiming at development of parental lines and genotypes with shoot fly resistance along with agronomic acceptability.

45. Sdf (Super dwarf) Mutant (IC0621946; INGR17072), a Extremely Dwarf Mutant of Jute (*Corchorus olitorius*) with around 1/10th Plant Height of Wild Type

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and

46. Llpf (Low Lignin Phloem Fibre) Mutant (IC0621948; INGR17073) of Jute (*Corchorus olitorius*) with Low Lignin Content of Fiber (6.7%) at 120 Days after Sowing. Unique Morphology having Undulated Stem, Petiole and Main Leaf Vein

SB Choudhary, HK Sharma, A Anil Kumar, J Mitra, PG Karmakar, J Souframanien[2] and Sanjay Jambhulkar

and

47. Pfr 59 (pre-mature flowering resistant 59) (IC0621949; INGR17074), a Jute (*Corchorus olitorius*) Germplasm with Absolute Absence of Pre-mature Flowering when Sown in First Week of February

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and

48. WCIN 009 (IC0621650; INGR17075), a Jute (*Corchorus olitorius*) Germplasm with High Iron content in leaves (173.75 mg/kg fresh weight)

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Tossa jute cultivars starts flowering even after 40 days of sowing without completing vegetative growth, if sown in February or March months. The phenomenon called pre-mature flowering and adversely affect both fibre yield and quality. A mutant germplasm (*pfr* 59) of *tossa* jute (*Corchorus olitorius* L.) found free from pre-mature flowering even after sowing in the 1st week of February during 2012-2015. In contrast, the best available check and parent of the mutant recorded significantly high pre-mature flowering (34.56%) over the years under identical conditions. It is noteworthy that the mutant recorded normal flowering after 140 days of sowing and produces viable seeds. Therefore, the mutant is pre mature flowering resistant. Further a low lignin phloem fiber mutant (*llpf*) of the species found morphologically distinct with undulated stem and petiole. Fibre of the mutant is low lignin containing (6.7%) compare to all *tossa* jute cultivars and genetic resources (13-18%). The attribute is important for realizing commercial potential of jute based diversified industrial products. In addition, an extremely dwarf mutant (*sdf*) of *tossa* jute (*Corchorus olitorius* L.) having only 1/10th plant height of the wild type (JRO 204). It can serve as one of the parent for developing plant height specific mapping population. A wild accession of *Corchorus aestuans* L. Bearing IC no. WCIN 009 found useful source of dietary nutrition particularly leaf iron and β-Carotene. It can utilize either directly by consuming young tender leaves as vegetable or indirectly as a high leaf iron source to bio-fortify iron content in jute leaves.

49. IC01572 (IC-001572; INGR17076), a Blackgram (*Vigna mungo*) Germplasm with Resistance to Mung Bean Yellow Mosaic Virus

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Low productivity of grain legumes is due to several biotic stresses especially yellow mosaic disease causing yellowing or chlorosis of leaves followed by necrosis, shortening of internodes and severe stunting of plants with no yield or few flowers and deformed pods with small, immature and shriveled seeds, Major problem for resistance breeding programme in blackgram is the lack of suitable resistant germplasm/genotype and also the unavailability of robust and efficient screening methods that make use of both field and artificial techniques. No specific large scale systematic screening has been conducted in India to identify resistant sources against yellow mosaic viruses by combining field screening, vector inoculation and agroinoculation. Therefore, 344 germplasm accessions originally collected from different geographic regions of India and conserved in the National Gene Bank at National Bureau of Plant Genetic Resources, India, were evaluated or their response against YMD. Based on disease incidence and severity of the symptoms under field conditions with natural disease pressure the response was different among the accessions during three cropping seasons (*Kharif* 2010, 2011, 2012). Field experiments were conducted at NBPGR experimental farm, New Delhi (geographical coordinates $28^{o}64^{/}$N, $77^{o/}$ E).Two popular blackgram cultivars namely Barabank Local (highly susceptible 0 and T-9 (high yielder) were used as checks. Germplasm accessions indicating resistance response during three consecutive years under natural disease pressure were further subjected to screening through artificial inoculation using viruliferous whiteflies. Those germplasm accessions which showed resistance response after whitefly inoculation were further tested for validation of the resistance through agro inoculation with the infectious cloned DNA-A and DNA-B components of a New Delhi isolate of MYMV. A germplasm (IC001572) collection from Delhi. India, was identified as highly resistant against MYMV. Yield attributing traits of selected accessions were also recorded along with susceptible (Barabanki local) and agronomic checks (T-9) and on his basis IC001572 germplasm also exhibited desirable agronomic attributes viz. short height (32.0cm), early maturity (75 days), medium to high grain yield (13.6 gm / plant) with medium seed size (100 seed weight 3.1 gm). The above mentioned germplasm accession can be used in YMD resistant breeding programme or can be released directly for cultivation after verifying its adaptation to various regions and accepting quality traits.

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50. DRMR-2019 (IC0598622; INGR17077), An Indian Mustard (*Brassica juncea*) Germplasm with White Rust Resistance

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and

51. DRMR-2035 (IC0598623; INGR17078), An Indian Mustard (*Brassica juncea*) Germplasm with White Rust Resistance

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Indian mustard (*Brassica juncea* L.) is an important oilseed crop contributes nearly 80 percent of the total rapeseed-mustard production in India experiences severe biotic and abiotic stresses. Among biotic stresses, white rust disease causes drastic yield losses, depending upon its severity. Therefore, the development of WR resistant genotypes is highly desirable to minimize the economic losses. Keeping this in view, two genotypes DRMR 2019 (EC399288/ BEC107) and DRMR 2035 (PHR1/ BEC107) were developed through systematic breeding at ICAR-DRMR, Bharatpur (India). These were selected through rigorous screening for WR during 2010-11 to 2016-17 at Bharatpur, Wellington (Hot Spot for WR) and different locations under AICRP-RM (NDN/ UND trials, 2015-16 & 2016-17) along with resistant (BIOYSR, PHR-2) and susceptible (Rohini, Varuna) checks (DRMR Annual Report, 2011-17; AICRP-RM Reports, 2016 & 2017). DRMR 2019 and DRMR 2035 exhibited stable resistance at different locations and identified as resistant sources for WR. The WR resistance of the genotypes has also been validated at molecular level using genotype non-specific molecular markers At541560 and At2g36360 reported (Panjabi *et al.*, 2010) closely linked with WR resistance loci AcB1-A4.1 and AcB1-A5.1. DRMR 2019 revealed distinguishing bands of size 430bp and 750bp with both the markers, respectively while DRMR 2035 revealed loci AcB1-A4.1 of size 430bp confirming their resistance. These genotypes had superiority over resistant checks for 1000-SW and seed yield. Additionally, DRMR 2035 exhibited tolerance to Sclerotinia rot which is highly devastating disease emerging in India (DRMR Annual Report, 2015-16). Thus these genotypes could be highly useful in breeding programmes for development of high yielding white rust resistant varieties.

