# Plant Germplasm Registration Notice*

The Plant Germplasm Registration Committee of ICAR in its XXXXIIInd meeting held on December 21st, 2020 at the National Bureau of Plant Genetic Resources, New Delhi approved the registration of following 39 germplasm lines out of 43 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. SC-11/SP70/TI-26/SB-8 (IC0635696; INGR20079), a Rice (*Oryza sativa*) Germplasm with Higher Culm Strength in Elite Genetic Background of Samba Mahsuri

**M Sheshu Madhav[1*], GS Laha[1], LV Subba Rao[1], RM Sundaram[1], AP Padma Kumari[1], P Senguttuvel[1], HK Patel[2] and RV Sonti[2]**

[1]*ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad, Telangana, India*
[2]*CSIR-Center for Cellular and Molecular Biology, Hyderabad, Telangana, India*
[*]*Email: sheshu24@gmail.com*

Strong culm is one of most important agronomical trait and directly involved in lodging resistance. Lodging resistance is a complex trait, determined by culm diameter, strength and elasticity of culm. To obtain novel genetic sources for strong culm, 10,500 EMS induced mutant population was developed in the genetic background of Samba Mahsuri in collaboration with CSIR-CCMB. The mutant, TI-26 (SP-70/SB-8/SC-11) had strong culm which can be used as donor material for rice improvement. The selection of strong culm mutant SC-11 was done in M2 generation after screening every season, selected single strong culm plant and advanced to M8 through panicle to row method.

**Morpho-agronomic characteristics:** The mutant, TI-26 (SP-70/SB-8/SC-11) was evaluated for their agro-morphological variations at Indian Institute of Rice Research (ICAR-IIRR); ICRISAT, Hyderabad and Kakanoor village, Ranga Reddy district during years 2013-2016. The important agro morphological traits are given in the table.

**Agro morphological traits**

| Characteristics | Description |
|---|---|
| Plant ht (cm) | 105 |
| No of tillers | 18 |
| No of panicles | 18 |
| Panicle length (cm) | 22 |
| Grains per panicle | 220 |
| Yield / plant (g) | 21.2 |
| Days of flowering (50%) | 100 |
| Grain type | Medium bold |

**Associated characters and cultivation practices Phenotyping for Strong Culm**

**TI-26 (SP-70/SB-8/SC-11)** was selected during the years of 2012-2016 by estimating the culm strength and diameter using prostate tester. SC-11 has more culm diameter and culm strength (11.5 mm, 31.5 Nu/$m^2$) than the wild type (5.1 mm, 25 Nu/$m^2$). Anatomical characters studied under scanning electron microscope (SEM) revealed an increase in the thickness of lignified epi/sub epidermal and lignified parenchymatous tissue layers and a decrease in the distance of inter vascular bundles which explain the strong culm nature of the mutant. Strong culm mutant also showed higher photosynthetic rate (9.8 µ mol $CO_2$ $m^2S^{-1}$) as compared to wild type (3.5 µ mol $CO_2$ $m^2S^{-1}$). Whereas, transcription rate of the mutant was lower (0.40 µ mol $H_2O$ $m^2$ $S^{-1}$) as compared to wild type (1.80 µ mol $H_2O$ $m^2$ $S^{-1}$). (IIRR newsletter, 2016; Gopi *et al*., 2019 presented poster at NCIPBB conference).

[*]*Compiled and edited by: Anjali Kak and Veena Gupta, Division of Germplasm Conservation, ICAR-National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi-110012*

**Table 1. Summary of the molecular analysis using SSR markers**

| Designation | Markers per chromosome | | | | | | | | | | | | Total | % of genomic similarity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | |
| TI-26 | 13 | 11 | 10 | 11 | 10 | 12 | 11 | 10 | 11 | 10 | 11 | 10 | 130# | 97% genomic similarity with wild type |
| | 13 | 11 | 10 | 11 | 8 | 10 | 11 | 10 | 11 | 10 | 11 | 10 | 126* | |

# is the total number of markers tested
* is the total number of monomorphic markers with wild type (BPT 5204)
Highlighted chromosomes has polymorphic regions

**Genotyping:** To know the allelic status of reported strong culm genes (*SCM2* and *SCM3*), PCR based allele mining was performed and determined that this mutant has novel allele than the reported alleles (Gopi *et al.,* 2019a (poster at NCIPBB conference)). For the estimation of genomic similarity with wild type a total of 130 SSR markers (selected based on a ~1 marker per 5Mb) which were spread uniformly across the twelve linkage groups were used. The results indicated that TI-26 (SP-70/ SB- 8/SC-11) has 97% of genomic similarity with wild type (BPT 5204) (Table 1). To identify mutated loci for conferring the culm strength, MutMap (NGS based approach) analysis was performed in strong culm and weak culm bulks of F2 population derived from BPT 5204 × TI-26. The sequence reads of strong culm bulk was compared with the wild type as well as reads of weak culm bulk was compared with the strong culm mutant. Analysis of SNP index plots (prepared based on the comparison of strong culm bulk with wild type) indicated two peak regions on chromosome 5 (27.7Mb-29.2Mb) & chromosome 6 (6.2Mb-10.8Mb), the peak at chromosome 6 matched with the QTLs (qSC-2 & qSC3) identified using F2 mapping population derived from TI-26 × TN1 (diverse parent) (Annexure B; Figure 3). Validation of identified SNPs, thereby identification of candidate gene(s) having correlation to the culm strength is in the progress (Gopi *et al*., 2019 (poster presented at NCIPBB conference). This identified mutant (SC-11) having strong culm is a novel genetic resource. Since, it shows strong culm nature which was deciphered through physical analysis, anatomical features and molecular characterization. Thus, SC-11 can be used as a donor in rice improvement programmes for imparting strong culm trait.

## References

IIRR Annual report 2017-18.

Gopi P, PK Guha, B Suneel, B Vishalakshi, GS Laha, LV Subba Rao, RM Sundaram, HK Patel, RV Sonti and M Sheshu Madhav (2019a) Identification and characterization of Samba Mahsuri mutants having strong culm for development of lodging resistant rice lines presented poster at NCIPBB conference during November 08-09, 2019 at Hyderabad, India.

Gopi P, GS Laha, B Vishalakshi, K Divya, L Swathi, PV Srividya, B Suneel, RM Sundaram, HK Patel, RV Sonti and MS Madhav (2019b) Identification of novel genetic resources for sheath blight tolerance from mutant lines of samba mahsuri presented poster at NCIPBB conference during November 08-09, 2019 at Hyderabad, India.

# 2. ShB-1/SB-5 (IC0635695; INGR20080), a Rice (*Oryza sativa*) Germplasm Highly Tolerant to Sheath Blight. Medium Slender Grain Type in Genetic Background of Samba Mahsuri.

**M Sheshu Madhav[1*], GS Laha[1], LV Subba Rao[1], RM Sundaram[1], AP Padma Kumari[1], P Senguttuvel[1], HK Patel[2] and RV Sonti[2]**

[1]*ICAR-Indian Institute of Rice Research, Rajendra Nagar, Hyderabad, Telangana, India*
[2]*CSIR-Centre for Cellular and Molecular Biology, Uppal Road, Hyderabad, Telangana, India*
[*]*Email: sheshu24@gmail.com*

Sheath blight is a major biotic stress in rice. There are no absolute resistance sources are available in the germplasm. To obtain novel resistant/tolerant sources for sheath blight, 10,500 EMS induced mutant population was developed in the genetic background of Samba Mahsuri in collaboration of ICAR-IIRR and CSIR-CCMB. The selection of sheath blight tolerant mutant (ShB-1/SB-5) was done at $M_2$ generation after screening multiple seasons, selected single tolerant plant is advanced to $M_8$ through panicle to row method.

**Morpho-agronomic characteristics:** The mutant ShB-1 was evaluated for the agro-morphological variations at Indian Institute of Rice Research Farm (ICAR-IIRR) during 2016 (Gopi *et al*., 2017a & b). All the cooking and eating quality characteristics were similar to that of Samba Mahsuri (wild type). The important agro morphological traits were given below

| Characteristics | Description |
|---|---|
| Plant ht (cm) | 85 |
| No of tillers | 13 |
| No of panicles | 13 |
| Panicle length (cm) | 16.2 |
| Grains per panicle | 210 |
| Yield / plant (g) | 16.2 |
| Days of flowering (50%) | 108 |
| Grain type | Medium slender |

**Associated characters and cultivation practices**

Phenotyping for Sheath blight tolerance: ShB-1 mutant was screened for sheath blight tolerance under field and laboratory conditions (detached leaf method) during the years of 2013-2015. The mutant ShB-1 showed mean score of '0' for sheath blight tolerance whereas Samba Mahsuri (wild type), showed mean score of 9.0 (Gopi *et al*., 2017a). ShB-1 also screened with 10 most virulent and diverse *R. solani* isolates (TN14-1, RNR 13-F, TTB-1, WGL-12-1, Gosaba-1, Kaual, PNT, Jamalpur-Bangar and Imphal-1) collected from various hotspot regions of India and showed resistance with a mean score of 2.84 and whereas wild type, TN1 (susceptible check) and Tetep (resistant check) showed mean score of 9.0, 9.0 and 4.45, respectively. Further, this mutant line screened at four hotspot locations (Kaul, Pantnagar, Chinsura and Monkompu) of India, which revealed mean score of 3.0. The identified mutant line can be served as best genetic resource in rice breeding programme as there are no reports on existence of absolute resistance genetic material in rice.

**Genotyping:** For the estimation of genomic similarity with wild type, a total of 130 SSR markers, which spread uniformly across the genome revealed 97% genomic similarity with wild type. Through MutMap analysis mutated locus on chromosome-1 was identified.

**References**

Gopi P, GS Laha, MD Ershad, RM Sundaram, LV Subba Rao, RV Sonti, P Sudhakar, AK Satya and MS Madhav (2017a) Identification of sheath blight tolerant through detached leaf method in samba Mahsuri (BPT 5204). *J. Pharmacogn. Phytochem.* ***SP1***: 234-235.

Gopi P, B Suneel, LV Subba Rao, RV Sonti, RM Sundaram, GS Laha, P Sudhakar, AK Satya and MS Madhav (2017b) Identification of Agro-morphological characters in sheath blight tolerant lines of Samba Mahsuri (BPT 5204) rice variety. *BEPLS* **6**: 41-45.

## 3. GW 2012-475 (IC0633421; INGR20081), an Early Maturity and High Yielding Wheat (*Triticum aestivum*) Germplasm

**JM Patel*, SK Patel and CR Patel**

*Wheat Research Station, Sardarkrushinagar Dantiwada Agricultural University, Vijapur, Gujarat, India*

**Email: jmwheat@sdau.edu.in*

Wheat is the second most important crop after rice both in terms of area and production in India. India produced a record 101.20 million tonnes of wheat from29.55 million hectares with a productivity of 34.24 q/ha in the year 2018-19 (ICAR- IIWBR, 2019). Wheat, a temperate crop, prefers a cooler climate for growth and reproduction. High temperatures during crop growth and grain filling stages are a major concern to its production. South Asia, comprising of India, Nepal, Pakistan and Bangladesh is one of the major wheat producing and consuming area in the world. This region suffers significant losses each year due to high temperature stress (Kumar *et al*., 2013). Earliness or early maturity is an adaptation strategy where early heading lines complete the initial seed setting and grain filling under favorable temperatures and avoid the late incidence of heat stress. Earliness has been suggested as a good approach for wheat breeding in the eastern Gangetic plains that suffers from high temperature stress during grain filling (Joshi *et al*., 2007). Improving the genetic adaptation of wheat cultivars to heat stress is an important objective in breeding programme. Looking to this need breeding work for early maturing and high grain yield was started at Wheat Research Station, Vijapur. Considering this aspect, cross was made using diverse genotypes (MACS 2496/CMH83.2578//GW 496/ WH 147//GW 496) and generation advancement was made using pedigree selection method (Allard, 1960). This genotype has been developed at Wheat Research

Station, SD Agricultural University at Vijapur for early maturity.

**Morpho-agronomic characteristics**: GW 2012-475 has semi-erect growth habit with medium broad leaves with 60 days to complete heading stage. During the period of testing, it was tested at national level under short duration screening nursery (SDSN) during the 2015-16 to 2017-18 (ICAR-IIWBR. 2019) in the central zone, in which GW 2012-475 found to be superior with 5.8 and 5.8 per cent higher grain yield over the years and locations to the check variety Sonalika, and WR 544, respectively.

**Table 1. Performance of GW 2012-475 genotype during 2015-16 to 2017-18**

| Trait | Year | Genotype | Checks | | |
|---|---|---|---|---|---|
| | | GW 2012-475 | Sonalika | HD 2932 | WR 544 |
| Mean Yield (g/plot) | 2015-16 | 486 | 442 | 406 | 436 |
| | 2016-17 | 465 | 485 | 520 | 465 |
| | 2017-18 | 518 | 461 | 517 | 488 |
| | Average | 490 | 463 | 481 | 463 |
| Heading days | 2015-16 | 61 | 59 | 62 | 55 |
| | 2016-17 | 59 | 60 | 62 | 58 |
| | 2017-18 | 61 | 58 | 62 | 60 |
| | Average | 60 | 59 | 62 | 58 |
| Maturity days | 2015-16 | 109 | 110 | 109 | 105 |
| | 2016-17 | 109 | 112 | 112 | 107 |
| | 2017-18 | 113 | 112 | 114 | 111 |
| | Average | 110 | 111 | 112 | 108 |
| Grains/spike | 2015-16 | 44 | 34 | 40 | 35 |
| | 2016-17 | 39 | 42 | 45 | 44 |
| | 2017-18 | 52 | 43 | 49 | 49 |
| | Average | 45 | 40 | 45 | 43 |
| 1000 gr.wt (g.) | 2015-16 | 43 | 44 | 42 | 41 |
| | 2016-17 | 44 | 46 | 43 | 43 |
| | 2017-18 | 40 | 42 | 38 | 38 |
| | Average | 42 | 44 | 41 | 41 |

**Associated characters and cultivation practices:** GW 2012-475 has medium broad leaves and flag leaf attitude is semi erect type, where as grains are bold, amber colour and oblong shape. Ear is having parallel shape and strong waxiness on ear and peduncle. It matures within 110 days; the agronomic practices for cultivation are to be followed as per late sown irrigated condition. This genotype is adapted to central zone.

## References

Allard RW (1960) Principles of Plant Breeding. John Wiley & Sons, Inc., New York.

ICAR-IIWBR (2019) Progress Report of AICRP on Wheat and Barley 2018-19, Ed(s): G Singh, R Chatrath, BS Tyagi, SK Singh, A Gupta, Satish Kumar, CN Mishra, K Venkatesh, V Gupta, C Singh, Gopalareddy K, H Khan, Raj Kumar, AK Sharma, Mamrutha HM, Bhumesh Kumar, Lokendra Kumar, S Sareen, R Tiwari, S Sheoran, Rinki, A Verma, Suman Lata, R Malik, OP Ahlawat, R Singh, P Sharma and GP Singh. ICAR-Indian Institute of Wheat and Barley Research, Karnal, Haryana, India.p.201.

Joshi AK, B Mishra, R Chatrath, G Ortiz-Ferrara and RP Singh (2007) Wheat improvement in India: Present status, emerging challenges and future prospects. *Euphytica* **157**: 431–446

Kumar S, P Kumari, U Kumar, M Grover, AK Singh, R Singh and RS Senger (2013) Molecular approaches for designing heat tolerant wheat. *J Plant Biochem Biotechnol*. **22**: 359–371

# 4. GW 2010-321 (IC0633420; INGR20082), an Early Maturing and High Yielding Wheat (*Triticum aestivum*) Germplasm

**JM Patel*, SK Patel and CR Patel**

*Wheat Research Station, Sardarkrushinagar Dantiwada Agricultural University, Vijapur-384570, Gujarat, India*
**Email: jmwheat@sdau.edu.in*

Wheat is the second most important crop after rice both in terms of area and production in India. India produced a record 101.20 million tonnes of wheat from 29.55 million hectares with a productivity of 34.24 q/ha in the year 2018-19 (ICAR-IIWBR, 2019). Wheat, a temperate crop, prefers a cooler climate for growth and reproduction. High temperatures during crop growth and grain filling stages are a major concern to its production. South Asia, comprising of India, Nepal, Pakistan and Bangladesh is one of the major wheat producing and consuming area in the world. This region suffers significant losses each year due to high temperature stress (Kumar *et al*., 2013). Earliness or early maturity is an adaptation strategy where early heading lines complete the initial seed setting and grain filling under favorable temperatures and avoid the late incidence of heat stress. Earliness has been suggested as a good approach for wheat breeding in the eastern Gangetic plains that suffers from high temperature stress during grain filling (Joshi *et al*., 2007). Improving the genetic adaptation of wheat cultivars to heat stress is an important objective in breeding programme. Looking to this need breeding work for early maturing and high grain yield started at Wheat Research Station, Vijapur. Considering this aspect, cross was made using diverse genotypes (GW 366/HW 1042//KAUZ*2//TC*6/RL 6081/3/KAUZ) and generation advancement was made using pedigree selection method (Allard, 1960). This genotype has been developed at Wheat Research Station, S.D. Agricultural University at Vijapur for early maturity.

**Morpho-agronomic characteristics**: GW 2010-321 has erect growth habit and it's mature within 108 days. During the period of evaluation, it was tested at national level under short duration screening nursery (SDSN) during the 2015-16 to 2017-18 (ICAR-IIWBR, 2019) in the North eastern plain zone (NEPZ), in which GW 2010-321 found to be superior with 30.8, 26.5, and 16.1 per cent higher grain yield over the years and locations to the check variety Sonalika, DBW 14 and WR 544 respectively.

**Table 1. Performance of GW 2010-321 genotype during 2015-16 to 2017-18**

| Trait | Year | Genotype | Checks | | |
|---|---|---|---|---|---|
| | | GW 2010-321 | Sonalika | DBW 14 | WR 544 |
| Mean Yield (g/plot) | 2015-16 | 290 | 215 | 254 | 247 |
| | 2016-17 | 531 | 434 | 455 | 504 |
| | 2017-18 | 541 | 393 | 368 | 422 |
| | Average | 454 | 347 | 359 | 391 |
| | % increase over check | - | 30.8 | 26.5 | 16.1 |
| Heading days | 2015-16 | 67 | 66 | 66 | 63 |
| | 2016-17 | 69 | 66 | 65 | 63 |
| | 2017-18 | 70 | 67 | 70 | 66 |
| | Average | 69 | 66 | 67 | 64 |
| Maturity days | 2015-16 | 104 | 102 | 105 | 104 |
| | 2016-17 | 108 | 105 | 105 | 104 |
| | 2017-18 | 112 | 108 | 109 | 107 |
| | Average | 108 | 105 | 106 | 105 |
| Grains/spike | 2015-16 | 51 | 43 | 47 | 44 |
| | 2016-17 | 53 | 42 | 41 | 42 |
| | 2017-18 | 40 | 40 | 42 | 44 |
| | Average | 48 | 42 | 43 | 43 |
| 1000 gr. wt (g.) | 2015-16 | 35 | 37 | 38 | 37 |
| | 2016-17 | 37 | 41 | 38 | 40 |
| | 2017-18 | 36 | 38 | 37 | 38 |
| | Average | 36 | 39 | 38 | 38 |

**Associated characters and cultivation practices:** GW 2010-321 has medium broad leaves and flag leaf attitude is semi erect type, whereas grains are medium, amber colour and oblong shape. Ear is having tapering shape and strong waxiness on peduncle. This genotype posses 48 grains per spike which is 10.41% higher over best checks DBW 14 and WR 544. It matures within 108; the agronomic practices for cultivation are to be followed as per late sown irrigated condition. This genotype is adapted to North eastern plain zone (NEPZ).

### References

Allard, RW (1960) Principles of Plant Breeding. John Wiley & Sons, Inc., New York.

ICAR-IIWBR (2019) Progress Report of AICRP on Wheat and Barley 2018-19, Crop Improvement. Ed(s): G Singh, R Chatrath, BS Tyagi, SK Singh, A Gupta, Satish Kumar, CN Mishra, K Venkatesh, V Gupta, C Singh, Gopalareddy K, H Khan, Raj Kumar, AK Sharma, Mamrutha HM, Bhumesh Kumar, Lokendra Kumar, S Sareen, R Tiwari, S Sheoran, Rinki, A Verma, Suman Lata, R Malik, OP Ahlawat, R Singh, P Sharma and GP Singh. ICAR-Indian Institute of Wheat and Barley Research, Karnal, Haryana, India. p. 201.

Joshi AK, B Mishra, R Chatrath, G Ortiz-Ferrara and RP Singh (2007) Wheat improvement in India: present status, emerging challenges and future prospects. *Euphytica* **157**: 431–446.

Kumar S, P Kumari, U Kumar, M Grover, AK Singh, R Singh and RS Senger (2013) Molecular approaches for designing heat tolerant wheat. *J Plant Biochem Biotechnol*. **22**: 359–371.

## 5. UPB 1065 (IC0635429; INGR20083), a Barley (*Hordeum vulgare*) Germplasm with Low Beta Glucan Content (<3.5%) – Malt Quality Trait. High Filtration Rate and Kolbach Index. High Yield and Resistance to Yellow Rust.

**Jai Prakash Jaiswal*, Swati, Anil Kumar, RS Rawat and KV Singh**
*GB Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India*
**Email: jpj.gbpu@gmail.com*

Barley is an important crop for the production of malt products such as beer, health drinks etc. β-glucans content is an indicator of malt modification and quality in barley. Beta glucans (β-D-(1-3), (1-4) glucans) are major constituents of barley endosperm walls (Palmer, 1989). In the process of barley malt production and beer brewing, the incomplete degradation of endosperm cell wall causes excessive wort beta glucan (WBG), which would influence the expansion of hydrolase and protease into the malt cells and decrease the extract content in the wort. Excessive residual β-glucan in the malt will lead to an increase of (VIS) viscosity, which is not conducive to the filtration of wort and beer, and results in reduced malt quality. In addition to viscosity, β-glucans has a relationship with other malt quality traits such as speed of filtration and Kolbach index and may affect extract value. Low level of glucans upto 3.5 is regarded as a good malting trait (Kumar *et al*., 2017). Since, there is scarcity of genotypes with low levels of β-glucans, thus the genotype UPB 1065 with a β-glucans content <3.5 can serve as an important source for malt barley breeding programme for incorporating low β-glucans, which is required for good malting quality. UPB 1065 has been developed through selection breeding method from ICARDA material at G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand in 2016-17.

**Morpho-agronomic characteristics:** UPB 1065 is a six rowed hulled barley genotype with a range of 58-89 days to heading, 118-133 days to maturity, 85-113 plant height, 71-125 tiller per meter, yellow grain color and thousand grain weight of 35-48 gm. It has been tested in AICRP Co-ordinated Trials (IVT-MB-TS, NWPZ) during 2016-17 and recorded an average yield of 46.0 quintals per hectare. Malt quality tests of IVT malt barley trial in North Western Plains (IVT-MB-TS, NWPZ) showed that UPB 1065 has low β-glucan content i.e. 3.3% as compared to checks during 2016-17. The genotype was also included in National Barley Genetic stock nursery (NBGSN, 2017-18) as a source for low beta glucan. It was further tested at IIWBR, Karnal in 2018-19 and revealed low β-glucan content i.e. 3.5%.

**Associated characters and cultivation practices:** In addition to β-glucan content, UPB 1065 possess other malt quality traits like, high filtration rate and kolbach index, which affects extract value. Generally, good malt quality lines have poor resistance to yellow rust, a serious disease of barley. High degree of resistance to yellow rust was observed in UPB 1065 in National Barley Disease Screening Nursery, 2016-17. Combination of good malt quality characters with high level of resistance

is an additional advantage for the breeding programme for developing good malt varieties.

### References

Palmer GH (1989) Cereals in malting and brewing. In: *Cereal Science and technology*, pp. 61-242. Ed. Aberdeen University Press, Aberdeen, U.K.

Kumar D, S Narwal, RPS Verma and AS Kharub (2017) Genotypic and growing location effect on grain β-glucan content of barley under sub-tropical climates. *Indian J. Genet*. **77(2)**: 235-241.

Progress Report of All India Coordinated Wheat & Barley Improvement Project (2016-17), Barley network, ICAR-IIWBR, Karnal, India. pp. 2.46, 3.15-3.19, 5.7-5.8

Progress Report of All India Coordinated Wheat & Barley Improvement Project (2017-18), Barley network, ICAR-IIWBR, Karnal, India. 2.65 p.

## 6. EP 87 (IC343586) (IC0343586; INGR20084), a Drought Tolerant Sorghum (*Sorghum bicolor*) Germplasm

**M Elangovan*, MY Samdur, HS Talwar and Prabhakar**

*ICAR-Indian Institute of Millets Research, Hyderabad, Telangana, India*

**Email: elangovan@millets.res.in*

Sorghum [*Sorghum bicolor* (L.) Moench] is one of the important dry-land crops of semiarid tropics It is mainly grown in the drought prone areas to meet the food and fodder security of the region especially Maharashtra, Karnataka, Andhra Pradesh and Telangana where occurrence of drought is very common. Grain and fodder of post-rainy harvest fetches more prices because of good quality grain and fodder (Seetharama *et al*., 2010). Drought is one of the most damaging abiotic stresses affecting agriculture (Boyer, 1982). If it occurs at flowering, or in the grain filling stages, it may lead to reduction in yield, or crop failure. Drought response in sorghum has been characterized at both pre- and post-flowering stages (Talwar *et al*., 2010).

Experiments were conducted by Samdur *et al.* (2020) for two consecutive years in same field using split plot design with three replications during post-rainy seasons 2015–2016 and 2016–2017at Centre on Rabi sorghum (ICAR-Indian Institute of Millets Research), Solapur, Maharashtra. The main plots consisted of three levels of moisture regimes (three environments), namely (1) drought stress environment at GS1 stage (vegetative phase 20–35 days after sowing) without irrigation after, (2) drought stress environment at GS2 stage (pre-anthesis 40–55 days after sowing) without irrigation after and (3) well-watered (non-stress) environment, where irrigation was given as per need of crop. The sub plots consisted of 42 and 25genotypes grown during post-rainy seasons 2015–2016 and 2016– 2017, respectively, including four check varieties (Phule Anuradha, Phule Suchitra, CSV26 and M35-1). These four varieties were usually used in the yield evaluation trials of All-India Coordinated Research Project on Sorghum as drought-tolerant and high yielding genotypes. The result shows two genotypes CSV 26 and EP 87 (IC 343586) were found to be moderately tolerant under GS1 and GS2 environments and showed moderate adaptability for stover yield. All these genotypes identified using WGMI for drought tolerance will be utilized in future breeding program. In an earlier experiment by Talwar *et al*., (2010) during three rabi seasons of 2007-08, 2008-09 and 2009-10, the sorghum germplasm EP 87 (IS 343586) has been identified as new sources having improved post-flowering drought tolerance based on the yield components and green leave area retention at the physiological maturity. The rabi sorghum germplasm EP 87 (IC 343586) has consistently proved as a drought tolerant germplasm in five years of experiment. It can be used as a parent in the breeding programme to develop drought tolerant variety.

### References

Boyer JS (1982) Plant productivity and environment.*Science* **218**: 443–448.

Samdur MY, PD Patroti, HS Talwar, KK Sharma, VA Tonapi, Prabhakar, M Elangovan and YS Kshirsagar (2020 Weighted Geometric Mean Index – A Model to Evaluate Drought Tolerance in Post- Rainy Season Sorghum (*Sorghum bicolor* (L.) Moench). Cereal Research Communications, DOI 10.1007/s42976-020-00096-z.

Seetharama N, S Audilakshmi, VA Tonapi and RKV Raghavendra (2010) Sorghum improvement in India. In: Research and development in millets, present status and future strategies. Directorate of Sorghum Research, Hyderabad, India. pp 12–19.

Talwar HS, B Prabhakar, M Elangovan, A Kumari, SS Rao, JS Mishra and JV Patil (2010) Strategies to improve post flowering drought tolerance in rabi sorghum for predicted climate change scenario. *Crop Improve* **37(2)**: 93–9.

# 7. SPV 2389/IIMR-SC-1542 (IC0485033; INGR20085), a Sorghum (*Sorghum bicolor*) Germplasm with Low HCN Content, High Protein Yield. High Seed Yielding Single-Cut Forage Genotype (Dual-Purpose Type).

**KN Ganapathy[1*], C Aruna[1], Sujay Rakshit[2], M Elangovan[1], AV Umakanth[1] and Vilas A Tonapi[1]**
[1]*ICAR-Indian Institute of Millets Research, Rajendranagar, Hyderabad-500030, Telangana, India*
[2]*ICAR-Indian Institute of Maize Research, PAU Campus, Ludhiana-141004, Punjab, India*
**Email: ganapathy@millets.res.in*

India faces a net deficit of 61.1 per cent green fodder, 21.9 per cent dry crop residues and 64 per cent feeds (Sunil Kumar *et al*., 2012).Forage sorghum has significant role in fulfilling the demand of green and dry fodder in the country. Both quantity and quality of the fodder is equally important in forage sorghum breeding. The quality of forage sorghum is determined by *in vitro* dry matter digestibility, protein content, protein yield and less HCN (Aruna *et al*., 2015). Hydrogen cyandide (HCN) is toxic to animals and can cause mild to severe reactions. High protein yield is preferred as it helps in improving the body weight of the animals. Low seed yield especially in forage lines is a drawback for farmers who take up seed production. Therefore high seed yielding forage lines are preferred. Genotypes which produces more green fodder at 50% flowering (Per day productivity) is economic trait among farmers.

SPV 2389 was developed at ICAR-Indian Institute of Millets Research, Hyderabad by crossing NSSV 13 × CSV 15 and subsequent selection was made through pedigree method till F6 generation. NSSV 13 is a sweet sorghum variety which has high juiciness content in its stalks and has high TSS%. CSV 15 is a dual purpose sorghum variety which has high grain yield as well as stover yields. The entry was tested for two years 2015 and 2016 under AICRP trials in 8-10 locations.

**Morpho-agronomic characteristics:** SPV 2389 takes 68 to 70 days for 50% flowering and has a plant height of 220-240 cms and 10- 12 leaves/plant. The proposed genotype SPV 2389 has low HCN content (95 ppm) very less than the safe limit (200 ppm). SPV 2389 has high protein yield with mean protein yield of 11.11q/ha over the better check CSV 21F (10.20 q/ha). SPV 2389 has highest seed yielding ability with mean seed yield of 2026 kg/ha as against the better check CSV 21F (1376 kg/ha). SPV 2389 has high per day productivity for green fodder yield with mean per day productivity of 6.8 q/ha/day over the better check CSV 21 F (6.4q/ha/day).

**Associated characters and cultivation practices:** The high brix/total soluble sugars recorded in SPV 2389 is also an important quality attribute which imparts to the palatability of the fodder and the line can serve as base material in forage breeding programs. The line also showed comparative resistance to foliar diseases (leaf blight, anthracnose and Zonate leaf spot and downey mildew) tested under AICSIP 2015. The proposed line can be important base material source while improving sorghum for fodder yield and quality for the Northern and southern forage growing states of the country.

## References

C Aruna, M Swarnalatha, P Praveen Kumar, V Devender, M Suguna, M Blummel and JV Patil (2015) Genetic options for improving fodder yield and quality in forage sorghum. Tropical Grasslands–*Forrajes Tropicales* **3(1)**: 49-58.

Sunil Kumar, RK Agrawal, AK Dixit, Arvind K Rai and SK Rai (2012) Forage Crops and their Management. Indian Grassland and Fodder Research Institute, Jhansi, Uttar Pradesh, India p. 1.

# 8. SPV 2315 (IC0635700; INGR20086), a Sorghum (*Sorghum bicolor*) Germplasm Resistance to Foliar Diseases (Anthracnose, Zonate leaf spot, Leaf Blight and Grey Leaf Spot). High Per Day Productivity for Green Fodder. High Seed Yield.

**KN Ganapathy[1*], B Venkatesh Bhat[1], Sujay Rakshit[2], M Elangovan[1], IK Das[1], B Amasiddha B[1] and Vilas A Tonapi[1]**

[1]*ICAR-Indian Institute of Millets Research, Rajendranagar, Hyderabad-500030, Telangana, India*
[2]*ICAR-Indian Institute of Maize Research, PAU Campus, Ludhiana-141004, Punjab, India*
**Email: ganapathy@millets.res.in*

In India, forage sorghum contributes to about 60-70% of the total green forage supply especially during Kharif and this can be enhanced by breeding cultivars with improved fodder yield. Foliar diseases (Anthracnose, leaf blight, Zonate leaf spot, grey leaf spot) are important biotic constraints to grain and forage sorghum production. Foliar diseases affect both the yield and quality of the fodder fed to animals. Foliar diseases can best be managed by host plant resistance.

The proposed single-cut forage sorghum genotype SPV 2315 was developed from double cross involving (CSV 20 × Pant Chari 5) × (CSV 20 × PVK 809)-4-2-2-2-1-2. CSV 20 and PVK 809 are dual purpose sorghum varieties while Pant Chari 5 is a forage sorghum variety) and subsequent selection through pedigree method till $F_8$ generation (Station code: DSR SC-40- 2). SPV 2315 was tested under All India Coordinated Research Trial for two years viz., *kharif* 2015 and *kharif* 2016.

**Morpho-agronomic characteristics:** The proposed genotype recorded multiple resistance to foliar diseases (Anthracnose, Zonate leaf spot, Leaf blight and Grey leaf spot). The entry showed 17.3, 15.59, 29.5, 57.3 per cent mean improvement over better check for Anthracnose, Zonate leaf spot, Leaf Blight and Grey leaf spot respectively. SPV 2315 also recorded high per day productivity for green fodder yield (6.38 q/ha/day) over better check CSV 21F (5.88 q/ha/day) and also recorded high seed yield 1690 kg/ha over the better check CSV 21F (1620 kg/ha).

**Associated characters and cultivation practices** SPV 2315 recorded 75 to 80 days for days to 50% flowering with a plant height of 230-250 cms having around 11-14 leaves/plant with leaf length of about 75 cm and leaf width of 7 cm. SPV 2315 showed average fodder yield of 540 q/ha (green) and 162 q/ha (dry).

**Mean performance of SPV 2315 for foliar diseases, per day productivity for green fodder yield and seed yield.**

| Year of testing | No of test locations | SPV 2315 | Latest varietal check CSV30F | CD@5% | %increase Overcheck |
|---|---|---|---|---|---|
| Anthracnose | | | | | |
| 2014 | 4 | 4.8 | 6.3 | 4.9 | 23.8 |
| 2015 | 3 | 4.3 | 4.7 | 1.1 | 8.5 |
| Mean | | 4.55 | 5.5 | | 17.3 |
| Zonate leaf spot | | | | | |
| 2014 | 3 | 4.2 | 5.9 | 4.7 | 28.8 |
| 2015 | 1 | 5 | 5 | 0.7 | 0.0 |
| Mean | | 4.6 | 5.45 | | 15.6 |
| Leaf Blight | | | | | |
| 2014 | 3 | 2.8 | 4.1 | 2.3 | 31.7 |
| 2015 | 1 | 2.7 | 3.7 | 1.1 | 27.0 |
| Mean | | 2.75 | 3.9 | | 29.5 |
| Grey leaf spot | | | | | |
| 2014 | 1 | 1 | 5.7 | 1.7 | 82.5 |
| 2015 | 1 | 2.5 | 2.5 | 0.7 | 0.0 |
| Mean | | 1.75 | 4.1 | | 57.3 |
| Per day productivity for green fodder yield | | | | | |
| 2014 | 11 | 6.79 | 5.99 | 0.64 | 13.4 |
| 2015 | 10 | 5.97 | 5.69 | 0.6 | 4.9 |
| Mean | | 6.38 | 5.84 | | 9.2 |
| Seed yield | | | | | |
| 2015 | 11 | 1690 | 1060 | 980 | 59.4 |
| Mean | | 1690 | 1060 | 980 | 59.4 |

*For disease resistance, scores recorded 1-9, values closer to 1 indicate resistance and closer to 9 indicate susceptible.