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52. DCA-121 (IC0610825; INGR17079), a Senna (*Cassia angustifolia*) Germplasm with Small Size Pod

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Senna (*Cassia angustifolia* Vahl.) is a medicinal plant used as purgative, laxative, expectorant, wound dresser, antidysentric, and carminative. The medicinal properties are attributed to production of sennosides (anthraquinone glycosides). Senna is cultivated commercially in India in arid parts of Rajasthan, Gujarat and Tamil Nadu. Leaves and pods are economic parts used in the treatment various Indian systems of medicine. India exports large quantity of senna leaves and pods in the world market and earns approximately Rs. 50 crores revenue every year. Germplasm constitute the basic raw materials required for the improvement of senna. Even though this crop is important and being cultivated for many centuries in India, the number of varieties released are less (Sona, KKM-01 and AFLT-2). Increasing demand of senna leaves and pods in the national and international market calls for the developing high yielding varieties with desired marker traits. For the first time, a selection

Table 1. Agro-morphological description of DCA-121 of Senna

Characteristics	DCA-121	ALFT-02
Morphological traits		
Plant habit	Erect	Erect
Leaf color	Dark green	Green
Leaf Apex shape	Acute	Acute
Leaf Apex habit	Straight	Straight
Leaf type	Normal	Normal
Flower bud size	Intermediate	Intermediate
Pod shape	Normal	Normal
Pod size	small	medium
Pod Pubescence	moderate	moderate
Stem pigmentation	Middle	Mostly basal
Seed shape	Narrowly obovate	Obovate
Agronomic traits		
Days to first phase of flowering (days)	108	100
Days to second phase of flowering (days)	194	181
Days to maturity (days)	234	234
Plant height (cm)	100	130
Number of primary branches (cm)	10	13
Number of racemes on main branch	7	9
Number of pods/raceme	15	9
Pod size (L × B cm)	Small (3 × 1 cm)	Medium (5 × 2 cm)
Test weight (g)	2.6	2.9
Trichome density (Adaxial)	27.7	25.3
Trichome density (Abaxial)	97.6	96.4
Sennoside content (%)	1.44	2.08
Elemental profile leaves		
Potassium (%)	0.406 (±0.003)	0.405 (±0.01)
Sodium (%)	0.067 (±0.008)	0.058 (±0.006)
Calcium (%)	0.894 (±0.012)	0.865 (±0.009)
Magnesium (%)	0.382 (±0.003)	0.362 (±0.004)
Zinc (ppm)	12.97 (±0.83)	9.26 (±1.7)
Copper (ppm)	2.52 (±0.35)	2.80 (±0.43)
Iron (ppm)	187.7 (±1.85)	159.3 (±6.2)
Manganese (ppm)	61.43 (±1.27)	36.24 (±2.06)

with small pod size (DCA-121) was identified at the ICAR-Directorate of medicinal and aromatic plants Research, Anand, Gujarat. DCA-121 was having a pod length of 3 cm and breath of 1 cm which was 50% smaller pod size than cultivar ALFT-2 which is having a pod size of length 5 cm and breath 2 cm (Table 1). The genotype DCA-121 produced smaller pods also at MPKV, Rahuri during 2015-16 indicating the stability of the character. The smaller pod size selection (DCA-121) could be an important source for natural alleles for pod size variation in senna which may be used to develop high pod yielding cultivars. The selection is stable, uniform and distinct and hence, may be used as an important allelic source to unravel genetics of pod size variation in senna. Further, this trait can be used as DUS character for identification of elite germplasm lines and cultivars.

53. DCA-124 (IC0610826; INGR17080), a Senna (*Cassia angustifolia*) Germplasm with Broad Leaves, Broad Pod Shape

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Table 1. Agro-morphological description of DCA-124, a broad pod and leaf germplasm

Characteristics	DCA-124	ALFT-02
Morphological traits		
Plant habit	Semi spreading	Erect
Leaf color	green	Green
Leaf Apex shape	Acute	Acute
Leaf Apex habit	Straight	Straight
Leaf type	Broad	Normal
Flower bud size	Intermediate	Intermediate
Pod Shape	Broad	Normal
Pod size	Medium	Medium
Pod Pubescence	Moderate	Moderate
Stem pigmentation	Mostly basal	Mostly basal
Seed shape	Obovate	Obovate
Agronomic traits		
Days to first flowering (days)	100	100
Days to second flowering (days)	179	181
Days to maturity (days)	219	234
Plant height (cm)	112	130
Number of primary braches (cm)	10	13
Number of racemes/main branch	10	9
Number of pods/raceme	11.9	9
Pod size	Medium	Medium
Test weight (g)	3.4	2.9
Trichome density (Adaxial)	33.00	25.3
Trichome density (Abaxial)	105.0	96.4
Sennoside content (%)	1.66	2.08
Elemental profile leaves		
Potassium (%)	0.443 (±0.01)	0.405 (±0.01)
Sodium (%)	0.072 (±0.003)	0.058 (±0.006)
Calcium (%)	0.892 (±0.005)	0.865 (±0.009)
Magnesium (%)	0.389 (±0.003)	0.362 (±0.004)
Zinc (ppm)	17.67 (±0.31)	9.26 (±1.7)
Copper (ppm)	2.94 (±0.16)	2.80 (±0.43)
Iron (ppm)	174.4 (±0.31)	159.3 (±6.2)
Manganese (ppm)	40.67 (±0.86)	36.24 (±2.06)

Senna (*Cassia angustifolia* Vahl. is synonymous with *Senna alexandria* Mill.), popular as "Tirunelveli senna" is used worldwide as natural laxative. The drug senna is mentioned in various texts of indigenous systems of medicine (Ayurveda, Siddha Unani and homoeopathy) in India, pharmacopeias of United States, United Kingdom, Germany and other counties. Tirunelveli is a place in south India where senna was introduced in India for the first time in the mid-eighteenth century and it is extensively cultivated, processed and exported to various countries under the brand name "Tirunelveli senna" hence the name. The drug senna is widely used as a purgative, laxative, expectorant, wound dresser, antidysentric, and carminative. The drug senna is also used as a cathartic, febrifuge, in treatment of splenetic enlargements, anemia, typhoid, cholera, biliousness, jaundice, gout, rheumatism and tumours. Even though the species brought to cultivation for many centuries, systematic efforts on germplasm management and development of high yielding varieties are getting important only in recent years. For developing high yielding varieties, the size of leaves besides the number of leaves is an important trait to get maximum economic yield. Interestingly, a germplasm, DCA-124 with a broad leaves and broad pod shape has been collected from Bikaner, Rajasthan during 2012 and characterized at ICAR-DMAPR, Anand, Gujarat during 2013-14 and at MPKV, Rahuri during 2015-16 (Table 1 and Figure 1-2). The accessions DCA-124 produced broad leaves and pods over locations and seasons indicating its stability. The broad pod shape collection DCA-124 could be an important novel source for natural alleles for broad pod shape and broad leaf variation in senna which may be used to develop high pod yielding cultivars. The selection is stable, uniform and distinct and hence, may be used as an important allelic source to unravel genetics of pod shape variation as well as broad leaf in senna. Further, this trait can be used as DUS character for identification of elite germplasm lines and cultivars.

54. Bharamputra–1(IC0610826; INGR17081), an Aromatic ginger (*Kaempferia galanga*) Germplasm with High rhizome yield (10 tones/ha) and Dry Rhizome Recovery. High Essential Oil.

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Kaempferia galanga, known as Chandramula in Hindi is a rhizomatous herb that belongs to the zingiberaceae family is cultivated mainly for its aroma and other medicinal importance. It is widely cultivated in India in the states of Tamilnadu, Kerela, Karnataka and West Bengal (Raina *et al*., 2015, Lal *et al.,* 2017).It is a potent aromatic medicinal plant suitable for cultivation in shady areas. Its growth, yield and quality are dependent on planting time and type of seed material. The use of this active secondary chemical compounds in the medicinal as well as perfumery holds a great promise in ancient as well as modern era. The rhizomes also have good nutritive value and are quite rich in protein and carbohydrate but low in fat.

In the view of the needs and great prospect of cultivation of this crop successfully in various region of India, it is necessary to evolve high rhizome yielding genotypes for respective locations (Lal *et al*., 2017). Due to the limited improved genotypes for high rhizome yield, its cultivation is not popular among farmers. The current price of the rhizome is more than Rs 400/- per kg. Therefore, there is a need to develop superior genotypes of *K. galanga* for high rhizome yield. Thirty-five germplasm of *K. galanga* were planted and propagated vegetatively in randomized complete block design keeping a check in respect of rhizome yield. A high rhizome yielding unique germplasm was identified yield named as Bharamputra-1.

The germplasm was planted in four different locations in Northeast India. The data showed that this new genotype contains more rhizome yielding capacity recorded at harvest was found to be 10 tons/hectare. The dry recovery was 32% of fresh rhizome yield and superior to the check variety. This elite variety maintained its superiority over the other varieties in terms of rhizome yield and named as Bharamputra-1. Plants of this variety were propagated through vegetative means using the rhizome. The plants are stable for commercial cultivation.

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55. IC0597686 (DOPR G 22; Palm no.45) (IC0597686; INGR17082), a Oil Palm (*Elaeis oleifera*) Germplasm with Slow Vertical Stem Growth (Low Annual Height Increment of 15 Cm per Year). Early Fruit Maturity (4.5 months) with Long and Slender Bunch Stalk. High Fruit Set of 53.4% than other Oleiferas (28.0% to 46.0%)

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American oil palm (*Elaeis oleifera* (HBK) Cortes) is endemic to tropical countries of South and Central America. A feature of the palm that distinguishes it from the widely cultivated oil palm (*Elaeis guineensis* Jacq.) is its dwarf and often procumbent trunk which facilitates easy harvesting of bunches. Reducing height has always been interest to oil palm industry because of high cost of harvesting tall palms which accounts up to 18% of the total production cost. (Murugsan and Sunilkumar, 2014).Developing dwarf planting material so as to overcome the difficulties of harvesting tall palms is one of the main objectives in the ICAR-IIOPR's oil palm breeding programme. There are four sources of wild oil palm available in India. Out of four sources three are available at ICAR-IIOPR Research Centre Palode and another source is located at Cithara estate of Oil Palm India Limited (OPIL), Kerala. One accession of Surinam origin (which was introduced along with commercial planting material and pedigree information is recorded in the germplasm register) planted during 1988 at Field Gene Bank of IIOPR Research Centre, Palode, Kerala was taken as experimental material (Murugesan *et al*., 2008; Anonymous 2010). Surinam is considered as one of the centres of diversity of *oleifera* which are found scattered throughout the forest, open pasture along banks of streams. According to Corley and Tinker (2003), *oleifera* stand in Surinam declined considerably and emphasized preservation of collected *oleifera* gene pool. Generally, *oleifera* shows poor fruit set with a range of 28 to 46% and present Surinam *oleifera* recorded 53.36% with 9.25% oil to bunch (Murugesan *et al*., 2011a; Murugesan *et al*., 2011b). The proposed genetic stock has precocity in bunch ripening (4.5 months, normal bunch takes 5.5-6.0 months) which is considered as desirable trait (Murugesan and Shareef 2014). In fruit and seed development study conducted in the proposed stock, fruit has been developing steadily in size and weight from anthesis (0.27 g) to (8.62 g) 135 days after anthesis (DAA). The kernel was liquid at 48 DAA and started solidification at 65 DAA onwards. The embryo matured at 78 DAA and shell became hard and lignified during 113 to 126 DAA. Surinam *oleifera* fruit bunches requires about 4.5 months (135 DAA) for fruit ripening and harvestable maturity (Murugesan *et al*., 2011) whereas other accessions of oleifera population took 186 days for fruit maturity, ripening and other physiological maturity (Murugesan *et al*, 2011).

Morpho-agronomic characteristics: The identified *oleifera* palm has short height (4.1m), reduced trunk increment (15cm), short leaflet length (97.3cm), breadth (6.2cm) and short intermodal length (6.2cm). This palm recorded 12.5 kg of bunch weight with average bunch yield of 75Kg FFB/Palm/year. This palm had 9.25% mesocarp oil to bunch and 3.1% kernel oil to bunch. It has recorded 54 % fruit to bunch and 76 % mesocarp to fruit. It has very less height increment of 15cm with frond production of 24 numbers per year. Other distinct characteristics of proposed genetic stock are early disintegration of bunch spathes, long slender bunch stalk of both male and female inflorescences (Murugesan and Sunil kumar, 2014). Colour of the petiole of selected palm is dark green colour similar to leaflet. The proposed genetic stock is considered as valuable resource because of less common fruit type which is deep orange to red at maturity and developed from green colour immature fruit turning olive green and pale yellow (Murugesan *et al*, 2009).