# 9. SPV-2296 (DSR 1145) (IC0635025; INGR20087), a Sorghum (*Sorghum bicolor*) Germplasm Tolerant to Shoot Fly and Downy Mildew. High Protein Content (12.2%) and High Grain Yield with Higher Nutrient-Use Efficiency.

**K Hariprasanna*, C Aruna, AV Umakanth, Vilas A Tonapi and M Elangovan**
*ICAR-Indian Institute of Millets Research, Hyderabad-500030, Telangana, India*
**Email: hari@millets.re.sin*

Breeding programmes aimed at development of high yielding genotypes endowed with resistance/tolerance to shoot fly and downy mildew have made significant progress. SPV 2296 is a *kharif* grain sorghum genotype with high grain yield and moderate tolerance to shoot fly and downy mildew, having higher protein content in the grains. It is a pedigree selection from the cross (RS 29 × NR 486) × NR 486. It has semi-loose symmetric panicles and medium bold elliptic seeds. In yield evaluation trials under AICRP-Sorghum, SPV 2296 recorded grain yield (2980 kg/ha) superiority of about 10% over the best performing grain yield check CSV 20 (2710 kg/ha) in Zone I (Tamil Nadu, Telangana, Andhra Pradesh, North Gujarat and Rajasthan) of sorghum growing area. At all India level SPV 2296 (3449 kg/ha) was marginally superior to the best check, CSV 20 (3397 kg/ha) in terms grain yield. It took 70-75 days to flower and 105-110 days to mature, and had an average plant height of 200-230 cm. It had medium bold seeds with average seed size of 2.45g/100 seeds. SPV 2296 has higher nutrient-use efficiency and can yield higher under good management. At 50% of RDF, SPV 2296 was 3% superior for grain yield over check CSV 20, while at 125% RDF it was superior by 2.3%. The loss in grain yield due to reduction in fertilizer dose by 50% was less (–7.6%) in SPV 2296 compared to CSV 20 (–13.1%), while the gain in grain yield due to higher dose of fertilizer was more in SPV 2296 (9.3%) compared to CSV 20 (3.7%).

For shootfly SPV 2296 recorded 4% less incidence of dead hearts under artificial infestation compared to CSV 20 (50.2%) and 28% lesser compared to susceptible check (DJ 6514). For stem borer it exhibited resistance on a par to the checks. SPV 2296 exhibited higher resistance to downy mildew (6.4%) compared to check (13.3%) and susceptible check (25.8%). It was on a par with the checks for resistance to other major diseases like grain mould (4.9 and 5.2 field grade and threshed grade, respectively, compared to 4.6 and 5.1 in check), anthracnose, leaf blight and zonate leaf spot at all India level.

The grains of SPV 2296 contain high protein content (12.19%) compared to check variety CSV 20 (10.97%) while for starch and fat contents, it (64.6% and 3.16%, respectively) was on a par with check (64.6% and 3.12%, respectively). For stover quality parameters the variety was on a par with check.

The breeding line SPV 2296 with high grain yield and medium bold seeds has exhibited good combining ability in subsequent crossing programmes. The high yield coupled with moderate resistance to major pest like shootfly and disease like downy mildew makes SPV 2296 an ideal base material for further sorghum improvement and consolidation of gains already achieved through recombination breeding.

# 10. EC718515 (EC718515; INGR20088), a Wild Lentil (*Lens orientalis*) Germplasm Resistant to Rust (*Uromyces fabae*) and Powdery Mildew (*Erysiphe trifolii*).

**Mohar Singh[1*], Sandeep Kumar[2], Ashwani Kumar Basandrai[3], Daisy Basandrai[3], Nikhil Malhotra[1], Deep Rattan Saxena[4], Dorin Gupta[5], Ashok Kumar[2], Ashutosh Sarker[6] and Kuldeep Singh[2]**

[1]*ICAR-NBPGR Regional Station, Shimla-171004, Himachal Pradesh, India*
[2]*ICAR-NBPGR, Pusa Campus-110012, New Delhi, India*
[3]*CSKHPKV Palampur-176062, Himachal Pradesh, India*
[4]*Rafi Ahmad Kidwai, College of Agriculture, Sehore-466001, Madhya Pradesh, India*
[5]*University of Melbourne, Australia*
[6]*South Asia and China Regional Programme of ICARDA, NASC Complex-110012, New Delhi, India*
[*]*Email: Mohar.Singh2@icar.gov.in*

The wild lentil accession EC718515 (ILWL230) belongs to *Lens orientalis* was identified after preliminary characterization and evaluation of 405 global wild annual lentil collections. The genotype was screened against rust (*Uromyces fabae* (Grev.) Fuckel) and powdery mildew (*Erysiphe trifolii*) under hot spot natural field condition at CSKHPKV Research and Extension centre Dhaulakuan Himachal Pradesh during 2012-2013 (Singh *et al.,* 2014). The genotype was further validated for confirming stable resistance against rust and powdery mildew during 2014-2015, 2015-2016 and 2016-2017(Singh *et al.,* 2020). Based on the disease score, an accession EC718515 (ILWL203) has been reported resistant against the rust and powdery mildew diseases.

**Morpho-agronomic characteristics**: Besides possessing resistance against rust and powdery mildew, an accession EC718515 (ILWL230) was also reported promising for other agro-morphological traits viz; number of pods plant$^{-1}$ (141) and number of seeds plant$^{-1}$(160). As far as distinct morphological traits are concerned, the following qualitative features were also reported using lentil descriptor states jointly developed by IBPGR/ ICARDA (Table 1).

The above mentioned important characters have their special significant value for enhancing genetic gains of cultivated varieties, which need to be considered while planning future lentil genetic improvement programme for introgressing resistance against rust and powdery mildew as well as agronomic improvement of cultivated gene pool.

**Table 1. Descriptor and descriptor state of EC718515 (ILWL230) for important qualitative characters**

| Descriptor | Descriptor state |
|---|---|
| Seedling stem pigmentation | Absent |
| Leaf pubescence | Slight |
| Tendril length | Rudimentary |
| Leaflet size | Large |
| Cotyledon colour | None |
| No. of pods/ plant | 141 |

## References

IBPGR/ICARDA (1993) Lentil descriptors: IBPGR Secretariat, Rome, Italy pp 15.

Singh M, IS Bisht, S Kumar, M Dutta, KC Bansal, A Sarker, A Amri, SK Agrawal and SK Datta (2014) Global wild annual *Lens* collection: a potential resource for lentil genetic base broadening and yield enhancement. *PLoS ONE*, **9(9)**: e107781. doi:10.1371/journal.pone.0107781

Singh M, **S** Kumar, AK Basandrai, D Basandrai, DR Saxena, A Sarker and K Singh (2020). Evaluation and identification of wild lentil accessions for enhancing genetic gain of cultivated varieties. *PLOS ONE* 15 (**3**) e0229554.

# 11. EC718266 (EC718266; INGR20089), a Wild Lentil (*Lens nigricans*) Germplasm Resistant against Rust (*Uromyces fabae* (Grev.) Fuckel)

**Mohar Singh[1*], Sandeep Kumar[2], Ashwani Kumar Basandrai[3], Daisy Basandrai[3], Nikhil Malhotra[1], Deep Rattan Saxena[4], Dorin Gupta[5], Ashok Kumar[2], Ashutosh Sarker[6] and Kuldeep Singh[2]**

[1]*ICAR-NBPGR Regional Station, Shimla-171004, Himachal Pradesh, India*
[2]*ICAR-NBPGR, Pusa Campus-110012, New Delhi, India*
[3]*CSKHPKV Palampur-176062, Himachal Pradesh, India*
[4]*Rafi Ahmad Kidwai, College of Agriculture, Sehore-466001, Madhya Pradesh, India*
[5]*University of Melbourne, Australia*
[6]*South Asia and China Regional Programme of ICARDA, NASC Complex-110012, New Delhi, India*
[*]*Email: Mohar.Singh2@icar.gov.in*

The wild lentil accession EC718266 (IG136639) belongs to *Lens nigricans* was identified after preliminary characterization and evaluation of 405 global wild annual lentil collections. The genotype was screened against rust (*Uromyces fabae* (Grev.) Fuckel) disease under hot spot natural field condition at CSKHPKV Research and Extension centre Dhaulakuan Himachal Pradesh during 2012-2013 (Singh *et al.,* 2014). The genotype was further validated for confirming stable resistance during 2014-2015, 2015-2016 and 2016-2017(Singh *et al.,* 2020). Based on the disease score, an accession EC718266 (IG136639) has been reported resistant against the rust.

**Morpho-agronomic characteristics**: Besides possessing resistance against rust disease, an accession EC718266 (IG136639) was also reported promising for other agro-morphological traits viz; number of pods plant$^{-1}$ (27) and number of seeds plant$^{-1}$(51). As far as distinct morphological traits are concerned, the following qualitative features were also reported using lentil descriptor states jointly developed by IBPGR/ICARDA (Table 1).

The above mentioned important characters have their special significant value for enhancing genetic gains of cultivated varieties, which need to be considered while planning future lentil genetic improvement programme for introgressing resistance against rust disease.

**Table 1. Descriptor and descriptor state of EC718266 (IG136639) for important qualitative characters**

| Descriptor | Descriptor state |
|---|---|
| Seedling stem pigmentation | Absent |
| Leaf pubescence | Slight |
| Tendril length | Rudimentary |
| Leaflet size | Large |
| Cotyledon colour | None |
| No. of pods/ plant | 27 |

## References

IBPGR/ICARDA (1993) Lentil descriptors: IBPGR Secretariat, Rome, Italy pp 15.

Singh M, IS Bisht, S Kumar, M Dutta, KC Bansal, A Sarker, A Amri, SK Agrawal and SK Datta (2014) Global wild annual *Lens* collection: a potential resource for lentil genetic base broadening and yield enhancement. *PLoS ONE*, **9(9)**:e107781. doi:10.1371/journal.pone.0107781.

Singh M, **S** Kumar, AK Basandrai, D Basandrai, DR Saxena, A Sarker and K Singh (2020). Evaluation and identification of wild lentil accessions for enhancing genetic gain of cultivated varieties. *PLOS ONE* **15(3)**: e0229554.

## 12. EC271515 (EC271515; INGR20090), a French Bean (*Phaseolus vulgaris*) Germplasm Resistant toWhite Mold Disease (*Sclerotinia sclerotiorum*)

**Mohar Singh[1*], Sonali Chauhan[2], Shabnam Katoch[2], SK Sharma[2], PN Sharma[2], JC Rana[3], Kuldeep Singh[4], Nikhil Malhotra[1] and Ashok Kumar[4]**
[1]*ICAR-NBPGR Regional Station, Shimla-171004, Himachal Pradesh, India*
[2]*CSKHPKV, Palampur-176062, Himachal Pradesh, India*
[3]*Bioversity International India Office, NASC Complex-110012, New Delhi, India*
[4]*ICAR-NBPGR Pusa Campus-110012, New Delhi, India*
[*]*Email: Mohar.Singh2@icar.gov.in*

The common bean (*Phaseolus vulgaris* L.) germplasm accession EC271515 was introduced from CIAT Columbia and screened against white mold (*Sclerotinia sclerotiorum*) under controlled environment at CSKHPKV Palampur. The germplasm was screened using various inoculation procedures and modified straw test method was found most promising. The genetic materials comprising of a panel of 516 common bean accessions were screened in controlled conditions which resulted into the identification of an accession EC271515 found resistant against white mold disease and subsequently validated thrice to confirm the stable resistance against the pathogen (Chauhan *et al.,* 2020).

**Table 1. Descriptor and descriptor state of EC271515 for important qualitative characters**

| Descriptor | Descriptor state |
|---|---|
| Plant growth habit | Semi pole |
| Leaflet shape | Ovate lanceolate |
| Flower colour | Light pink |
| Pod shape | Round |
| Seed colour | Maroon |
| Pod pubescence | Absent |
| Pod colour | Green |
| No. of pods plant$^{-1}$ | 08 |
| No. of seeds pod$^{-1}$ | 06 |

The above mentioned important agro-morphological characters have their significant value for enhancing genetic gains, which need to be considered while planning future common bean genetic improvement programme for introgressing resistance against white mold.

**Morpho-agronomic characteristics**: Besides possessing resistance against white mold, an accession EC271515 was also reported promising for other agro-morphological traits viz; number of pods plant$^{-1}$ (08) and number of seeds pod$^{-1}$ (6). As far as distinct morphological traits are concerned, the following qualitative characters were also reported using common bean descriptor states jointly developed by IBPGR/NBPGR (Table 1).

### References

Chauhan S, S Katoch, SK Sharma, PN Sharma, JC Rana, K Singh and M Singh (2020) Screening and identification of resistant sources against *Sclerotinia sclerotiorum* causing white mold disease. *Crop Sci.* **60**: 1986–1996.

IBPGR/NBPGR (1993) Common bean descriptors: IBPGR Secretariat, Rome, Italy pp 15.

## 13. IC278744 (IC0278744; INGR20091), a French Bean (*Phaseolus vulgaris*) Germplasm Resistant toWhite Mold Disease (*Sclerotinia sclerotiorum*)

**Mohar Singh[1*], Sonali Chauhan[2], Shabnam Katoch[2], SK Sharma[2], PN Sharma[2], JC Rana[3], Kuldeep Singh[4], Nikhil Malhotra[1] and Ashok Kumar[4]**
[1]*ICAR-NBPGR Regional Station, Shimla-171004, Himachal Pradesh, India*
[2]*CSKHPKV, Palampur-176062, Himachal Pradesh, India*
[3]*Bioversity International India Office, NASC Complex-110012, New Delhi, India*
[4]*ICAR-NBPGR Pusa Campus-110012, New Delhi, India*
[*]*Email: Mohar.Singh2@icar.gov.in*

The common bean (*Phaseolus vulgaris* L.) germplasm accession IC278744 was collected from Chhogtali Sirmour Himachal Pradesh and screened against white mold (*Sclerotinia sclerotiorum*) under controlled

environment at CSKHPKV Palampur. The germplasm was screened using various inoculation methods and modified straw test method was found most appropriate. The genetic materials comprising of a panel of 516 common bean accessions were screened in controlled conditions which resulted into the identification of an accession IC278744 found resistant against white mold disease and subsequently validated thrice to confirm the stable resistance against the pathogen (Chauhan *et al.,* 2020).

**Morpho-agronomic characteristics**: Besides possessing resistance against white mold, an accession IC278744 was also reported promising for other agro-morphological traits viz; number of pods plant$^{-1}$ (10) and number of seeds pod$^{-1}$ (6). As far as distinct morphological traits are concerned, the following qualitative characters were also reported using common bean descriptor states jointly developed by IBPGR/NBPGR (Table 1).

The above mentioned important agro-morphological characters have their significant value for enhancing genetic gains, which need to be considered while planning future common bean genetic improvement programme for introgressing resistance against white mold.

**Table 1. Descriptor and descriptor state of IC278744 for important qualitative characters**

| Descriptor | Descriptor state |
|---|---|
| Plant growth habit | Pole type |
| Leaflet shape | Ovate |
| Flower colour | White |
| Pod shape | Slightly curved |
| Seed colour | Maroon |
| Pod pubescence | Intermediate |
| Pod colour | Green |

## References

Chauhan S, S Katoch, SK Sharma, PN Sharma, JC Rana, K Singh and M Singh (2020). Screening and identification of resistant sources against *Sclerotinia sclerotiorum* causing white mold disease. *Crop Sci.* **60**: 1986–1996.

IBPGR/NBPGR (1993) Common bean descriptors: IBPGR Secretariat, Rome, Italy pp 15.

# 14. NIPB-1 & NIPB 1B (IC0637026 & IC0637027; INGR20092), a Cytoplasmic Male Sterile Line of Cauliflower (*Brassica oleracea* var. *botrytis*) with Compact Creamy White Curd. Strongly Waxy with Bluish Green Broad Leaves.

**Rohit Chamola*, SR Bhat, RC Bhattacharya, Anshul Watts and Deepak Singh Bisht**
*ICAR-National Institute for Plant Biotechnology, Pusa Campus-110012, New Delhi, India*
**Email: rohitchamola@gmail.com*

Higher yield, greater uniformity and quality of F1 hybrids call for heterosis breeding in cauliflower. Attempts therefore have long been made to generate CMS lines in *B. oleracea* by means of different cytoplasmic sources for hybrid production (Shiga and Baba, 1973; Renard *et al*., 1992; Zhu and Wei, 2009 and Kamiński, Dyki and Stępowska, 2012). However, not all have been successful mainly due to poor stability of CMS and/or adverse effect on agronomic traits. At NIPB, *Erucastrum canariense* credited male sterility was successfully transferred from *B. napus* background to cauliflower to yield a CMS cauliflower line called 'NIPB-1'. In 2010, cauliflower variety Pusa Meghna (CC – 2n=2x=18) as male parent was crossed with CMS- (*E. caneriense*) *B. napus (*AACC – 2n=4x=38) to obtain F1 plants. In subsequent backcrosses, cauliflower (Pusa Meghna) was used as recurrent male parent to recover the cauliflower genotype with male sterile flowers. Crosses at initial stages could not be obtained at field level due to embryo degeneration occurring within 12-14 days of hand pollination. Therefore, embryo rescue technique/ ovary culture has to be resorted every time after some days of pollination to recover the succeeding backcross generations. Pistils harvested at 14 days after pollination (14 DAP) for embryo rescue gave the best results (Table 1). At every cycle of crossing some crosses were always left in the field till maturity to see the possibility of any natural seed setting. Eventually, at BC4 stage some seeds were formed on hybrids plants. Plants obtained from such seeds were very healthy that formed perfect cauliflower curd. Subsequent advancement of generations never required embryo rescue.