Utilization of genetic stock: Currently interspecific hybrids and progenies developed from the genetic stocks are being evaluated in the field trial to develop compact varieties. The selected *oleifera* accession has been backcrossed with high yielding *E.guineensis* to produce interspecific hybrids to retain unique characteristics in the planting material to be developed using promising palms of *E. guineensis.*

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57. IC0597687 [EC382627; DOPR G53 (61)] (IC0597687; INGR17083), a Oil Palm (*Elaeis guineensis*) Germplasm withVirescens Fruit Colour. Dura Fruit Forms

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Fruit colour is an important trait in terms of bunch harvesting at right stage of maturity and, to obtain maximum oil extraction rate in oil palm. A change in color is associated with fruit ripeness in oil palm. For this reason, this trait is one of the indicators usually used by field workers to help identify ripe bunches during harvest. However, sometimes this indicator is not adequate for bunches of *nigrescens* fruits (black color in normal type), because the color change when ripe is often subdued and the workers frequently cut bunches with sub-optimal degrees of ripeness and lower oil contents. The oil palms produce either *nigrescens* or *virescens* fruit types. *Nigrescens* fruits are usually deep violet to black at the apex and yellow at the base when unripe, with minimal change in colour of the apex upon ripening. For *nigrescens* palms, harvesters rely on the presence of detached fruits on the ground to determine that bunches are ripe. Although the *virescens* trait is dominant, the number of *virescens* palms found in natural populations is small. *Virescens* palms were used in ancient ceremonial rites explaining their occurrence among wild-type *nigrescens* palms, trees matching the description of *virescens* palms were reportedly used in tribal sacrificial ceremonies in West Africa (Zeven, 1967). *Virescens* palms are recorded by Singh (2014) which were from either the Ghana or Nigeria collections. However, majority of them were reported as heterozygous.

Morpho-agronomic characteristics: The proposed genetic stock was developed from open pollinated fruit samples of palm collected from Tanzania Accession No DOPR G53 (61)) which were planted during 1998 at DOPR Research Centre, Palode and identified through evaluation and intensity of fruit colour is prominent bright indicating reflecting degradation of chlorophyll and accumulation of carotenoids predominantly (Pillai *et al*. (2000)). The Tanzanian accessions (TS-10) were collected from grove consisting all *virescens* bearing palms located at a place called Ujiji in Tanzania with thin shell of dura fruit form (Pillai, 1995). The majority of the TS-10 progeny populations were exhibited *virescens* fruit forms (Anonymous 2009-10). Phenotypic screens of these collections as per IBPGR (1989) descriptors revealed a significant diversity for the valuable agronomical characteristics. The reported germplasm with *virescens* and *dura* fruit characteristics was selected based on the phenotypic data described by Corley *et al*. (1971), such as: (1). Bunch number, weight and production; (2) fresh fruit bunch and oil content; (3) vegetative characters; (4) fruit shell thickness; (5) fruit colour etc., and bunch analysis as per Blaak *et al*. (1963). All the vegetative characters were measured during June month of every year and average of four years was reported. Bunch production and number of bunches were recorded quarterly, bunch analysis was done for three bunches during peak season and average of four years were reported for all the measured parameters.

Associated characters and cultivation practices: Since, virescence character is governed by dominant gene 'Vr' it would be advantageous to develop planting materials with *virescens* fruits so as to have harvesting of ripe bunches with higher oil contents. A *virescens* fruit type has also non fruit shedding traits and has long shelf life. The proposed *virescens dura* genetic stock of DOPR G53 (61) was crossed with DOPR G54 (E65) of *virscenspisifera* for the production of hybrid *tenera* population which were later planted in the farmers field in Andhra Pradesh. The results revealed that almost all the progeny population (99%) exhibited *virsecenstenera* fruit form. The phenotypic evaluation was also resembled with its progenitors.

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57. IC0597688 (DOPRG-44-E 33) (61) (IC0597688; INGR17084), an Oil palm (*Elaeis guineensis*) Germplasm with Long Bunch Stalk (53 cm)

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Oil palm growers are demanding for agronomic traits, such as low growth rate and broad ecological adaptations, for which restricted genetic variability has been found on *E. guineensis* germplasm (Simmonds, 1993). In oil palm, male and female flowers occur separately on the same palm. Each inflorescence consists of a stout peduncle of 30-45 cm length with spikelets arranged spirally around it which varies both with age and position in the rachis. The fruits are very compact due to the arrangement of spikeletís and bunches are housed in leaf axils. This creates problem while harvesting bunches in matured palms. The female inflorescence at anthesis is in the axils of the 17th leaf from the center spear and by the time the bunch is ripe, it is subtended by about the 30th leaf. The bunch leans out from it subtending leaf on to a leaf in a lower whorl, so it is not the leaf subtending the bunch that support. In oil palm bunches appears very compact due to the arrangement of spikeletes and fruits and they are housed in leaf axils leading to harvest problem especially in matured palms. Character of obvious importance for easy harvest in oil palm is bunch stalk (peduncle). Bunch stalk is housed inside the leaf axils. Bunches possessing long stalk facilitates access for effortless harvest and pollination. Extremely low values have been observed for percentage of long bunch stalk (peduncle) for material collected in Brazil (Miranda Santos *et al*., 1984). Ooi *et al*. (1981) emphasized these characteristics, pointing out that in some cases this was as low as 6.0 cm.

Morpho-agronomic characteristics: To broaden the oil palm genetic base, Pillai *et al*. (2000) collected different exotic genetic resources during 1995. Thirty one accessions of such resources were planted during 1998 in the field gene bank at ICAR-Indian Institute of Oil Palm Research (Formerly known as Directorate of Oil Palm Research), Research Centre, Palode. Asapart ofcrop improvement programme, characterization andyield evaluation wasundertaken asperIBPGR (1989) descriptor withnecessary additional characteristics. The proposed genetic stock (GB palm no.33) has long bunch stalk (53 cm) and possess high sex ratio (DOPR annual report 2009-10). This character (Fig. 1) has been introgressed into new oil palm breeding lines.

Associated characteristics and cultivated practices: The advantage of long bunch stalk is ease of harvesting without the requirement of pruning the frond below the bunch. Another advantage of long bunch stalk is its protruding structure that allows the convenience of weevil pollinators to pollinate the entire inflorescence to produce well pollinated fresh fruit bunch. Oil palm hybrid with lower height and short fronds and compact crown results in higher economical life span; hence space efficient and 148 palms can be planted per hectare; high number of fresh fruit bunch with average weight helps to buffer against the environmental stress for consistent fresh fruit bunch production and oil extraction rate. Other advantages include smaller palm size, small and lighter fronds thus easier for harvesting (http://www.aarsb.com.my/the-advancement-of-oil-palm-breeding). Murugesan and Gopakumar (2010) had reported maximum mean length of 18.13cm in Guinea Bissau population at Athirapilli field gene location of Kerala, India. Rajanaidu (1984) reported variation in preponderance of female inflorescence in African germplasm and bunch characteristics in the germplasm planted in Malaysia.

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58. IC0597689 (EC382636; DOPRG-54-E65)(IC0597689; INGR17085), an Oil Palm (*Elaeis guineensis*) Germplasm with Sterile Pisifera Palm. Virescens Fruit

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The narrowness of gene pool is considered as a major obstacle to increase the productivity as the oil palm planting materials are presently derived from an extremely narrow genetic base (Corley RHV and PBH Tinker, 2003).Oil palm is propagated commercially through hybrid seeds and the cultivated species *Elaeis guineensis* Jacq. the African oil palm has three distinct fruit forms, which are distinguished by shell thickness *viz*: 1) *dura* (thick shell of 2-8 mm), 2) *tenera* (hybrid between *dura* × *pisifera* cross with thin shell of 0.5 to 4 mm) and 3) *pisifera* (shell-less and female sterile). The *pisifera* palms are classified either as fertile (producing mature ripe bunches with high fruit set) or semi fertile (with partial fruit set) or sterile forms (no fruit set). The sterile *pisiferas* are preferred in hybrid seed production and used as male parent in *Dura*× *Pisifera* hybridization programme for the production of cultivated *tenera*. Preliminary investigations on *pisifera* palms characterization and allied components were studied by Pillai and Nampoothiri (1981). Characterization of *pisifera* palms were also undertaken in a *tenera* inter se matted progeny population as a part of breeding for hybrid seed production by Murugesan *et al*. (2008) using Thodupuzha materials which were extensively used in the Indian breeding programme. However, there is a necessity to introgress new and distant *pisifera* sources into the ongoing programme and identify potential *pisiferas* for the pollination of many *dura* mother palms over a long period. The benefit to be obtained from *pisifera* progeny testing will depend on the amount of genetic variation within *pisifera* population.

Morpho-agronomic characteristics: To broaden the oil palm genetic base, Pillai *et al*. (2000) collected different exotic genetic resources during 1995 under FAO sponsored programme. Thirty one accessions of such resources were planted during 1998 in the field gene bank at ICAR-Indian Institute of Oil Palm Research (Formerly known as Directorate of Oil Palm Research), Research centre Palode. Phenotypic screenings of these collections are done as per IBPGR (1989) descriptors (whichever characters available for *pisifera* fruit form) revealed a significant diversity for the valuable agronomical characteristics. The reported germplasm with *virescens* and sterile fruit characteristics was selected based on the phenotypic data described by Corley *et al*. (1971), such as: (1). bunch numbers, weight and production; (2) fresh fruit bunch and oil content; (3) vegetative characters; (4) fruit shell thickness; (5) fruit colour and bunch analysis as per Blaak *et al*. (1963). All the vegetative characters were measured during June month of every year and average of four years was reported. Bunch production and number of bunches were recorded quarterly, bunch analysis was done for three bunches during peak season and average of four years were reported for all the measured parameters.

Associated characters and cultivation practices: The fruit form analysis in the open pollinated progeny population of exotic oil palm block revealed that out of 87 individual palms of 37 accessions, three *pisifera*, one *tenera* and 83 *dura* palms were recorded. The identified three *pisifera* palms were further evaluated by

Murugesan and Goutam Mandal (2010) for vegetative and bunch characteristics and the results revealed that two *pisiferas* (DOPRG-53-E-75 and DOPRG-54-E-65) showed aborted bunches throughout the evaluation period where as other one *pisifera* (DOPRG-53-E-66) showed fertile character which recorded normal bunch and fruit development with 25% fruit to bunch ratio. Few fruit set occurred two times in IC0597689 due to spraying of 2,4,5-TP (2,4,5- Trichlorophenoxy propionic acid) revealed the presence of *virescens* fruit colour and presence of shell less kernel. Close examination of these fruits revealed that the stylar ends of the fruits were either dark green or orange in colour and their pedicellar ends were creamy white or yellow and weight ranged from 1g to 5g. Oil analysis revealed that orange colour fruits recorded 89 % of oil/fruit, whereas green coloured and white fruits recorded no oil. The reported sterile *pisifera* with *virescens* (IC0597689) in terms of vegetative characteristics showed no significant differences with other two checks (DOPRG-53-E-66 and DOPRG-53-E-75) (Anonymous, 2009). The frequency of *virescens* in the natural population in Nigeria was unexpectedly low even though gene controlling this particular character is dominant. This type is relatively uncommon which was noticed only in *dura* and *tenera* forms of fruits. *Virescens pisifera* are very rare which are called 'Gracilinux'– *virescens pisifera* as reported by Chevalier during 1910. It would be advantageous to produce planting materials with *virescens* fruits for easy identification of ripe bunches. The reported *pisifera* palm DOPRG-54-E65 (IC0597689) with *virescens* fruit and sterile characteristics is considered as valuable genetic resource with practical utility as it could be used as male parent along with *virescens dura* parent available with ICAR-IIOPR for the production of *virescens tenera*. DOPRG-54-E65 could be considered as ideal *pisifera* and the general as well as specific combining ability is being tested with advanced *dura* mother palms for hybrid seed production and supply to farmers.

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59. IC0597690 (DOPR G23-48) (IC0597690; INGR17086), a Dwarf Oil Palm (*E. guineensis* × *E. oleifera*) Germplasm with 12 cm Annual Height Increment. High Fruit Set (69.09%)

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The genus *Elaeis* consists of two species namely, *Elaeis oleifera* HBK and *Elaeis guineensis* Jacq. The former one is called American oil palm which is a wild relative of cultivated type. Wild oil palm has low oil yield but it has several desirable characteristics, *viz.* slow vertical growth, disease resistance and best oil quality. A palm oil with a greater proportion of unsaturated fatty acids attracts new market opportunities for oil palm planters (Montoya *et al.* 2013). American oil palm is native to Central America and northern South America, is an important source of genetic variability for oil palm breeding. To sustain high yields, *E. oleifera* × *E. guineensis* (O×G) hybrids are backcrossed with *E. guineensis* and the progenies resulting from this breeding strategy present variability.