**Morpho-agronomic characteristics:** NIPB-1 has strongly waxy bluish green leaves, light yellow sterile flowers, anthers are short with absence of pollen grains, nectaries are good making it attracted to bees, an

**Table 1. Summary of results of embryo rescue towards the recovery of interspecific hybrids between *B. napus* × cauliflower**

| Cross | Time of sampling of ovaries | No. of ovaries cultured | No. of surviving ovaries | No. of ovules obtained and cultured | No. of plants recovered |
|---|---|---|---|---|---|
| | 5 DAP | 60 | 0 | 0 | 0 |
| CMS (*E. canariense*) *B. napus* × *B. oleracea* | 9 DAP | 60 | 28 | 23 | 2 |
| | 14 DAP | 60 | 32 | 47 | 5 |

advantage for hybrid seed production. It belongs to mid early maturity group which bears compact big circular curd not covered with young leaves and mostly shows anthocyanin pigmentation just before its opening to flower. Though, Pusa Meghna was the recurrent parent in synthesis of NIPB-1, it is different for some of the morphological features such as curd size, anthocyanin pigmentation and leaf size and colour which may be attributed to *caneriense* cytoplasm or effect of residual *Brassica napus* linked genes.

**Associated characters and cultivation practices:** NIPB-1 is a cauliflower CMS line which can be used as such as a valuable CMS female parent for production of hybrid variety or can be used as a source of male sterility for integration in other female combiners. Some incidences of cabbage butterfly larvae were seen during its early growth which was secured by insecticidal spray. No major incidences of other diseases and insects were noticed during the course of development of this material. It grows well under standard cultural practices normally followed for cauliflower farming.

## References

Kamiński P, B Dyki, and AA Stępowska ( 2012) Improvement of Cauliflower Male Sterile Lines with *Brassica Nigra* Cytoplasm, Phenotypic Expression and Possibility of Practical Application. *Journal of Agricultural Science*. **4(4)**: 190-200.

Renard M, R Delourme, J Mesquida , G Pelletier, C Primard, L Boulidard, C Dore, V Ruffio, J Morice (1992) Male sterilities and F1 hybrids in Brassica In: Datte Y, Dumas C, Gallais A (Eds.) Reproductive Biology and Plant Breeding. Springer, Berlin Heidelberg New York, pp 107-119

Shiga T and S Baba (1973) Cytoplasmic male sterility in oilseed rape (*Brassica napus* L.) and its utilisation to breeding. *Japan J. Breed.,* **23**: 187-193.

Zhu Peng-fang and Yu-tang Wei (2009) Compatibility, production of interspecific F1 and BC1 between improved CMS *Brassica campestris* ssp. *pekinensis* and *B. oleracea* var. *acephala*. *J. Plant Breed. Crop Sci.*, **1(6)**: 265-269.

# 15. DRMR 2300 (NPJ-149) (IC0609646; INGR20093), an Indian Mustard (*Brassica juncea*) Germplasm with High Temperature Tolerance at Seedling Stage.

**DK Yadava[1], VV Singh[2], Sujata Vasudev[1], Naveen Singh[1], Navinder Saini[1], Rajendra Singh[1], Yashpal[1], HS Meena[2], HK Sharma[2], I Mowlong[2], Balbeer[2], J Nanjundan[1] and PK Rai[2]**

[1]*ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur-321303, Rajasthan, India*

[2]*ICAR-Indian Agricultural Research Institute, Pusa Campus-110012, New Delhi, India*

[*]*Email: singhvijayveer71@gmail.com*

DRMR 2300 (IC609646; NPJ149) is an advanced breeding line of Indian mustard (*B. juncea*) procured from IARI, New Delhi. DRMR 2300 was tested for physio-biochemical parameters (RWC, Chlorophyll stability index (CSI) during 2016-17 at DRMR, Bharatpur. The genotype DRMR 2300 was superior over checks (BPR-543-2, Urvashi) in terms of percent increase of RWC (Bud stage, 0.49%) and CSI (pod stage, 3.08%) under stress condition. DRMR 2300 showed seedling mortality ≤20% and DW/10 seedlings ≥ 4g under field conditions at DRMR, Bharatpur during 2017-18.

During 2018-19 DRMR 2300 was evaluated for high temperature tolerance at seedling stage under field conditions at 3 locations (Dholi, Kanpur and Ludhiana) along with checks. Average seedling mortality (%) of DRMR 2300 over three locations was 18.2% and DW/10 seedlings over three locations was 7.0 g (Table 1). Genotype DRMR 2300 showed average SPAD value of 41.4 and RWC 83.3% over 3 locations (Dholi, Kanpur and Ludhiana) which is higher than checks at seedling stage.

During 2018-19 proposed germplasm DRMR 2300 was evaluated for high temperature tolerance at seedling stage under field conditions at 3 locations (Dholi, Kanpur, Ludhiana) along with checks under plant physiological traits (AICRP-RM, 2019, page PHY 1). Seedling mortality ≤20% and DW/10 seedlings ≥ 40mg rated genotypes tolerant under field conditions.

**Table 1. Pooled data of DRMR 2300 over three locations (Dholi, Kanpur, Ludhiana) for high temperature tolerance at seedling stage under AICRP-RM 2018-19 under field trials**

| Genotypes | Seedling mortality (%) | DW/10 seedlings (g) | SPAD | RWC (%) |
|---|---|---|---|---|
| DRMR 2300 | 18.2 | 7.0 | 41.4 | 83.3 |
| RGN 73 (ZC) | 34.2 | 6.3 | 36.4 | 72.5 |
| PM 25 (NC) | 19.8 | 5.5 | 40.1 | 72.2 |
| Kranti (NC) | 27.4 | 5.1 | 36.8 | 72.0 |
| RH 749 (ZC) | 23.2 | 5.7 | 37.5 | 66.9 |

Average seedling mortality (%) over three locations was 18.2% and DW/10 seedlings over three locations was 7.0g (Table 3). Genotype DRMR 2300 showed average SPAD value of 41.4 and RWC 83.3%over3 locations (Dholi, Kanpur and Ludhiana) which is higher than checks (AICRP-RM, 2019, page PHY 5, Table 4) at seedling stage.

## References

DRMR Annual Report, 2016-17, page 29

DRMR Annual Report, 2018-19, page 46.

Annual Progress Report, AICRP-RM, 2019, page PHY 1,4-5

**Table 3. Screening of genotypes from different agro-climatic zones for high temperature at seedling stage under field conditions**

| Genotypes | Seedling mortality (%) (<20%) | | | | DW/10 seedlings (g) (≥ 4g) | | | |
|---|---|---|---|---|---|---|---|---|
| | Dholi | Kanpur | Ludhiana | Average | Dholi | Kanpur | Ludhiana | Average |
| DRMR 2300 | 19.9 | 16.5 | 18.2 | 18.2 | 9.2 | 4.5 | 7.2 | 7.0 |
| RGN 73 (ZC) | 34.9 | 42.8 | 25.0 | 34.2 | 8.9 | 3.5 | 6.6 | 6.3 |
| Pusa Mustard 25 (NC) | 27.6 | 15.8 | 16.0 | 19.8 | 5.8 | 4.7 | 6.0 | 5.5 |
| JD 6 (ZC) | 34.8 | 50.2 | 14.4 | 33.1 | 3.8 | 2.8 | 4.9 | 3.8 |
| Kranti (NC) | 32.5 | 28.8 | 20.8 | 27.4 | 4.6 | 3.4 | 7.3 | 5.1 |
| RH 749 (ZC) | 40.4 | 14.6 | 14.5 | 23.2 | 4.2 | 4.6 | 8.3 | 5.7 |
| Mean | 31.3 | 35.2 | 18.1 | | 5.5 | 3.5 | 6.6 | |
| CD (p=0.05) | 3.12 | 4.7 | 4.2 | | 1.04 | 0.50 | 1.33 | |

(AICRP-RM, 2019 Page: PHY 4)

**Table 4. Effect of high temperature at seedling stage on SPAD and RWC under field conditions**

| Genotypes | SPAD | | | | RWC(%) | | | |
|---|---|---|---|---|---|---|---|---|
| | Dholi | Kanpur | Ludhiana | Average | Dholi | Kanpur | Ludhiana | Average |
| DRMR 2300 | 46.5 | 41.5 | 36.3 | 41.4 | 89.9 | 77.5 | 82.6 | 83.3 |
| Pusa Mustard 25 (NC) | 42.3 | 41.9 | 36.2 | 40.1 | 78.8 | 76.5 | 61.3 | 72.2 |
| Pusa Mustard 30 (LR) | 35.3 | 33.3 | 34.9 | 34.5 | 76.3 | 73.6 | 49.2 | 66.4 |
| JD 6 (ZC) | 37.3 | 36.6 | 34.4 | 36.1 | 78.5 | 67.7 | 52.3 | 66.2 |
| Kranti (NC) | 35.1 | 39.2 | 36.2 | 36.8 | 76.7 | 72.4 | 66.9 | 72.0 |
| RH 749 (ZC) | 34.8 | 42.0 | 35.6 | 37.5 | 67.3 | 76.7 | 56.8 | 66.9 |
| Mean | 38.6 | 37.6 | 35.6 | | 77.9 | 73.1 | 68.7 | |
| CD (p=0.05) | 1.17 | 2.8 | 0.73 | | 1.61 | 1.8 | 9.5 | |

(AICRP-RM, 2019 Page: PHY 5)

**Morphological Characters of DRMR2300**

| | Value |
|---|---|
| Plant Height (cm) | 195.0 |
| Days to maturity | 138.0 |
| Primary branches/plant (no.) | 8.0 |
| Secondary branches/plant (no.) | 14.0 |
| Main shoot length (cm) | 75.0 |
| Siliquae/plant (no.) | 307.0 |
| Siliqua length (cm) | 4.3 |
| Seeds/siliqua (no.) | 16.0 |
| 1000 seed weight (g) | 6.2 |
| Oil content (%) | 41.90 |
| Seed yield/plant (g) | 20.1 |

# 16. ICIRG226-29-2-2 (IC0636678; INGR20094), a Castor (*Ricinus communis*) Germplasm with High Ricinoelic Acid. Early Maturity.

**J Jawahar Lal* and Praduman Yadav**
*ICAR-Indian Institute of Oilseeds Research, Hyderabad, Telangana, India*
*Email: j.jawaharlal@icar.gov.in*

Castor (*Ricinus communis* L.) oil demand is increasing globally because of presence of 85-88% ricinoelic acid (RA) in oil which is the only natural source of RA. Any increase in RA content beyond the existing level (85-88%) would increase the value of oil and benefit the industry and farmers. So far no high ricinoleic type (>88% ricinoleic acid) castor cultivars are available in the world as there were no donors for high RA content for developing the cultivars. Therefore, the ICAR-Indian Institute of Oilseeds Research (ICAR-IIOR), Hyderabad, has developed the first high ricinoleic type inbred line *viz.,* ICIRG226-29-2-2 from germplasm. It was evaluated in randomized block design with two replications at multilocations for two years.

**Morpho-agronomic characteristics:** Ricinoleic acid content in ICIRG226-29-2-2 was 91.5% (Table 1) and oil content was 45%. It matured in 106 days and gave 17% higher seed yield (2438 kg/ha) than the early check, DCS-9 (2075 kg/ha) in multilocation trial (Table 2). It has red stem with bloom on it and medium size spiny capsules and seeds.

**Associated character and utility:** Low node number (11) and short plant height (77 cm) are the other traits of ICIRG226-29-2-2. This inbred line would serve as a unique souse of high RA content coupled with early maturity and high yield in castor breeding for developing early maturing high ricinoleic type-high yielding hybrids and varieties. ICIRG226-29-2-2 would also serve as base material for studying genetics and inheritance of high RA content trait, and for developing/identifying genes/ markers for high RA content for intensifying molecular breeding research in castor.

**Table 1. Ricinoleic acid content in ICIRG226-29-2-2**

| Inbred line | Ricinoleic acidc ontent (%) | | | | | | | Mean over years |
|---|---|---|---|---|---|---|---|---|
| | Irrigated | | Rainfed | | | Overall mean | | |
| | S.K.Nagar | | Palem | ICAR-IIOR | | | | |
| | 2018 | 2019 | 2019 | 2018 | 2019 | 2018 | 2019 | |
| ICIRG226-29-2-2 | 90 | 91 | 92 | 92 | 92 | 91 | 92 | 91.5 |
| DCS-9 (early check) | 88 | 89 | 89 | 88 | 89 | 88 | 89 | 88.5 |
| GC3 (check) | 88 | 86 | 88 | - | 88 | 88 | 87 | 87.5 |
| CV (%) | 1.3 | 0.9 | 0.2 | 0.5 | 0.8 | | | |
| CD (P=0.05) | 1.002 | NS | 0.8 | 1.3 | NS | | | |

**Table 2. Mean phenological traits and seed yield of ICIRG226-29-2-2**

| Inbred line | Days to 50% flowering | | Mean | Days to maturity | | Mean | Seed yield (kg/ha) | | Mean |
|---|---|---|---|---|---|---|---|---|---|
| | 2018 | 2019 | | 2018 | 2019 | | 2018 | 2019 | |
| ICIRG226-29-2-2 | 44 | 42 | 43 | 114 | 98 | 106 | 3196 | 1679 | 2438 |
| DCS-9 (early check) | 45 | 45 | 45 | 114 | 104 | 109 | 2603 | 1547 | 2075 |
| GC3 (check) | 45 | 51 | 48 | 114 | 109 | 112 | 4501 | 2195 | 3348 |

## Reference

Ghadge SV and H Raheman (2005) Biodiesel production from mahua (*Madhuca indica*) oil having high free fatty acids. *Biomass Bioenergy* **28:** 601-605.

Yadav P and K Anjani (2017) Assessment of variation in castor genetic resources for oil characteristics. *J. Am. Oil Chem. Soc.* DOI 10.1007/s11746-017-2961-7

# 17. CSIR-IHBT-ST-03 (IC0635703; INGR20095), a Tetraploid Stevia (*Stevia rebaudiana*) Germplasm with Large Leaf Size

**Ashok Kumar*, Sanatsujat Singh, Dinesh Kumar and Ram Kumar Sharma**
*CSIR-Institute of Himalayan Bioresource Technology, Palampur-176061, Himachal Pradesh, India*
**Email: ashok@ihbt.res.in*

*Stevia rebaudiana* (Bertoni) is a herbaceous perennial plant of the Asteraceae family and native to Paraguay (South America). The chromosome count of stevia is 2 n=22 (diploid) and genome size (2C value) is estimated to be 2.72 pg or 2660 Mbp (Yadav *et al.*, 2014) The genus *Stevia cav.* consists of approximately 230 species of herbaceous, shrub and sub-shrub plants. It has been recognized worldwide for its excellent sweetening property. Leaves of stevia produce diterpene glycosides (stevioside and rebaudiosides), which are non-toxic, high-potency sweeteners (300 times sweeter than sucrose) and substitutes for sugar (Megeji *et al.*, 2005, Rajasekaran *et al*., 2007) in different drinks, beverages and bakery products (Abou-Arab *et al.*, 2010). Manipulation of ploidy is a valuable tool which has been recognized in plant breeding programmes to improve agronomic traits, particularly biomass yield. For polyploidization in plants, colchicine is being widely used since its first report having this property (Blakeslee and Avery 1937). Colchicine treatment disrupts the polymerization of microtubules, and hence, interrupts spindle-fiber development during cell division (Bartels and Hilton 1973).

Leaves being the economic part in stevia, where steviolglycoside synthesis takes place, improvement in leaf characteristics will have direct influence on leaf biomass yield. With an aim to increase leaf size resulting into high leaf biomass yield, tetraploid stevia genotype CSIR-IHBT-ST-03 (C-7-3-4) has been developed through colchicine treatment of stevia seeds (Fig. 1). Polyploidy status (tetraploid) was analyzed and confirmed through flow cytometry and cytology of root tips (Yadav *et al*., 2013). The genotype CSIR-IHBT-ST-03 was evaluated for morphological as well as biochemical traits along with control. Tetraploid stevia (CSIR-IHBT-ST-03) is having large leaf size (max. leaf length and width: 11.34 cm × 7.80 cm respectively) as compared to diploid control (5.75 cm × 3.45). The autotetraploids in stevia had significantly increased leaf size (Yadav *et al*., 2013). The genotype CSIR-IHBT-ST-03 was developed at CSIR-Institute of Himalayan Bioresource Technology, Palampur, Himachal Pradesh (Latitude: 32.0934° N, Longitude: 76.5439° E and at an altitude of 1300m amsl).

**Morpho-agronomic characteristics:** The genetic stock CSIR-IHBT-ST-03 has increased leaf size, internode length, stem thickness, stevioside and rebaudioside-content and has potential to be utilized as low calorie natural sweetener which is a substitute for sugar or zero calorie synthetic sweeteners.

**Associated characters and cultivation practices:** *Stevia rebaudiana* (Bertoni) is a herbaceous perennial plant of the Asteraceae family, native to Paraguay (South America). Propagation of stevia is through seeds as well as clonal (Yadav *et al.*, 2010). Leaves of stevia is the economic part which produces diterpene glycosides (stevioside and rebaudiosides), which are high-potency sweeteners (300 times sweeter than sucrose) and substitutes for sugar or synthetic sweeteners.