Morpho-agronomic characteristics: The interspecific hybrid combinations evolved from the pure stand of *E. oleifera* of exotic germplasm accession planted at the field gene bank established during 1994 under the tropical climate of Kerala, South India (8° 45'N and 77° 59' E and 210 m above sea level) were utilized to develop promising palms of O × G hybrids. *E. oleifera* has a marked tendency towards the production of parthenocarpic fruits. This character is fully dominant in the hybrid. Because of this the percentage fruit per bunch in the hybrids tends to become higher than *E. guineensis* partly offsetting the lower percentage oil to mesocarp. Hybrid progenies of *E. guineensis* × *E. oleifera* were planted during 1998 in forest laterite soil at Research Centre of ICAR-Indian Institute of Oil Palm Research. A transfer of genes from the species *Elaeis oleifera* to the oil palm species (*Elaeis guineensis*) was made using backcrosses, with an objective of obtaining a cultivar with high fruit and oil production per unit of area with slow rate of growth. A progeny population from one combination namely (progenitor 16 *Elaeis oleifera (1992planting)* × 18 *Elaeis guineensis (1992)* observed with unique characteristics *viz*., high fruit set and unique fruit colour (deep red skin and yellow mesocarp) apart from compact slow height increment.

Associated characters and cultivation practices: According to Escobar and Alvarado, (2004), the original compact palm (OCP) was discovered in observation plots planted in Coto, Costa Rica, which were planted with open-pollinated seeds from an *E. oleifera* × *E. guineensis* inter-specific hybrid (O × G) with outstanding characteristics of slow growth and short leaves, identified in 1966 in Quepos, Costa Rica, but unfortunately their bunches were reported to be poor in fruit set, whereas proposed genetic Stock DOPRG 23 (IC 0597690) has compact characteristics and high fruit set (DOPR Annual Report 2009-10, DOPR Vision, 2030, DARE/ICAR Annual Report, 2010-11). The progenies generated from the proposed genetic stock also recorded compact characteristics; high fruit set and exhibited stabilised characteristics similar to that of cultivated type of oil palm (DOPR News, 2012).

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60. IC0597691 (DOPR G21-221)(IC0597691; INGR17087), an Oil Palm (*Elaeis guineensis*) Germplasm with Slow Vertical Stem Growth (low annual height increment of 25 cm per year). Compact Palm with Tenera (thin shell thickness of 1.56 mm) Fruit Form

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The Oil palm (*Elaeis guineensis* Jacq.) is a commercial crop demanding large tracts of land for its exploitation. High yielding compact palms with slow stem elongation and short leaves become good alternative for prolonging commercial exploitation (Escobar and Alvarado, 2004). Advantage of reduced height increment is only seen after many years, when height starts to have an effect on harvesting cost. Reducing height has always been interest to oil palm industry because of the high cost of harvesting tall palms (Bakoume and Louise, 2007). However, selection for yield will tend to favour taller palms and Corley and Lee (1992) reported that selected Deli *dura* were 15-22% taller at the same age than unselected material. Dumortier (2000) found a significant positive correlation between progeny means for yield and height. According to Corley and Tinker (2003), finding special small and productive palms with potential commercial value is not an easy task and only a few examples of such palms have been documented worldwide. Nampoothiri (1998) emphasized the usefulness of compact characters in breeding for dwarfness for sustainable development of oil palm in India. Several exotic germplasm collections were made from different oil palm growing countries to India (Pillai, 1994).

The Nigerian *tenera* population with the progenitor of 26.3999 D × 25.380P were introduced to India through National Bureau of Plant Genetic Resources (NBPGR) vide code number E 130756 during 1979 which were field planted at Research Centre of ICAR-IIOPR at Palode during 1981. One *tenera* palm from Nigerian introduction showed dumpy characteristics (Pillai, 1994; Nampoothiri, 1998) as they recorded low vertical growth compared to similar aged and simultaneously planted crosses/progenies. Dwarf *tenera* was subjected to characterization and yield evaluation as per IBPGR (1989) descriptor with necessary additional characteristics. Bunch Analysis was done as per standard procedures. Five Fresh Fruit Bunches (FFB) from each palm were utilized for bunch analysis.

Morpho-agronomic characteristics: The results of evaluation in terms of morpho-agronomic characters revealed that the proposed dwarf *tenera* recorded an average yield of 118 kg/palm/year with 9.1 bunch numbers and 24 cm height increment (Murugesan *et al*., 2008). Rajanaidu and Jalani (1994) reported short height increment of 15-25 cm within dwarf populations from Nigerian collections at Palm Oil Research Institute of Malaysia (PORIM). The present proposed genetic stock has short rachis length (4.85 m), inter nodal leaflet distance (2.5 to 3 cm), leaflet length (85.33 cm), petiole width (8 cm), petiole depth (2.92 cm), leaflet breadth (4 cm), frond base length (75 cm), frond base width (10 cm), frond base scar measured at two feet from the ground level (5 cm) and other vegetative characteristics when compared to commercial *tenera* of same age planted adjacent to this palm. Adon *et al*. (2001) observaed high heritability for oil palm height increment. Other notable compact characters of the proposed *tenera* were stunted fronds with reduced leaflet length, compact crown, dumpy canopy structure and reduced inter nodal leaflets (Murugesan *et al*., 2009; Murugesan and Sunil Kumar, 2014).

Associated characters and cultivation practices: Considering over all dumpy nature, the proposed palm of genetic stock DOPR G1 (221) has been incorporated into breeding programme of ICAR-Indian Institute of Oil Palm Research (IIOPR) and this palm has been subjected to selfing and *inter se* crossing and progenies were established at ICAR-IIOPR, Pedavegi, Andhra Pradesh. Out of the 58 palms evaluated, 23 recorded height increment of < 40 cm, four palms recorded < 30 cm and one palm recorded 25 cm annual height increment with Bunch Index of 0.43 as against the standard value of 0.30 for normal *tenera* (*dura* × *pisifera*) material (Anonymous, 2012; Anonymous, 2013). Four individual palms which were screened from the progeny trial were selfed/ *inter se* mated for the establishment of seed garden and seed production for dwarf palms.

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61. IIHRG 6 (IC0621473; INGR17088), a Gladiolus (*Gladiolus hybridus*) Germplasm with Unique Floret Colour [Purple (78.A) middle, Red–Purple (72.A) Margin with Green-Yellow (1.D) blotch], Open-faced Floret and Double Rows of Floret Placement

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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 6 is derived from the cross Poonam x Gold Medal 412 followed by selection and it was developed at ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka (13^{o} 58' N Latitude, 78^{o}E Longitude and at an altitude of 890 meter above mean sea level), India. The hybrid selection IIHRG 6 is unique for its floret colour [Purple (78.A) middle. Red–Purple (72.A) margin with Green-Yellow (1.D) blotch], open-faced floret and floret placement is in double rows.

Morpho-agronomic characteristics: The plants are tall (121.85 cm) and on an average produces florets in 65.03 days. Its average spike length is 104.55 cm and rachis length (45.80 cm) which bears 13.01 florets per spike. On an average, it also produces 1.82 number of marketable spikes per corm, 2.22 number of corms and 27.24 number of cormels per mother corm.

Associated characters and cultivation practices: Gladiolus is commercially propagated through corms and cormels. It grows well in sandy loam soil rich in organic matter and nutrients with pH of 6.5 to 7. The corms of 4 to 5 cm diameter should be planted at a spacing of 30 cm × 20 cm at about 5 cm depth of the soil. Before planting, brown scales on the corms are removed and the corms have to be treated with carbendazim (0.2%) and captan (0.2%) for 15 to 20 minutes for protection against *Fusarium* wilt. In general, recommended dose of fertilizer is 25 tones of farmyard manure, 200 kg N, 200 kg P_2O_5 and 200 kg K_2O per hectare as basal dose (Rao *et al.,* 2010). Earthing up to a height of 10-15 cm at three and six leaf stage is required. In and around Bangalore planting during the June, October and November months found to be the best considering the quality of the spike. The major insect pests of gladiolus are thrips, caterpillar and mites. In India, it is grown in Uttar Pradesh, Maharashtra, Sikkim, Delhi, Punjab, Karnataka, West Bengal, Jammu and Kashmir, Himachal Pradesh, Haryana, Assam, Nagaland and Rajasthan.

Table 1. Morpho-agronomic description of Gladiolus hybrid selection IIHRG 6

Trait Description	Pooled data of three years
Days to spike emergence	54.09
Days to flower	65.03
Plant height (cm)	121.85
Spike length (cm)	104.55
Rachis length (cm)	45.80
Floret size (cm)	9.61
No. of florets per spike	13.01
Florets remain open at a time (No.)	6.38
Total spikes per corm (No.)	2.00
Marketable spikes per corm (No.)	1.82
Flowering duration (Days)	8.18
Vase life (Days)	7.67
Spike weight (g)	48.33
Corm per corm (No.)	2.22
Cormel per corm (No.)	27.24
Size of corm (cm)	5.99
Size of cormel (cm)	1.08
Weight of corm (g)	60.33
Weight of comel (g)	0.56

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62. IIHRG 12 (IC0621474; INGR17089), a Gladiolus (*Gladiolus hybridus*) Germplasm with Unique Floret Colour [Purple Violet (82.A) having Purple (77.A) Margin, Green White (157.C) Line on Lower Lip] and Early Flowering (61.54 Days)

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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 12 is derived from the cross Junior prom × Poonum followed by selection and it was developed at ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka (13°58' N Latitude, 78°E Longitude and at an altitude of 890 meter above mean sea level), India. The hybrid selection IIHRG 12 is unique for its floret colour [Purple Violet (82.A) having Purple (77.A) margin. Green White (157.C) line on lower lip] and early flowering.

Morpho-agronomic characteristics: The plants are tall (131.00 cm) and on an average produces florets in 61.54 days. Its average spike length is 107.66 cm and rachis length (51.87 cm) which bears 14.88 florets per spike. On an average, it also produces 1.59 number of marketable spikes per corm, 1.82 number of corms and 52.56 number of cormels per mother corm.

Associated characters and cultivation practices: Gladiolus is commercially propagated through corms and cormels. It grows well in sandy loam soil rich in organic matter and nutrients with pH of 6.5 to 7. The corms of 4 to 5 cm diameter should be planted at a spacing of 30 cm x 20 cm at about 5 cm depth of the soil. Before planting, brown scales on the corms are removed and the corms have to be treated with carbendazim (0.2%) and captan (0.2%) for 15 to 20 minutes for protection against *Fusarium* wilt. In general, recommended dose of fertilizer is 25 tones of farmyard manure, 200 kg N, 200 kg P_2O_5 and 200 kg K_2O per hectare as basal dose (Rao *et al.,* 2010). Earthing up to a height of 10-15 cm at three and six leaf stage is required. In and around Bangalore planting during the June, October and November months found to be the best considering the quality of the spike. The major insect pests of gladiolus are thrips, caterpillar and mites. In India, it is grown in Uttar Pradesh, Maharashtra, Sikkim, Delhi, Punjab, Karnataka, West Bengal, Jammu and Kashmir, Himachal Pradesh, Haryana, Assam, Nagaland and Rajasthan.

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Table 1. Morpho-agronomic description of Gladiolus hybrid Selection IIHRG 12

Trait Description	Pooled data of three years
Days to spike emergence	51.54
Days to flower	61.54
Plant height (cm)	131.00
Spike length (cm)	107.66
Rachis length (cm)	51.87
Floret size (cm)	9.62
No. of florets per spike	14.88
Florets remain open at a time (No.)	5.59
Total spikes per corm (No.)	1.85
Marketable spikes per corm (No.)	1.59
Flowering duration (Days)	9.63
Vase life (Days)	8.00
Spike weight (g)	58.33
Corm per corm (No.)	1.82
Cormel per corm (No.)	52.56
Size of corm (cm)	5.16
Size of cormel (cm)	1.12
Weight of corm (g)	55.22
Weight of comel (g)	0.69
Floret Type	Open-faced
Floret texture	Medium
Floret structure	Wavy
Floret placement	Good

63. IIHR 3-34 (IC06214771; INGR17090), a Gerbera (*Gerbera jamesonii*) Germplasm with Unique Flower Head Colour (68D, Red Purple Group) and Double Type Flower Head

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Gerbera (*Gerbera jamesonii* Bolus ex. Hooker F.), family Asteraceae, is one of the important cut-flowers grown for domestic and export markets. Gerbera is grown under 820 ha with productivity of 17,500 t/ha, amounting to the fourth most important cut-flower in India. The gerbera hybrid IIHR 3-34 is novel genetic stock for its flower head colour (68D, Red Purple Group) and double type flower head. It was developed through half-sib method of breeding where superior line IIHR-3 was crossed with pollen mixed from different varieties. The F_1 hybrids seeds obtained from this cross were germinated *in vitro* on suitable media. A large number of plants were obtained through tissue culture to initially evaluate for novel traits and flower quality. This hybrid was developed at ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka (13^{o}58' N Latitude, 78^{o}E Longitude and at an altitude of 890 meter above mean sea level), India.