## References

Abou-Arab AE, AA Abou-Arab and MF Abu-salem (2010) Physico-chemical assessment of natural sweeteners steviosides produced from *Stevia rebaudiana* Bertoni plant. *African J. of Food Sci.* **4(5)**: 269-281.

Megeji NW, JK Kumar, S Virendra, VK Kaul and PS Ahuja (2005) Introducing *Stevia rebaudiana*, a natural zero-calorie sweetener. *Curr. Sci.* **88**: 801-4

Rajasekaran T, P Giridhar and GA Ravishankar (2007) Production of steviosides in *ex vitro* and *in vitro* grown *Stevia rebaudiana* Bertoni. *J. of the Sci. of Food and Agricul.* **87**: 420–4.

Yadav AK, S Singh, D Dhyani and PS Ahuja (2010). A review on the improvement of stevia [*Stevia rebaudiana* (Bertoni)]. *Can. J. Plant Sci.* **91**: 1-27. doi:10.4141/CJPS10086.

Yadav AK, S Singh, SC Yadav, D Dhyani, G Bhardwaj, A Sharma and B Singh (2013) Induction and morpho-chemical characterization of *Stevia rebaudiana* colchiploids. *Indian J. of Agri. Sci.,* **83(2)**: 159–65.

Yadav AK, S Singh and G Bhardwaj (2014) Nuclear DNA content and genome size estimation of *Stevia rebaudiana* using flow cytometry. *Minerva Biotec,* **26(3)**: 143-8.

Bartels PG and JL Hilton (1973) Comparison of trifluralin, oryzalin, pronamide, propham and colchicines treatments on microtubules. *Pestic. Biochem. and Physiol.* **3**: 462–72.

Blakeslee AF and AG Avery (1937) Methods of inducing doubling of chromosomes in plants. *J. Hered.* **28**: 393-411.

## 18. CSIR-IHBT-VJ-05 (IC0630604;INGR20096), a Tagar IndianValerian (*Valeriana jatamansi*) Germplasm with High Fresh Root Biomass Yield of 2.71 kg/plot (6 sqm). Essential oil content: 0.31%.

**Sanatsujat Singh, Ashok Kumar, Probir Kumar Pal, Ram Kumar Sharma and Dinesh Kumar**
*CSIR-Institute of Himalayan Bioresource Technology, Palampur-176061, Himachal Pradesh, India*
**Email: sanatsujat@ihbt.res.in*

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

Nine accessions of Indian valerian were initially shortlisted based on root biomass accumulation and essential oil content over two years. The progeny plants of these nine accessions were evaluated in multi-location trials for root biomass and essential oil content at four locations in mid- and high-altitude regions over a period of two years along with check variety 'Himbala'. Overall, CSIR-IHBT-VJ-05 performed better than check at all the four locations with root biomass yield of 2.71 kg/plot (6 sqm) and essential oil content of 0.31%. The genotype CSIR-IHBT-VJ-05 was developed at CSIR-Institute of Himalayan Bioresource Technology, Palampur, Himachal Pradesh (Latitude: 32.0934° N, Longitude: 76.5439° E and at an altitude of 1300m amsl).

**Morpho-agronomic characteristics:** The characteristic features of CSIR-IHBT-VJ-05 are plant height of about 45 cm, large leaf size with serrated margins and pointed apex. The selection CSIR-IHBT-VJ-05 is vigorous in growth and has a potential to be utilized as aromatic plant on commercial basis.

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

### References

Mahajan M and PK Pal (2016) Growing conditions influence non-destructive estimation of chlorophyll in leaves of *Valeriana jatamansi*. *J. Appl. Res. Med. Aromat. Plants*. **3**: 131-135. https://doi.org/10.1016/j.jarmap.2016.05.005.

Nayar MP and ARK Sastry (1998) Red data book of Indian plants. Botanical Survey of India, Kolkata.

## 19. IIHR-CA-13 (IC0618244; INGR20097), a Bramhi/Indian Birthwort (*Centella asiatica*) Germplasm with Higher Asiaticoside Content (3.73%). Higher Total Triterpene Content (7.67%). Higher Dry Biomass Content (2276 kg/ha).

**DH Sukanya, A Rekha, VK Rao, D Kalavannan and Rohini MR**
*ICAR-Indian Institute of Horticultural Research, Bengaluru-560089, Karnataka, India*
**Email: Rohini.R@icar.gov.in*

Indian Pennywort (*Centella asiatica*) belonging to the family Apiaceae is one of the important medicinal herb that is used as a memory booster. Triterpenoids like asiaticoside, madecassoside, asiatic acid and madecassic acid contribute to the medicinal properties. IIHR-CA-13 genetic stock is a clonal selection from the germplasm collected from Shimoga, Karnataka. The genotype has high asiaticoside content (3.73%) and higher tri- terpenoid content (7.67 %). This line is particularly good for pharmaceutical industries for extraction of triterpenoids. It was developed at ICAR-Indian Institute of Horticultural Research (ICAR-IIHR), Bengaluru.

**Morpho-agronomic characteristics:** IIHR-CA-13 is characterized by erect growth habit and medium sized leaves. Important traits are mentioned as below based on 3 years pooled data.

**Associated characters and cultivation practices:** IIHR-CA-13 is moderately tolerant to leaf spot caused by *Cercospora centellae*. The crop requires damp, moist and shady habitats for its growth. Clayey soils with good moisture along with organic matter suits very well for the crop. The plant is propagated through stem cuttings comprising of rooted node with few leaves @ 1,10,000 cuttings/ha. The cuttings are planted at a spacing of 30 × 30 cm in the main field preferably during June-July. Organic manuring should be done with 20t/ha FYM per year.

| Traits | IIHR CA-13 | Vallabh medha (check) | CD (5%) | CV |
|---|---|---|---|---|
| Asiaticoside (%) | 3.73 | 1.94 | 0.42 | 13.27 |
| Total Triterpenes (%) | 7.67 | 5.00 | 0.27 | 7.19 |
| Dry biomass yield (kg/ha/year) | 2276 | 1421.67 | 4.00 | 6.16 |
| Plant Height (cm) | 8.52 | 6.71 | 1.72 | 11.95 |
| No. of primary branch per plant | 5.20 | 7.27 | 2.08 | 7.94 |
| No. of Nodes per plant | 8.00 | 8.40 | 2.27 | 9.08 |
| No of Leaves per plant | 29.00 | 33 | 7.88 | 6.98 |
| Leaf Length (cm) | 2.59 | 2.45 | 0.25 | 5.52 |
| Leaf Width (cm) | 4.03 | 3.73 | 0.72 | 9.79 |
| Internodal length (cm) | 6.89 | 7 | 0.48 | 4.06 |
| Rosette diameter (cm) | 13.04 | 12.13 | 1.01 | 5.06 |
| Petiole length (cm) | 9.63 | 7.37 | 1.29 | 9.47 |
| Swollen petiole base (mm) | 4.00 | 4.50 | 1.17 | 14.81 |
| petiole thickness (mm) | 1.83 | 1.93 | 0.61 | 17.44 |
| Length between leaf base (cm) | 1.53 | 0.97 | 0.36 | 15.33 |
| Stem thickness (mm) | 1.25 | 1.25 | 0.11 | 4.41 |

**References**

Gohil KJ, JA Patel, AK Gajjar (2010) Pharmacological Review on *Centella asiatica*: A Potential Herbal Cure-all. *Indian J. Pharm. Sci.* **72(5)**: 546-556.

## 20. IIHR-CA-1 (IC0618233; INGR20098), a Bramhi/Indian Birthwort (*Centella asiatica*) Germplasm with Higher Fresh Biomass Yield of 15t/ha/year. Higher Total Carotenoid (32.33 mg/100g) and Iron (149.5 ppm) Content, Broad Sized Leaves with Long Petiole.

**DH Sukanya, A Rekha, VK Rao, D Kalavannan and Rohini MR**
*ICAR-Indian Institute of Horticultural Research, Bengaluru-560089, Karnataka, India*
**Email: Rohini.R@icar.gov.in*

Indian Pennywort (*Centella asiatica*) belonging to the family Apiaceae is one of the important medicinal herb that is used as a memory booster. Triterpenoids like asiaticoside, madecassoside, asiatic acid and madecassic acid contribute to the medicinal properties. It is also used as a green leafy vegetable because of high vitamin and mineral content. IIHR-CA-1 genetic stock is a clonal selection from the germplasm collected from Pune, Maharashtra. The genotype has very broad leaves with long petiole (12.17 cm) and high fresh biomass (15038 kg/ha/year) and dry biomass yield (2506.33 kg/ha/year). This line is good for both medicinal and vegetable purpose as it has broad leaves, more biomass yield and high carotenoid and iron content. It is developed at ICAR-Indian Institute of Horticultural Research (ICAR-IIHR), Bengaluru.

**Morpho-agronomic characteristics:** It is characterized by erect growth habit and very broad sized leaves, long

petiole, easy to harvest and can be harvested at every 30 days interval. Important traits are mentioned as below based on 3 years pooled data.

**Associated characters and cultivation practices:** IIHR-CA-1 is moderately tolerant to leaf spot caused by *Cercospora centellae*. The crop requires damp, moist and shady habitats for its growth. Clayey soils with good moisture along with organic matter suits very well for the crop. The plant is propagated through stem cuttings comprising of rooted node with few leaves @ 1,10,000 cuttings/ha. The cuttings are planted at a spacing of 30 × 30cm in the main field preferably during June-July. Organic manuring should be done with 20t/ha FYM per year.

| Traits | IIHR CA-1 | Vallabh Medha (check) | CD (5%) | CV |
|---|---|---|---|---|
| Fresh biomass yield (kg/ha/year) | 15038 | 8530 | 9.80 | 6.61 |
| Dry biomass yield (kg/ha/year) | 2506.33 | 1421.67 | 4.00 | 6.16 |
| Total carotenoids (mg/100g fresh weight) | 32.33 | 26.58 | - | - |
| Iron (ppm) | 149.5 | 128 | - | - |
| Asiaticoside (%) | 1.207 | 1.94 | 0.42 | 13.27 |
| Total Triterpenes (%) | 4.19 | 5.00 | 0.27 | 7.19 |
| Plant Height (cm) | 10.92 | 6.71 | 1.72 | 11.95 |
| No. of primary branch per plant | 5.73 | 7.27 | 2.08 | 7.94 |
| No. of Nodes per plant | 6.07 | 8.40 | 2.27 | 9.08 |
| No of Leaves per plant | 25 | 33 | 7.88 | 6.98 |
| Leaf Length (cm) | 3.79 | 2.45 | 0.25 | 5.52 |
| Leaf Width (cm) | 5.54 | 3.73 | 0.72 | 9.79 |
| Intermodal length (cm) | 10.03 | 7 | 0.48 | 4.06 |
| Rosette diameter (cm) | 19.8 | 12.13 | 1.01 | 5.06 |
| Petiole length (cm) | 12.17 | 7.37 | 1.29 | 9.47 |
| Swollen petiole base (mm) | 9.00 | 4.50 | 1.17 | 14.81 |
| petiole thickness (mm) | 2.83 | 1.93 | 0.61 | 17.44 |
| Length between leaf base (cm) | 3.07 | 0.97 | 0.36 | 15.33 |
| Stem thickness (mm) | 2.45 | 1.25 | 0.11 | 4.41 |

## References

Gohil KJ, JA Patel and AK Gajjar (2010) Pharmacological Review on *Centella asiatica*: A Potential Herbal Cure-all. *Indian J Pharm Sci*. 72(**5**):546-556. doi:10.4103/0250-474X.78519

# 21. PR-9 (IC0636677; INGR20099), a Dwarf Tuberose Selection (*Polianthes tuberosa*) with Average Plant Height 48.49 cm. Short and Straight Spikes Suitable for Pot Culture, Vertical Panel and other Purposes

**Tarak Nath Saha[1], P Naveen Kumar[1], Ganesh B Kadam[1], Prashant G Kawar[1], Prasanna Holajjer[2] and KV Prasad[1]**

[1]*ICAR-Directorate of Floricultural Research, Shivajinagar, Pune-411005, Maharashtra, India*
[2]*ICAR-NBPGR Regional Station, Rajendranagar, Hyderabad-500030, Telangana, India*
**Email: tnsaha1981@gmail.com*

Tuberose (*Polianthes tuberosa* L.) is one of the important fragrant bulbous ornamental cultivated for loose & cut flower, extraction of essential oil, etc. It belongs to the family Amaryllidaceae. It has gained popularity on account of ease in cultivation, fragrance, keeping quality, economic returns, wide adaptability to varied climate and soil (Safeena *et al*., 2015). The tuberose variety PR-9 was developed at ICAR-Directorate of Floricultural Research, Pune, Maharashtra (latitude of 18.5204° N, longitude of 73.8567° E and altitude of 560 MSL on the western margin of the Deccan plateau). It is a selection among the Open Pollinated Population of the cv. 'Phule Rajani'. The plants as well as spikes are very short unlike the parent Phule Rajani. It was evaluated for three years (2017-18 to 2019-20) along with parent as check.

**Table 1. Performance of the Identified Variety 'PR-9' over Parent' Phule Rajani' During 2017-18 to 2019-20.**

| Character | 2017-18 | | 2018-19 | | 2019-20 | | Average | |
|---|---|---|---|---|---|---|---|---|
| | PR-9 | Phule Rajani | PR-9 | Phule Rajani | PR-9 | Phule Rajani | PR-9 | Phule Rajani |
| Plant height (cm) | 39.6 | 78.8 | 54.3 | 90.6 | 51.58 | 94 | 48.49 | 87.80 |
| Spike length (cm) | 32.2 | 67.6 | 44 | 80.4 | 46 | 82.5 | 40.73 | 76.83 |
| Rachis length (cm) | 22.2 | 37 | 31 | 43.6 | 24.52 | 42 | 25.91 | 40.87 |
| Number of leaves | 10.8 | 12 | 9.7 | 13.4 | 8.8 | 13 | 9.77 | 12.80 |
| Days to flowering | 98 | 90 | NA | NA | NA | NA | 98.00 | 90.00 |
| Number of florets per spike | 39.2 | 27.2 | 46.3 | 38.6 | 46 | 37.5 | 43.83 | 34.43 |
| Floret diameter (cm) | 3.6 | 3.8 | 4.2 | 5 | 4.78 | 4.8 | 4.19 | 4.53 |
| Floret length (cm) | 4 | 6 | 5 | 6.9 | 6.08 | 6.2 | 5.03 | 6.37 |
| Stem thickness (cm) | 1.3 | 1.2 | 1.5 | 1.1 | 1.3 | 1.3 | 1.37 | 1.20 |
| Spike longevity (in field days) | 7 | 6 | 8 | 8.5 | 8 | 7.5 | 7.67 | 7.33 |
| Number of bulbs per clump | 10 | 12 | 13 | 15 | 12 | 13 | 11.67 | 13.33 |
| Vase life of spike in tap water (days) | 6 | 6 | 7 | 7 | 7 | 7 | 6.67 | 6.67 |
| No of spikes per clump | 5 | 5.2 | 5.5 | 4.8 | 6 | 6.5 | 5.50 | 5.50 |
| Plants pread (cm) | 51 | 78.4 | 54 | 98.4 | 58.5 | 86 | 54.50 | 87.60 |

**Morpho-agronomic characteristics**: It is very dwarf (average plant height 48.49 cm) with short and straight spikes. The florets are with light pink tinge (63B, Red-Purple Group) at bud stage, turning greenish white (NN 155B, White Group) at opening/ anthesis. Petals show a distinguished spot/mark in the outer end. Stems are sturdy with thickness more than the parent variety (1.37 cm against 1.20 cm). Average rachis length is 25.91 cm with 43.83 numbers of florets per spike. Each bulb produces on an average5.50 spikes per clump per year (Table.1).

**Associated characters and cultivation practices:** The variety PR-9 produces dwarf plants which are well suited to pot-culture, for vertical gardening (vertical panels) and best suited for urban dwellers (for terrace/roof gardening). Flowering commences 98 days after planting and continues almost through the year. However, during winter months (Nov- Jan) growth gets slowed down. The florets are arranged compactly on short rachis giving an impression of hyacinth spike. Also, the floret opening is proper till the end of spike. Sweet fragrance of the florets is an additional attraction. Spikes can be used for vase decoration also (with a shelf-life of 6.67 days in vases). Bulbs can be lifted after 2-3 years depending on the growth & flowering, purpose and climate. On an average 11.67 bulbs are produced from each clump per year. It is propagated by bulbs and can be planted during March-June. The optimum growing temperature requirement is 25-30 °C. It can be grown on a wide range of soil. However, it prefers deep friable soil rich in organic content having good water holding capacity and pH around 6.5-7.5. NPK @ 300:250:300 kg/ha along with FYM (20t/ha) is recommended for good growth and flowering.

### References

Safeena SA, M Thangam, S Priya Devi, AR Desai and NP Singh (2015) Ready Reckoner on Cultivation of Tuberose (T.B.No:50), ICAR-CCARI, Ela, OldGoa-403402, Goa, India pp. 25.

## 22. CSIR-IHBT-Gr-11-6 (IC0630601; INGR20100), a Gerbera (*Gerbera jasmeonii*) Germplasm with Double Flower Shape

**Sanatsujat Singh, Ashok Kumar, Bhavya Bhargav and Ram Kumar Sharma**
*CSIR-Institute of Himalayan Bioresource Technology, Palampur-176061, Himachal Pradesh, India*
**Email: sanatsujat@ihbt.res.in*

Gerbera (*Gerbera jamesonii* Bolus ex Hook. f.), family Asteraceae, is one of the important cut-flowers used for cut-flower, aesthetic decoration, bouquet making and has high demand in domestic and export markets (Singh *et al*., 2017). Gerbera holds the fifth position among the top ten traded flowers in the world and have a market

of €140 million. In 2017, a total of 1074 million gerbera cut-flowers sold worldwide (Holland, 2018). In India, the production of gerbera was estimated to be 5020 tonnes of loose flowers and 20.53 lakh number of cut flowers from an area 1150 ha (NHB 2018). It is widely grown in Karnataka, Maharashtra, Chhattisgarh and North Eastern states. It is a dwarf perennial herbaceous plant, growing in clumps with solitary flower heads on long slender stems which grow well above the foliage. In general, gerbera is grown in protected condition to meet the quality standards of international and domestic market.

In India, exotic cultivars of gerbera are predominantly grown on commercial scale. Indigenous cultivars may play an important role to combat import of gerbera cultivars and save our valuable foreign exchange in terms of royalty which we pay to foreign breeder companies. With an objective to develop unique selections of gerbera, hybridization program was undertaken involving elite and diverse parental lines differing for flower color (Singh *et al*., 2013), shapes and size at CSIR-Institute of Himalayan Bioresource Technology (CSIR-IHBT), Palampur, Himachal Pradesh, India (Singh *et al*., 2009 & 2011). CSIR-IHBT has developed a gerbera selection (CSIR-IHBT-Gr-11-6) through breeding program. The hybrid $F_1$ genotypes of gerbera were developed through controlled crossing program to obtain mature seeds from different cross combinations. The seeds were initially cultured on MS basal medium for development of micro-shoots and re-cultured on MS media supplemented with different doses of growth regulators (BAP, IBA, NAA), to achieve shoot proliferation. Highest number of micro-shoots, number of leaves and leaf length were observed in MS medium supplemented with 1 mg/L BAP + 0.03mg/L IBA + 0.025 mg/L NAA. For *in vitro* rooting, half strength MS medium supplemented with 0.4 mg/L IBA was found best. Rooted plantlets were successfully hardened in trays filled with moist sand and transferred to sleeves for cultivation in soil.

The hybrid $F_1$ genotypes were morphologically characterized under field conditions with respect to floral traits and evaluated for agronomic performance over a period of four years. Based on mean performance of hybrid gerbera genotypes compared to respective parents, gerbera genotype CSIR-IHBT-Gr-11-6 was found promising having double flower shape of mini size (flower diameter of 9.65 cm) and is light yellow in color. The genotype CSIR-IHBT-Gr-11-6 has been developed at CSIR-IHBT, Palampur, Himachal Pradesh (Latitude: 32.0934° N, Longitude: 76.5439° E and at an altitude of 1300m amsl).

**Morpho-agronomic characteristics:** CSIR-IHBT-Gr-11-6 was found promising having double flower shape of mini size (flower diameter of 9.65 cm) and is light yellow in colour.

**Associated characters and cultivation practices:** 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. (Aswath *et al.*, 2015).

## References

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

Holland RF (2018) Annual report 2017 Available: file http:// jaarverslag. royalfloraholland. com/#/feiten-en-cijfers/ snijbloemen.

Singh P, A Bhardwaj, R Kumar and D Singh (2017) Evaluation of Gerbera Varieties for Yield and Quality under Protected Environment Conditions in Bihar. *Int. J. Curr. Microbiol. App. Sci*. 6(**9**): 112-116

NHB (2018) Area and production statistics of horticultural crops, New Delhi: National Horticulture Board.

Singh S, D Dhyani, S Karthigeyan (2009) Characterization of variability in $F_1$ progeny of inter-varietal cross of gerbera (*Gerbera jamesonii* Bolus ex. Hooker F). *Journal of Ornamental Horticulture*. **12(4)**: 225-231.

Singh S, D Dhyani and Ashok Kumar (2011) Flower colour variations in gerbera (*Gerbera jamesonii*) population using image analysis. *Indian Journal of Agricultural Sciences.* **81(12)**:1130-1136.

Singh S, A Kumar and D Dhyani (2013) Inheritance of pigment markers associated with flavonoid and carotenoid pigmentation in flowers of *Gerbera jamesonii*. *Canad. J. Plant Breed*. **1(3)**: 110-114.

# 23. CSIR-IHBT-Gr-Y-1 (IC0630600; INGR20101), a Gerbera (*Gerbera jasmeonii*) Germplasm with Double Flower Shape. Standard Size (>10 cm).

**Sanatsujat Singh, Ashok Kumar, Bhavya Bhargav and Ram Kumar Sharma**
*CSIR-Institute of Himalayan Bioresource Technology, Palampur-176061, Himachal Pradesh, India*
**Email: sanatsujat@ihbt.res.in*

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

Hybrid $F_1$ genotypes of gerbera were developed through controlled crossing program and mature seeds obtained from different cross combinations were used for the establishment of *in vitro* gerbera cultures. Seeds were cultured on MS basal medium and the developing micro-shoots from seeds were further cultured on MS media supplemented with different doses of growth regulators to achieve shoot proliferation. Of the different media, highest number of micro-shoots, number of leaves and leaf length were observed in MS medium supplemented with 1 mg/L BAP + 0.03mg/L IBA + 0.025 mg/L NAA which gave best proliferation among the gerbera genotypes. Half strength MS medium supplemented with 0.4 mg/L IBA was found best for *in vitro* rooting. Rooted plantlets were successfully hardened in trays filled with moist sand and transferred to sleeves for cultivation in soil. The hybrid $F_1$ genotypes were morphologically characterized under field conditions with respect to floral traits and evaluated for agronomic performance over a period of four years. Based on mean performance of hybrid gerbera genotypes compared to respective parents, gerbera genotype CSIR-IHBT-Gr-Y-1 was found promising having double flower shape of standard size (flower diameter of 10.84 cm) and is yellow in color. The genotype CSIR-IHBT-Gr-Y-1 has been developed at CSIR-Institute of Himalayan Bioresource Technology, Palampur, Himachal Pradesh (Latitude: 32.0934° N, Longitude: 76.5439° E and at an altitude of 1300m amsl).

**Morpho-agronomic characteristics:** CSIR-IHBT-Gr-Y-1 was found promising having double flower shape of standard size (flower diameter of 10.84 cm) and is yellow in color.

**Associated characters and cultivation practices:** 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. (Aswath *et al*., 2015)

## References

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

Tjia B (2001) Cooperative extension services.International Food and Agricultural Science.University of Florida.1-5.

Singh S, D Dhyani and S Karthigeyan (2009) Characterization of variability in F1 progeny of inter-varietal cross of gerbera (*Gerbera jamesonii* Bolus ex. Hooker F). *J. Ornam. Hortic.***12(4)**: 225-231.

Singh S, D Dhyani and Ashok Kumar (2011) Flower colour variations in gerbera (*Gerbera jamesonii*) population using image analysis. *Indian J. of Agric. Sci*. **81(12)**: 1130-1136.

Singh S, A Kumar and D Dhyani (2013) Inheritance of pigment markers associated with flavonoid and carotenoid pigmentation in flowers of *Gerbera jamesonii*. *Canad. J. Plant Breed*. **1(3)**: 110-114.

# 24. IIHRGO-1 (IC0632739; INGR20102), a Gerbera (*Gerbera jasmeonii*) Germplasm for Flower Colour and Flower Form: Bright Red (RHS colour: 40A, Red Group) and Double Type Flowers. Ability to Grow under Open Field Conditions.

**C Aswath*, Rajiv Kumar and T Manjunatha Rao**
*ICAR-Indian Institute of Horticultural Research, Bengaluru-560089, Karnataka, India*
**Email: Aswath.C@icar.gov.in*

Gerbera, family *Asteraceae*, is one of the important cut-flowers grown for domestic and export markets. In India, Gerbera was grown in 1180 ha with production of 212 lakhs of cut flowers, amounting to the fourth most important cut-flower. Highest production of Gerbera comes from Uttarakhand with 7.80 (000' MT), while share of Karnataka is 6.2 (000' MT) (Anon., 2017-18). In India, all the gerbera varieties are imported and suitable for growing inside the polyhouse. However, to reduce the cost of cultivation, the genotype for growing outside is required. The Gerbera germplasm IIHRGO-1 was developed from the cross between IIHR99-5 × Savana followed by selection at $F_1$ stage, 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 germplasm IIHRGO-1 was evaluated for flower quality traits, reaction to insect-pests and diseases under open grown condition in Randomized Complete Block Design, during 2016-17 to 2018-19.The germplasm IIHRGO-1 is unique for flowers with bright red flower colour (RHS colour: 40A, Red Group), double type flowers and its ability to grow under open field conditions. It is suitable for bedding, cut flower and flower arrangement.

**Morpho-agronomic characteristics:** The Gerbera germplasm IIHRGO-1 flowers is having bright red colour (RHS colour: 40A, Red Group) and double type flowers. On an average, it has recorded flower stalk length (41.90 cm), stalk diameter (0.52 cm), flower diameter (8.51 cm), vase life (8.08 days) and number of flowers/plant/month (4.03) (Table 1).

**Associated characters and cultivation practices:** This hybrid selection possess moderate resistance to thrips and leaf miner. It has leaf thrips damaged (7.8%) during summer under Good Agricultural Practices (GAP), bud borer flowers damaged (4.89%) and leaf spot leaf damaged (5.12%) (Table 2).

**Table 1. Evaluation of genetic stock IIHRGO-1 with Arka Krishika (check) for flower quality and flower yield traits (pooled data of three years)**

| Genotype | Stalk length (cm) | Stalk diameter (cm) | Flower diameter (cm) | Vase life (days) | Number of flowers/plant/month |
|---|---|---|---|---|---|
| IIHRGO-1 | 41.90 | 0.52 | 8.51 | 8.08 | 4.03 |
| Arka Krishika | 39.09 | 0.60 | 8.11 | 7.94 | 4.09 |
| C.D. at 5% | NS | 0.07 | NS | NS | NS |

**Table 2. Flower quality traits, disease and insect-pests reaction of genetic stock IIHRGO-1 and Arka Krishika (check)**

| Trait | IIHRGO-1 | Arka Krishika |
|---|---|---|
| RHS Colour Chart | Red Group, 40A | Yellow group, 10A |
| Flower form | Double | Semi-double |
| Thrips (% leaf damaged) during summer under GAP | 7.8 | 6.9 |
| Bud borer (% flowers damaged) | 4.89 | 5.10 |
| Leaf spot (% leaf damaged) | 5.12 | 5.65 |

Gerbera is generally grown under polyhouse with shade net, however, IIHRGO-1 is highly suitable for open grown conditions. It grows best in well drained loamy soil, rich in organic matter, having adequate moisture holding capacity with soil pH (5.5-6.5) and EC less than 1 dS/cm$^2$. The suckers with 4-5 leaves to be planted on raised beds at a spacing of 60 cm between rows and 30 cm between plants accommodating 9 plants/m$^2$. The water requirement during the peak summer is 4-6 litres/m$^2$/day and 2 to 3 litres/m$^2$/day during the winter.

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

## References

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

## 25. CSIR-IHBT-TM-09 (IC0630603; INGR20103), a Marigold (*Tagetes minuta*) Germplasm with High biomass yield 58.11kg/plot (24sqm). Essential Oil Content 0.343%.

**Ashok Kumar, Sanatsujat Singh, Probir Kumar Pal, Rakesh Kumar, Ram Kumar Sharma and Dinesh Kumar**
*CSIR-Institute of Himalayan Bioresource Technology, Palampur-176061, Himachal Pradesh, India*
**Email: ashok@ihbt.res.in*

Wild marigold (*Tagetes minuta*; family Asteraceae) is an aromatic herb, commercially cultivated for its essential oil present in aerial parts of the plant. Volatile oil of wild marigold is used in perfumery and as a flavor component in food products, and have suppressive biological activity against different pathogens and insects (Vasudevan *et al*., 1997). Due to high demand of its essential oil, there has been increasing interest in the cultivation of this plant for commercial production (Singh *et al*., 2003). The (Z)-β-ocimene (52.01 %) content was highest in inflorescence while dihydrotagetone (84.85 %) content was highest in foliage (Kumar *et al*., 2020). In this context, with an aim of varietal development, selective breeding of wild marigold was done using progeny selection approach. Based on biomass production, nine breeding lines were selected for further evaluation in multi-location trials at four locations over two years. 'Him Gold' variety of wild marigold was used as the check variety. CSIR-IHBT-TM-09 performed well at all the locations with biomass yield of 58.11 kg/ plot (24 sqm) and essential oil content of 0.343% (3.43 g/ kg). The genotype CSIR-IHBT-TM-09 was developed at CSIR-Institute of Himalayan Bioresource Technology, Palampur, Himachal Pradesh (Latitude: 32.0934° N, Longitude: 76.5439° E and at an altitude of 1300m amsl).

**Morpho-agronomic characteristics:** The characteristic features of CSIR-IHBT-TM-09 are plant height of more than two meters, secondary branches more than 40 and large leaf size (leaf length more than 11 cm and width more than 5 cm) and has potential to be utilized as aromatic plant on commercial basis.

**Associated characters and cultivation practices:** Wild marigold is an annual crop suitable for cultivation in the plain and hilly areas, as a monocrop or intercrop. In India, wild marigold is found naturally in the western Himalayas between altitudes range of 1000–2500 m.

### References

Singh V, B Singh and VK Kaul (2003) Domestication of wild marigold (*Tagetes minuta* L.) as a potential economic crop in western Himalaya and north Indian plains. *Econ. Bot*. **57**: 535–544.

Vasudevan P, K Suman and S Satyawati (1997) Tagetes: a multipurpose plant. *Bioresour. Technol.* **62(29)**: 33.

Kumar Ajay, RD Gautam, Ashok Kumar and S Singh (2020) Floral biology of wild marigold (*Tagetes minuta* L.) and its relation to essential oil composition. *Industrial Crops & Products* (in press) https://doi.org/10.1016/j.indcrop.2019.111996

## 26. CSIR-IHBT-TM-03 (IC0630602; INGR20104), aMarigold (*Tagetes minuta*) Germplasm for High Essential Oil Content: 0.375% (3.75g/kg).

**Ashok Kumar*, Sanatsujat Singh, Ram Kumar Sharma and Dinesh Kumar**
*CSIR-Institute of Himalayan Bioresource Technology, Palampur-176061, Himachal Pradesh, India*
**Email: ashok@ihbt.res.in*

Wild marigold (*Tagetes minuta*; family Asteraceae) is an aromatic herb, commercially cultivated for its essential oil present in aerial parts of the plant. Volatile oil of wild marigold is used in perfumery and as a flavor component in food products, and have suppressive biological activity against different pathogens and insects (Vasudevan *et al*., 1997). Due to high demand of its essential oil, there has been increasing interest in the cultivation of this plant for commercial production (Singh *et al*., 2003). The (Z)-β-ocimene (52.01 %) content was highest in inflorescence while dihydrotagetone (84.85 %) content was highest in foliage (Kumar *et al*., 2020). Nine breeding lines were evaluated in multi-location trials at four locations over two years for essential oil content. 'Him Gold' variety of wild marigold was used as the check variety. CSIR-IHBT-TM-03 performed better than check at all the

locations with essential oil content of 0.375% (3.75 g/kg). The genotype CSIR-IHBT-TM-03 was developed at CSIR-Institute of Himalayan Bioresource Technology, Palampur, Himachal Pradesh (Latitude: 32.0934° N, Longitude: 76.5439° E and at an altitude of 1300m amsl).

**Morpho-agronomic characteristics:** The characteristic features of CSIR-IHBT-TM-03 are plant height of about two meters, high number of secondary branches (40). It has potential to be utilized as aromatic plant on commercial basis.

**Associated characters and cultivation practices:** Wild marigold is an annual crop suitable for cultivation in the plain and hilly areas, as a monocrop or intercrop. In India, wild marigold is found naturally in the western Himalayas between altitudes range of 1000–2500 m.

### References

Singh V, B Singh and VK Kaul (2003) Domestication of wild marigold (*Tagetes minuta* L.) as a potential economic crop in western Himalaya and north Indian plains. *Econ. Bot*. **57**: 535–544.

Vasudevan P, K Suman and S Satyawati (1997) Tagetes: a multipurpose plant. *Bioresour. Technol*. **62(29)**: 33.

Kumar Ajay, RD Gautam, Ashok Kumar and S Singh (2020) Floral biology of wild marigold (*Tagetes minuta* L.) and its relation to essential oil composition. *Industrial Crops & Products* (in press) https://doi.org/10.1016/j.indcrop.2019.111996.

## 27. CSIR-IHBT-RD-04 (IC0635435; INGR20105), a Damask Rose (*Rosa damascena*) Germplasm for High Flower Yield 4.92 kg/plot (12sqm).

**Sanatsujat Singh*, Ashok Kumar, Probir Kumar Pal, Rekesh Kumar, Ram Kumar Sharma and Dinesh Kumar**

*CSIR-Institute of Himalayan Bioresource Technology, Palampur-176061, Himachal Pradesh, India*
**Email: sanatsujat@ihbt.res.in*

Damask rose (*Rosa damascena*) is an important essential oil bearing plant which has high demand globally in manufacture of perfumes, colognes and cosmetics. It originated in Damascus region of Asia minor and occupies one of the most important position as an aromatic plant for the extraction of essential oil. It is cultivated in Bulgaria, France, Italy, Turkey, Iran, Morocco and U.S.A for the production of attar (otto) of rose or oil of roses and is suitable for cultivation under sub-tropical and temperate conditions. It belongs to Rosaceae family and is an erect, perennial, hermaphrodite shrub possessing multiple green prickly stems up to 1−2 m in height, compound leaves with oval serrated leaflets. Flowering occurs during onset of summer season and continues for 30-35 days. The flowers are renowned for their fine fragrance, and are commercially harvested for rose oil (either "rose otto" or "rose absolute") used in perfumery and to make rose water and "rose concrete".