Morpho-agronomic characteristics: The hybrid IIHR3-34 recorded flower diameter (10.85 cm), flower stalk length (61.06 cm), flower stalk diameter (6.42 mm), number of flowers/month (3.23), vase life (7.30 days) and flower head colour as per RHS colour chart (68D, Red Purple Group) (Table 1).

Associated characters and cultivation practices: The hybrid IIHR 3-34 is novel for its flower head colour as per RHS Colour Chart (68D, Red Purple Group) and

Table 1. Evaluation of gerbera hybrid IIHR 3-34 for flower quality traits under polyhouse

Hybrid/ genotype	Flower diameter (cm)	Flower stalk length (cm)	Flower stalk diameter (mm)	No. of flowers/ month	Vase life (days)	Thrips (% flowers damage)	Whitefly (Nos. on 3rd leaf)	Mites damage (Nos./leaf)	RHS Colour Chart
IIHR 3-34	10.85	61.06	6.42	3.23	7.30	17.75	7.15	5.35	68D, Red Purple Group
IIHR-3 (parent)	11.41	49.75	6.74	2.83	7.05	17.05	7.30	5.67	52A, Red Group
Elite (check)	10.91	60.38	6.62	2.96	7.47	18.85	7.40	5.27	24A, Orange Group
SEm±	0.18	1.85	0.04	0.12	-	-	-	-	-
CD at 5%	0.55	5.55	0.16	0.36	NS	NS	NS	NS	-

double type flower head. It recorded % flowers damage by thrips (17.75), number of whitefly on 3rd leaf (7.15), number of mites damage/leaf (5.35). However, data on damage from thrips, white fly and mites was on par with the parent and the check variety. Gerbera is commercially gerbera is grown in polyhouse or shade house. Day temperature of 22°-25°C and night temperature of 12-16°C is ideal for growth and flower production. It grows well on raised beds of loamy soil, rich in organic matter with soil pH of 5.5-6.5 and EC less than 1 dS/cm^2. The beds are drenched with commercial formalin to minimize infestation of soil-borne pathogens. On average water requirement may be 500 to700 ml/plant/day (4.5-6.0 litres/day/m^2). During first three months of planting apply 10:15:20g 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, better growth and increased flower production. Application of micronutrients *viz.,* boron, calcium, magnesium and copper @ 0.15% once in a month is desirable for obtaining good quality flowers (Aswath *et al,* 2015).

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64. IIHR 8-45 (IC0621472; INGR17091), a Gerbera (*Gerbera jamesonii*) Germplasm with Unique Flower Head Colour (50A, Red group) and Double Type Flower Head

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Gerbera (*Gerbera jamesonii* Bolus ex. Hooker F.), family Asteraceae, is one of the important cut-flowers grown for domestic and export markets. Gerbera is grown under 820 ha with productivity of 17,500 t/ha, amounting to the fourth most important cut-flower in India. The gerbera hybrid IIHR 8-45 is novel genetic stock for its flower head colour (50A Red Group) and double type flower head. It was developed through half-sib method of breeding where superior line IIHR-1 was crossed with pollen mixed from different varieties. The F_1 hybrids seeds obtained from this cross were germinated *in vitro* on suitable media. A large number of plants were obtained through tissue culture to initially evaluate for novel traits and flower quality. This hybrid was developed at ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka (13° 58´ N Latitude, 78°E Longitude and at an altitude of 890 meter above mean sea level), India.

Morpho-agronomic characteristics: The hybrid IIHR8-45 recorded flower diameter (10.43 cm), flower stalk length (61.11 cm), flower stalk diameter (5.63mm), number of flowers/month (2.89), vase life (7.15 days) and flower head colour as per RHS Colour Chart (50A Red Group) (Table 1).

Associated characters and cultivation practices: The hybrid IIHR 8-45 is novel for its flower head colour as per RHS Colour Chart (50A Red Group) and double type flower head. It recorded % flowers damage by thrips (17.89), number of whitefly on 3rd leaf (7.31), number of mites damage/leaf (5.15). However, data on damage from thrips, white fly and mites was on par with the parent and the check variety. Gerbera is commercially gerbera is grown in polyhouse or shade house. Day temperature of 22^{o}-25^{o}C and night temperature of 12-16^{o}C is ideal for growth and flower production. It grows well on raised beds of loamy soil, rich in organic matter with soil pH of 5.5-6.5 and EC less than 1 dS/cm^2. The beds should be drenched with commercial formalin to minimize infestation of soil-borne pathogens. On average water requirement may be 500 to 700 ml/plant/day (4.5-6.0 litres/day/m^2). During first three months of planting apply 10:15:20g 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, better growth and increased flower production. Application of micronutrients *viz.*, boron, calcium, magnesium and copper @ 0.15% once in a month is desirable for obtaining good quality flowers (Aswath *et al.*, 2015).

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Aswath C, Rajiv Kumar, T M Rao, M V Dhananjaya, V Sridhar, S Sriram and Sudha Mysore (2015) Polyhouse cultivation of gerbera. *Extension Folder No.* 91. Director, ICAR-IIHR, Bangalore.

Table 1. Evaluation of gerbera hybrid IIHR8-45 for flower quality traits under polyhouse

Hybrid/ genotype	Flower diameter (cm)	Flower stalk length (cm)	Flower stalk diameter (mm)	No. of flowers/ month	Vase life (days)	Thrips (% flowers damaged)	Whitefly (Nos./3rd leaf)	Mites (Nos./leaf)	RHS Colour Chart
IIHR 8-45	10.43	61.11	5.63	2.89	7.15	17.89	7.31	5.15	50A Red Group
IIHR1 (parent)	10.25	51.98	4.69	2.49	7.00	17.62	7.42	5.35	30A, Orange Red
Elite (check)	10.91	61.38	6.63	2.96	7.25	18.85	7.41	5.25	24A, Orange Group
SEm±	-	0.93	0.06	0.14	-	-	-	-	-
CD at 5%	NS	2.79	0.18	0.39	NS	NS	NS	NS	-