With an objective to improve productivity of damask rose through breeding, four clones of damask rose (*Rosa damascena*) along with check varieties 'Jwala' and 'Himroz' were evaluated for flower yield (kg) and essential oil content (mg/kg) at four locations in plains, mid- and high-altitude regions over a period of two years. Flower yield in CSIR-IHBT-RD-04 was 4.92 kg/plot (12 sqm plot) which was 22.6% higher than check variety Jwala. The genotype CSIR-IHBT-RD-04 was developed at CSIR-Institute of Himalayan Bioresource Technology, Palampur, Himachal Pradesh (Latitude: 32.0934° N, Longitude: 76.5439° E and at an altitude of 1300m amsl).

**Morpho-agronomic characteristics:** The characteristic features of CSIR-IHBT-RD-04 are plant height of nearly two meters when left unpruned. The plants are vigorous in growth and flower in the month of April and May. The essential oil content was observed to be *at par* with check varieties.

**Associated characters and cultivation practices:** Damask rose is suitable for cultivation in sub-tropical northern plains, mid hills and mild temperate regions (Kumar *et al*., 2013). The plants are short, compact, bushy and flower in March-April under sub-tropical conditions. It flowers for 25-30 days in a year.

### References

Kumar R, S Sharma, S Sood, VK Agnihotri and B Singh (2013). Effect of diurnal variability and storage conditions on essential oil content and quality of damask rose (*Rosa damascena* Mill.) flowers in north western Himalayas. *Sci Hortic.* **154**: 102–108.

# 28. CSIR-IHBT-CH-14-1 (IC0635436; INGR20106), a Chrysanthemum (*Dendranthema grandiflora*) Germplasm with Yellow Flower Colour. Double Flower Shape (8.36cm diamter). Spray type.

**Ashok Kumar*, Sanatsujat Singh, Bhavya Bhargav and Ram Kumar Sharma**
*CSIR-Institute of Himalayan Bioresource Technology, Palampur-176061, Himachal Pradesh, India*
**Email: ashok@ihbt.res.in*

Chrysanthemum is one of the important ornamental cut flower plants globally and is ranked second among the top ten cut flowers sold in the global market. It highly attractive and charming flowering plant and commercially grown for cut flowers, garden display and pot culture (Kameswari *et al.,* 2014; Joshi *et al*., 2010; Jamal Uddin *et al*., 2015).Floriculture is a fast emerging in India due to its varied agro-climatic conditions (Suvija *et al*., 2016). Chrysanthemum belongs to the oldest ornamental plants of humanity and is still improved and cultivated (Halmagyi *et al*., 2004). It belongs to the family Asteraceae and is well adapted to different agro-climatic conditions. Chrysanthemum is a highly heterozygous plant that shows inbreeding depression and self-incompatibility; as a result, conventional crossbreeding is a powerful method for developing modern chrysanthemum cultivars (Su *et al*., 2019). To create unique flower types in Chrysanthemum $F_1$ hybrids were developed through a controlled crossing program. The $F_1$ chrysanthemum genotypes were morphologically characterized under field conditions with respect to floral traits and evaluated for agronomic performance. The selected $F_1$ hybrids of Chrysanthemum were evaluated for morphological and floral traits under protected cultivation over a period of four years from 2015 to 2018. Based on mean performance of these selections, the genotype CSIR-IHBT-CH-14-1 was found promising having yellow (9A, yellow group) coloured double flower shape, large size flowers 8.36 cm flower head diameter, suitable as cut flower chrysanthemum. The genotype CSIR-IHBT-CH-14-1 was $F_1$ selection from a cross between Yellow puma × White star, developed at CSIR - Institute of Himalayan Bioresource Technology, Palampur, Himachal Pradesh (Latitude: 32.0934° N, Longitude: 76.5439° E and at an altitude of 1300m amsl).

**Morpho-agronomic characteristics:** The genotype CSIR-IHBT-CH-14-1 has large flower head diameter of 8.36 cm, number of flowers /plant (54.76) and plant height is 72.28cm. It is suitable for spray and cut flower. It has a potential for commercial utilization as cut flower.

**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.

## References

Kameswari PL, M Pratap, Anuradha G and Begum H (2014) Genetic divergence studies in Chrysanthemum (*Dendranthema grandiflora*) *Ind. J. Sci. Res. and Tech.* **2(3)**: 4-10.

Su Jiangshuo, Jiang Jiafu, Fei Zhang, Ye Liu, Lian Ding, Sumei Chen and Fadi Chen (2019). Current achievements and future prospects in the genetic breeding of Chrysanthemum: a review *Horticulture Research* 6: 109 https://doi.org/10.1038/s41438-019-0193-8

Halmagyi A, G Fischer-Kliiver, G Mix-Wagner, HM Schumacher (2004) Cryopreservation of *Chrysanthemum morifolium* (*Dendranthema grandiflora* Ramat.) using different approaches. *Plant Cell Rep*. **22**: 371–375. DOI 10.1007/s00299-003-0703-9

Suvija NV, J Suresh, SR Kumar and M Kannan (2016) Evaluation of Chrysanthemum (*Chrysanthemum morifolium* Ramat) genotypes for loose flower, cut flower and pot mums. *Int. J. Innov. Res. Adv. Stud.* **3(4)**: 100-1004.

Joshi M, LR Verma and MM Masu (2010) Performance of different varieties of Chrysanthemum in respect of growth, flowering and flower yield under north Gujarat condition. *The Asian J. Hort*. **4(2)**: 292-294.

Jamal Uddin AFM, T Taufique, AF Ona, S Shahrin and H Mehraj (2015) Growth and flowering performance evaluation of thirty two chrysanthemum cultivars. *Journal of Bioscience and Agriculture Research* **04(01)**: 40-51.

# 29. CSIR-IHBT-CH-14-2 (IC0635437; INGR20107), a Chrysanthemum (*Dendranthema grandiflora*) Germplasm with Brick Red Flower Colour with Bicoloured Florets (Yellow Colour on Floret Tips). Spray Type.

**Ashok Kumar*, Sanatsujat Singh, Bhavya Bhargav and Ram Kumar Sharma**
*CSIR-Institute of Himalayan Bioresource Technology, Palampur-176061, Himachal Pradesh, India*
**Email: ashok@ihbt.res.in*

Chrysanthemum is one of the most important ornamental cut flower plants and is ranked second among top ten cut flowers sold in the global market. It is commercially grown for cut flowers, garden display and pot culture (Kameswari *et al.,* 2014; Joshi *et al.,* 2010; Jamal Uddin *et al*., 2015). It belongs to the family Asteraceae and is well adapted to different agro-climatic conditions (Suvija *et al.,* 2016).Chrysanthemum is a highly heterozygous plant that shows inbreeding depression and self-incompatibility; as a result, conventional crossbreeding is a powerful method for developing modern chrysanthemum cultivars (Su *et al*., 2019). With an objective to develop unique flower types in chrysanthemum $F_1$ hybrids were developed through different cross combinations in controlled crossing program. The hybrid $F_1$ genotypes were morphologically characterized under field conditions with respect to floral traits and evaluated for agronomic performance. The selected $F_1$ hybrids of chrysanthemum were evaluated for morphological and floral traits under protected cultivation over a period of four years from 2015 to 2018. Based on mean performance, the genotype CSIR-IHBT-CH-14-2 was found promising having brick red (185A, greyed purple) flowers with bicoloured florets (yellow colour on floret tip 5A, yellow group) spray chrysanthemum. The genotype CSIR-IHBT-CH-14-2 was $F_1$ selection from Yellow Puma × Shyamal, developed at CSIR-Institute of Himalayan Bioresource Technology, Palampur, Himachal Pradesh (Latitude: 32.0934° N, Longitude: 76.5439° E and at an altitude of 1300m amsl).

**Morpho-agronomic characteristics:** The genotype CSIR-IHBT-CH-14-2 has flower head diameter of 6.19 cm, number of flowers /plant 48.56 and plant height is 63.46 cm. It is spray type chrysanthemum.

**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.

## References

Kameswari PL, M Pratap, G Anuradha and H Begum (2014) Genetic divergence studies in Chrysanthemum (*Dendranthema grandiflora*) *Ind. J. Sci. Res. and Tech.* **2(3)**: 4-10.

Su Jiangshuo, Jiang Jiafu, Fei Zhang, Ye Liu, Lian Ding, Sumei Chen and Fadi Chen (2019) Current achievements and future prospects in the genetic breeding of Chrysanthemum: a review *Horticulture Research* **6**: 109 https://doi.org/10.1038/s41438-019-0193-8

Suvija NV, J Suresh, SR Kumar and M Kannan (2016) Evaluation of Chrysanthemum (*Chrysanthemum morifolium* Ramat) genotypes for loose flower, cut flower and pot mums. *Int. J. Inn. Res. and Adv. Stud.*.**3(4)**: 100-1004.

Joshi M, LR Verma and MM Masu (2010) Performance of different varieties of Chrysanthemum in respect of growth, flowering and flower yield under north Gujarat condition. *The Asian J. Hort.* **4(2)**: 292-294.

Jamal Uddin AFM, T Taufique, AF Ona, S Shahrin and H Mehraj (2015) Growth and flowering performance evaluation of thirty two chrysanthemum cultivars. *Journal of Bioscience and Agriculture Research* **04(01)**: 40-51.

# 30. CSIR-IHBT-CH-14-4 (IC0635438; INGR20108), a Chrysanthemum (*Dendranthema grandiflora*) Germplasm for Pink Flower Colour. Flower Diameter 9.94cm. Plant Height 100.97cm.

**Ashok Kumar*, Sanatsujat Singh, Bhavya Bhargav and Ram Kumar Sharma**
*CSIR-Institute of Himalayan Bioresource Technology, Palampur-176061, Himachal Pradesh, India*
**Email: ashok@ihbt.res.in*

Chrysanthemum is one of the most important ornamental cut flower plants and is ranked second among top ten cut flowers sold in the global market. It is commercially grown for cut flowers, garden display and pot culture (Kameswari *et al.,* 2014; Joshi *et al*., 2010; Jamal Uddin *et al*., 2015). It belongs to the family Asteraceae and is well adapted to different agro-climatic conditions (Suvija *et al.,* 2016). Chrysanthemum is a highly heterozygous plant that shows inbreeding depression and self-incompatibility; as a result, conventional crossbreeding is a powerful method for developing modern chrysanthemum cultivars (Su *et al*., 2019). With an objective to develop unique flower types in chrysanthemum $F_1$ hybrids were developed through different cross combinations in controlled crossing program. The hybrid $F_1$ genotypes were morphologically characterized under field conditions with respect to floral traits and evaluated for agronomic performance. The selected $F_1$ hybrids of chrysanthemum were evaluated for morphological and floral traits under protected cultivation over a period of four years from 2015 to 2018. Based on mean performance, the genotype CSIR-IHBT-CH-14-4 was found unique having pink (61A, red purple group) flowers, double korean flower shape, flower diameter 9.94 cm, plant height 100.97 cm. The genotype CSIR-IHBT-CH-14-4 was F1 selection from Yellow Puma × Shyamal, developed at CSIR-Institute of Himalayan Bioresource Technology, Palampur, Himachal Pradesh (Latitude: 32.0934° N, Longitude: 76.5439° E and at an altitude of 1300m amsl).

**Morpho-agronomic characteristics:** The genotype CSIR-IHBT-CH-14-4 has flower head diameter of 9.94 cm, number of flowers /plant 46.12 and plant height is 100.97cm. It has a potential for commercial utilization as cut flower.

**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.

## References

Kameswari PL, M Pratap, G Anuradha and H Begum (2014) Genetic divergence studies in Chrysanthemum (*Dendranthema grandiflora*) *Ind. J. Sci. Res. and Tech.* **2(3)**: 4-10.

Su Jiangshuo, Jiang Jiafu, Fei Zhang, Ye Liu, Lian Ding, Sumei Chen and Fadi Chen (2019). Current achievements and future prospects in the genetic breeding of Chrysanthemum: a review *Horticulture Research* **6**: 109 https://doi.org/10.1038/s41438-019-0193-8

Suvija NV, J Suresh, RK Subesh, M Kannan (2016) Evaluation of Chrysanthemum (*Chrysanthemum morifolium* Ramat) genotypes for loose flower, cut flower and pot mums. *Int. J. Inno. Res. Adv. Stud.* **3(4)**: 100-1004.

Joshi M, LR Verma and MM Masu (2010) Performance of different varieties of Chrysanthemum in respect of growth, flowering and flower yield under north Gujarat condition. *The Asian J. Hort*. **4(2)**: 292-294.

Jamal Uddin AFM, T Taufique, AF Ona, S Shahrin and H Mehraj (2015) Growth and flowering performance evaluation of thirty two chrysanthemum cultivars. *Journal of Bioscience and Agriculture Research* **04(01)**: 40-51.

# 31. CSIR-IHBT-CH-14-8 (IC0635439; INGR20109), a Chrysanthemum (*Dendranthema grandiflora*) Germplasm for Dark Pink Flower colour. Spatulate (Fluted) Florets. Flower diameter 7.99cm.

**Ashok Kumar*, Sanatsujat Singh, Bhavya Bhargav and Ram Kumar Sharma**
*CSIR-Institute of Himalayan Bioresource Technology, Palampur-176061, Himachal Pradesh, India*
**Email: ashok@ihbt.res.in*

Chrysanthemum is one of the important ornamental cut flower plants globally and is ranked second among the top ten cut flowers sold in the global market. It highly attractive and charming flowering plant and commercially grown for cut flowers, garden display and pot culture (Kameswari *et al.,* 2014; Joshi *et al.,* 2010; Jamal Uddin *et al.,* 2015). Floriculture is a fast emerging in India due to its varied agro-climatic conditions (Suvija *et al.,* 2016). Chrysanthemum belongs to the oldest ornamental plants of humanity and is still improved and cultivated (Halmagyi *et al.,* 2004). It belongs to the family Asteraceae and is well adapted to different agro-climatic conditions. Chrysanthemum is a highly heterozygous plant that shows inbreeding depression and self-incompatibility; as a result, conventional crossbreeding is a powerful method for developing modern chrysanthemum cultivars (Su *et al*., 2019). To create unique flower types in Chrysanthemum $F_1$ hybrids were developed through a controlled crossing program. The $F_1$ chrysanthemum genotypes were morphologically characterized under field conditions with respect to floral traits and evaluated for agronomic performance. The selected $F_1$ hybrids of Chrysanthemum were evaluated for morphological and floral traits under protected cultivation over a period of four years from 2015 to 2018. Based on mean performance of these $F_1$ hybrids, the genotype CSIR-IHBT-CH-14-8 was found unique having dark pink flowers (59A, red purple group) with quilled/spatulate florets, flower diameter 7.99 cm, spray chrysanthemum. The genotype CSIR-IHBT-CH-14-8 was $F_1$ selection from Purnima × Shyamal, developed at CSIR-Institute of Himalayan Bioresource Technology, Palampur, Himachal Pradesh (Latitude: 32.0934° N, Longitude: 76.5439° E and at an altitude of 1300m amsl).

**Morpho-agronomic characteristics:** The genotype CSIR-IHBT-CH-14-8 has flower head diameter of 7.99 cm, number of flowers /plant 32.98 and plant height is 75.20cm. It is spray type chrysanthemum and has a potential for commercial utilization as cut flower as well as garden purpose.

**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.

## References

Kameswari PL, M Pratap, G Anuradha and H Begum (2014) Genetic divergence studies in Chrysanthemum (*Dendranthema grandiflora*) *Ind. J. Sci. Res. and Tech.* 2(**3**): 4-10.

Su Jiangshuo, Jiang Jiafu, Fei Zhang, Ye Liu, Lian Ding, Sumei Chen and Fadi Chen (2019) Current achievements and future prospects in the genetic breeding of Chrysanthemum: a review *Horticulture Research* **6**: 109 https://doi.org/10.1038/s41438-019-0193-8

Halmagyi A, G Fischer-Kliiver, G Mix-Wagner and HM Schumacher (2004) Cryopreservation of *Chrysanthemum morifolium* (*Dendranthema grandiflora* Ramat.) using different approaches. *Plant Cell Rep*. **22**: 371–375. DOI 10.1007/s00299-003-0703-9

Suvija NV, J Suresh, SR Kumar and M Kannan (2016)Evaluation of Chrysanthemum (*Chrysanthemum morifolium* Ramat) genotypes for loose flower, cut flower and pot mums. *Int. J. Inno. Res. Adv. Stud.* **3(4)**: 100-1004.

Joshi M, LR Verma and MM Masu (2010) Performance of different varieties of Chrysanthemum in respect of growth, flowering and flower yield under north Gujarat condition. *The Asian J. Hort*. **4(2)**: 292-294.

Jamal Uddin AFM, T Taufique, Ona AF, S Shahrin and H Mehraj (2015) Growth and flowering performance evaluation of thirty-two chrysanthemum cultivars. *Journal of Bioscience and Agriculture Research* **04(01)**: 40-51.

# 32. AS 04-1687 (IC0636675; INGR20110), a Sugarcane (*Saccharum officinarum*) Germplasm with Drought and Water Logging Tolerance.

**A Suganya*, P Govindaraj, A Selvi and G Hemaprabha**
*ICAR-Sugarcane Breeding Institute, Coimbatore-641007, Tamil Nadu, India*
**Email: suganyamuns@rediff.com*

Development and identification of climate resilient crop varieties with enhanced tolerance to heat, drought, salinity, excess water/ flooding, chilling are essential in order to sustain and improve crop yields to manage the challenges of climate change (Maheshwari *et al*., 2015). Introgression of abiotic tolerant genes into climate resilient varieties depends upon the availability of potential sources from wild relatives and their exploitation. *Saccharum spontaneum* has been utilized in sugarcane breeding since 1912 due to its wider adaptability under biotic and abiotic conditions. The proposed genetic stock AS 04-1687 having drought and waterlogging tolerance is an interspecific hybrid derived from a cross between sugarcane commercial cultivar (BO 102) and the wild species *S. spontaneum* (IND 84-337) having the cytotype 2n=56 which was not used in the breeding programme earlier. The hybrid AS 04-1687 is characteristic with erect habit, purple coloured cylindrical internode and leaf sheath which is tight and glabrous with brown coloured dewlop and deltoid auricle.

**Evaluation for drought and water logging tolerance:** Twenty-seven ISH/IGH hybrids with diverse genetic base were tested for tolerance to drought at four AICRP(S) centres and water logging at 3 centres located in both tropical (Padegaon and Anakapalle/ Kolhapur and Vuyyuru) and subtropical (Karnal and Faridkot/ Pusa) regions along with 3 standards for each centre in replicated trials (Alpha design) during 2016-17 (Plant crop) and 2017-18 (Plant and ratoon crops). Drought was imposed by withdrawing irrigation between 60 and 150 days after planting and harvesting in plant and ratoon crops respectively. Water logging was imposed under either natural water logging or water stagnation (minimum 15 cm) condition for 150-210 days after planting/harvesting. Data obtained at harvest from all the centres under both normal and drought/waterlogging conditions in two plant and one ratoon crops for the important traits viz., cane yield (t/ha), CCS yield (t/ha), juice sucrose %, single cane weight (kg), cane diameter, tillers mortality %, relative water content after drought and number of millable canes (‘000/ha) were considered for pooled analysis and percent changes due to drought and waterlogging were estimated.

**Performance of the proposed clone AS 04-1687 under drought conditions:** Among the entries evaluated, the clone AS 04-1687 exhibited the best performance with less than 20% reduction for cane yield t/ha (18.5%), CCS t/ha (10.08%) and NMC (‘000/ha) (13.01%) under drought condition while in the checks, reductions were 29.77%, 29.73% and 17.57% respectively for these three characters. The traits viz., cane diameter and relative water content after drought had shown least impact due to drought condition with 1.01% and 2.11% reductions respectively. In the checks 3.58% reduction for cane diameter and 4.31% reduction for relative water content after drought were observed. Tillers mortality % was less in AS 04-1687% with 30.09% while it was higher with 39.84 in the checks (Table 1). Among the entries

**Table 1. Performance of the proposed clone AS 04-1687 under drought conditions**

| Characters | AS 04 -1687 | | | Checks*** | | |
|---|---|---|---|---|---|---|
| | Normal | Drought | % change | Normal | Drought | % change |
| Cane yield t/ha | 116.15 | 94.66 | -18.51 | 94.0 | 66.01 | -29.77 |
| CCS t/ha | 8.79 | 7.9 | -10.08 | 12.15 | 8.53 | -29.73 |
| NMC* (000’/ha) | 173.12 | 150.61 | -13.01 | 83.8 | 69.07 | -17.57 |
| Cane Diameter (at 360 days) | 1.97 | 1.95 | -1.01 | 2.65 | 2.54 | -3.58 |
| Tillers mortality % | 33.45 | 30.09 | -10.07 | 39.97 | 39.84 | -0.32 |
| RWC** after drought | 78.43 | 76.77 | -2.11 | 83.66 | 80.05 | -4.31 |

* Number of millable canes (Thousands/ha)**RWC Relative water content
***Mean of 9 checks viz., Co 92005, CoM 0265, Co 86032, CoV 94101, CoV 92102, CoV 09356, BO 91, BO 154 and BO 145
(Source: PICI – AICRP(S) annual report for the year 2016-17 and 2017-18)

tested, the clone AS 04-1687 was identified as a best clone for drought tolerance.

**Performance of the proposed clone AS 04-1687 under waterlogging conditions:** Pooled analysis indicated that the proposed clone AS 04-1687 exhibited low percent reduction for many traits after the waterlogging period. The clone showed 2.01%, 8.26 % and 5.20% reduction for CCS t/ha, single cane weight (kg) and NMC (000'/ha) respectively while the checks showed 19.79%, 20.04% and 10.05% reduction respectively for these traits (Table 2). Cane yield also exhibited less reduction (16.42%). Sucrose % was unaffected in AS 04-1687 while the checks recorded 5.24 % reduction. Considering the superior performance for the above traits, AS 04-1687 was considered as a better waterlogging tolerant clone.

The interspecific genetic stock AS 04-1687 developed through hybridization between the subtropical commercial variety- BO 102 and *S. spontaneum* (IND 84-337) is identified as a superior genetic stock (IC0636675:INGR20110) as it is tolerant to both drought and waterlogging conditions. The clone has broad genetic base as it was developed from the new cytotype 2n=56 of *Saccharum spontaneum* as the present day varieties are the derivatives of the cytotype 2n=64 and 2n=112. This clone can be effectively utilized in sugarcane breeding to develop climate resilient varieties to withstand drought as well as water logging conditions.

## Reference

M Maheswari, B Sarkar, M Vanaja, M Srinivasa Rao, Ch Srinivasa Rao, B Venkateswarlu and AK Sikka (2015) Climate Resilient Crop Varieties for Sustainable Food Production under Aberrant Weather Conditions. NICRA-Bulletin No.4

**Table 2. Performance of the proposed clone AS 04-1687 under waterlogging condition**

| Characters | AS 04- 1687 | | | Checks** | | |
|---|---|---|---|---|---|---|
| | Normal | Water logging | % change | Normal | Water logging | % change |
| Cane yield t/ha | 90.86 | 75.94 | -16.42 | 74.23 | 61.26 | -17.47 |
| CCS t/ha | 8.14 | 7.98 | -2.01 | 10.51 | 8.43 | -19.79 |
| Sucrose % at harvest | 12.91 | 13.02 | 0.85 | 18.69 | 17.71 | -5.24 |
| Single Cane Weight (kg) | 0.73 | 0.67 | -8.26 | 1.05 | 0.84 | -20.04 |
| NMC (000'/ha)* | 108.84 | 103.18 | -5.20 | 67.96 | 61.13 | -10.05 |

* Number of millable canes (Thousands/ha)
** Mean of 12 checks viz., Co 86032, CoM 0265, CoM 88121, 83 R 23, CoA 06231, CoA 92081, Co 0238, BO 91, CoJ 88 (two locations), Co 98014 (two locations)
(Source: PICI – AICRP(S) annual report for the year 2016-17 and 2017-18)

# 33. BM 1010-168 (IC0636674; INGR20111), a Sugarcane (*Saccharum* sp.) Germplasm Tolerant to Drought. High Relative Water Content under Drought.

**P Govindaraj* and Bakshi Ram**
*ICAR-Sugarcane Breeding Institute, Coimbatore-641007, Tamil Nadu, India*
**Email: govindsbi1912@gmail.com*

Drought is the important yield limiting factor in sugarcane which is recurrent now-a-days hence development of drought tolerant sugarcane varieties in the climate change scenario is assuming more importance. INGR 20111, a genetic stock possessing drought tolerance and high relative water content under drought was the selection from Co 98010 × (Co 1148 x SES 404) at ICAR-Sugarcane Breeding Institute, Coimbatore. It was evaluated for drought tolerance in two plant and one ratoon crops under AICRP(S) programme in four locations viz., Padegaon (Peninsular Zone), Anakapalle (East Coast Zone), Faridkot (North West Zone) and Karnal (North West Zone). Drought was imposed by withdrawing irrigation between 60 and 150 days and data were compared with the normal crop raised under recommended irrigation.

INGR 20111 recorded 73.28 t/ha of cane yield under drought condition and showed 21.19 % reduction compared to normal condition while the checks recorded higher 29.78 % reduction (Table 1). Relative water content was unaffected due to imposition of drought in INGR 20111, but the 4.31 % reduction was observed with the checks. The clone showed less reduction for cane yield, CCS t/ha, single cane weight, number of

millable canes and relative water content after drought period hence can be used as a potential parent for the developing drought tolerant varieties. The genetic stock has long and erect canes with long internodes.

SES 404, a new *S. spontaneum* species clone was not exploited in sugarcane varietal development programme so far hence utilization of the proposed genetic stock with SES 404 in its pedigree as parent in hybridization will help in broadening the genetic base of the new sugarcane varieties. This genetic stock was resistant and moderately resistant to red rot for cf671 and cf94012 pathotypes respectively.

**Table 1. Performance of INGR 20111 under drought and normal conditions**

| Characters | BM 1010-168 | | | Checks** | | |
|---|---|---|---|---|---|---|
| | Normal | Drought | % change | Normal | Drought | % change |
| Cane yield t/ha | 92.99 | 73.28 | -21.19 | 94.00 | 66.01 | -29.78 |
| CCS t/ha | 9.49 | 7.64 | -19.47 | 12.15 | 8.53 | -29.79 |
| Single Cane Weight (kg) | 0.83 | 0.74 | -10.46 | 1.14 | 0.99 | -13.12 |
| NMC (000'/ha)* | 115.58 | 96.13 | -16.83 | 83.80 | 69.07 | -17.58 |
| Relative Water Content after drought | 80.30 | 80.31 | 0.01 | 83.66 | 80.05 | -4.31 |

* Number of millable canes (Thousands/ha)

** Mean of 12 checks viz., Co 86032, CoM 0265, CoM 88121, 83 R 23, CoA 06231, CoA 92081, Co 0238, CoPb 91, CoJ 88 (two locations), Co 98014 (two locations)

## Reference

Annual reports (2016-17) and (2017-18) Crop Improvement – AICRP (Sugarcane).

# 34. SBIEC 14006 (IC0636673; INGR20112), a Wild Sugarcane (*Erianthus arundinaceus*) Germplasm for High Harvestable Biomass. High Fibre Content.

**P Govindaraj* and Bakshi Ram**

*ICAR-Sugarcane Breeding Institute, Coimbatore-641007, Tamil Nadu, India*

**Email: govindsbi1912@gmail.com*

Biomass based industries like power generation, paper production and particle board manufacturers require quality and uninterrupted supply of biomass as raw materials. INGR 20112 was first generation selection from the open pollinated fluff of *E. arundinaceus* clone IK 76-75 at ICAR-Sugarcane Breeding Institute, Coimbatore. It recorded the highest mean harvestable biomass of 265.28 t/ha across three plant and one ratoon crops with average fibre content of 27.54% (Table). It also recorded 2.18 cm cane diameter and 1.24 kg of single cane weight. The cane grows up to 4 -5 m tall

**Table. Performance of SBIEC 14006 for harvestable biomass yield (t/ha) and fibre % in cane under four environments**

| Clones | HBM t/ha | | | | | Fibre % | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2013-14 (P) | 2014-15 (P) | 2015-16 (P)* | 2016-17 (R)** | Mean | 2013-14 | 2014-15 | 2015-16 (P) | 2016-17 (R) | Mean |
| SBIEC 14001 | 132.12 | 145.23 | 182.00 | 191.23 | 162.64 | 24.23 | 25.21 | 26.11 | 26.48 | 25.51 |
| SBIEC 14002 | 186.92 | 200.00 | 234.22 | 206.75 | 206.97 | 20.41 | 20.48 | 21.32 | 22.20 | 21.10 |
| SBIEC 14003 | 158.08 | 159.14 | 212.15 | 226.78 | 189.04 | 21.98 | 20.27 | 20.18 | 21.11 | 20.88 |
| SBIEC 14004 | 136.15 | 161.34 | 185.21 | 186.27 | 167.24 | 25.24 | 22.04 | 25.00 | 23.13 | 23.85 |
| SBIEC 14005 | 143.08 | 158.12 | 162.16 | 194.25 | 164.40 | 26.50 | 23.38 | 25.88 | 23.28 | 24.76 |
| SBIEC 14006 | 233.65 | 249.29 | 282.83 | 295.34 | 265.28 | 27.24 | 26.99 | 28.22 | 27.70 | 27.54 |
| INGR 12017 | 203.00 | 217.12 | 227.77 | 228.98 | 219.22 | 21.17 | 20.79 | 21.58 | 20.05 | 20.90 |
| CD | 24.04 | 28.16 | 23.08 | 17.37 | | 2.86 | 1.83 | 1.09 | 1.22 | |
| CV | 12.23 | 15.86 | 17.95 | 14.66 | | 5.97 | 7.26 | 10.03 | 12.52 | |

* Plant crop ** Ratoon crop

in 12 months. The leaf sheath is tightly attached to the cane hence available up to harvest without wasting the biomass. Tall and non-lodging nature of canes makes the genetic stock amenable for mechanical harvesting. It can be ratooned for at least 7-8 years hence no need for replanting every year which brings down the cost of cultivation in ratoon crop. This is as an ideal Type II energy cane due to more biomass yield per unit area and requires low input and low nutrient requirements and incurs less production cost.

### Reference

Govindaraj P (2020) SBIEC 14006 – A high biomass energy cane for power, alcohol and paper industries. *J. Sugarcane Res.* **10(1)**: 100-106

## 35. Pune Selection-2 (IC0637024; INGR20113), a Papaya (*Carica papaya*) GermplasmTolerant to Papaya Ringspot Virus and Yellow Flesh

**VV Datar, SJ Singh, VM Chavan, KK Zote, SK Sharma, GK Mahapatro*, Raj Verma, S Tripathi, Swati Saha, SPS Tome and, AU Sonawane**

*ICAR-IARI Regional Station, Pune-411007, Maharashtra, India*

**Email: head_pune@iari.res.in*

Pune Selection-2 (PS-2) is a near homozygous, yellow (mango-yellow) fleshed, dioecious papaya (*Carica papaya* L.) line. The line is consistently showing field tolerance to *Papaya Ring Spot Virus* strain papaya (PRSV-P) with appreciable yield (Sharma and Tripathi, 2019). The parental material was a segregating local collection of papaya named 'Madhubala'. PS-2 was selected from the segregating population (Datar *et al*., 2013). Since then, it is developed into a line by sib-mating and selection at IARI, Regional Station, Pune. The PRSV tolerant PS-2 line has good potential in resistance breeding and as target variety for vegetable purpose specifically in Northern States of India (Sharma *et al.,* 2017; Mahapatro *et al*., 2019).

**Morpho-agronomic characteristics:** Mean height of the plant is 164 cm, mean stem girth is 40 cm, leaf shape is palmate type and petiole colour is green. Petal colour is cream yellow. Average fruiting height is 91 cm. Average length of the fruiting column is 45cm. Mean fruit weight is 1455g. Average yield per plant is 25.98 kg. Shape of the fruit is oblong. Average thickness of flesh is 3.22 cm with yellow colour and average TSS value of 8.16 ºBrix. Average intensity of PRSV intensity of Red Lady was 20.48 which were four times higher than Pune Selection-2 (5.88). The line performed better than both the checks (papaya cv. Red Lady and Pusa Nanha) under severe PRSV-P pressure.

**Associated characters and cultivation practices:** PS-2 exhibits remarkable field tolerance to PRSV-P. It shows late and mild PRSV infection. Growth, fruiting characters and incidence of PRSV-P in PS-2 along with two checks of papaya, namely, Red Lady and Pusa Nanha are given in Table 1.

Under Pune conditions, it is recommended to plant seedlings having six to eight leaves in spring season (February-March) since the virus transmitting aphid-vector population is minimal from February to June. Seedlings should be raised in insect-proof polyhouse. Being a dioecious line, two seedlings per hill should be planted to maintain higher ratio of productive female plants. Per plant space required is 4.3 to 4.4 square meters that can be achieved by maintaining row to row and plant to plant distance of 2.4m × 1.8 m respectively or by square plantation of 2.1 m × 2.1 m. About 2,300 plants can be accommodated per hectare under both spacing. One square foot FYM, 2 kg neem seed cake and 1 kg sterameal should be applied per hill before plantation. Inorganic fertilizers N:P:K at the rate of 300:300:300 g/plant should be applied in four split doses at alternate month. Foliar application of a balance mix of all micronutrients (2g/L) at alternate month along with additional spray of boron (2g/L) at the time of fruit setting, and calcium (2g/L) before fruit ripening is recommended.

Papaya is one of the cite-worthy fruit crops of the tropical region with major commercial importance owing to its rich nutritive and medicinal value. However, its true potential has remained under-exploited due to inadequate quality planting materials of right varieties, high pre- and post-harvest losses. This crop is ought to be popularized amongst Indian farmers as a nutrition-rich source for poor; and moreover, the PRSV tolerant

**Table 1. Comparison of growth, fruiting characters, yield and PRSV reaction of Pune Selection-2 with local checks (Red Lady and Pusa Nanha**

| Variety | PS-2 | | | | Red Lady | | | | Pusa Nanha | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Characters | 2016-17 | 2017-18 | 2018-19 | Avg. | 2016-17 | 2017-18 | 2018-19 | Avg. | 2016-17 | 2017-18 | 2018-19 | Avg. |
| Plant Height (cm) | 167 | 174 | 151 | 164 | 148 | 175 | 147 | 157 | 103 | 106 | 91 | 100 |
| Stem girth (cm) | 37 | 45 | 38 | 40 | 35 | 46 | 36 | 39 | 29 | 32 | 27 | 29 |
| Fruiting Height (cm) | 107 | 82 | 83 | 91 | 86 | 90 | 75 | 84 | 45 | 55 | 45 | 48 |
| Fruiting Column Length (cm) | 27 | 64 | 44 | 45 | 31 | 54 | 51 | 45 | 36 | 41 | 39 | 39 |
| Yield (kg/plant) | 19 | 36.44 | 22.5 | 25.98 | 15.47 | 19.13 | 17 | 17.20 | 19 | 13.06 | 16.69 | 16.25 |
| Average fruit weight (g) | 1520 | 1470 | 1375 | 1455 | 1289 | 1677 | 1087 | 1351 | 1215 | 712 | 879 | 935 |
| Flesh Thickness (cm) | 4 | 2.67 | 3 | 3.22 | 2.6 | 2.83 | 2.5 | 2.64 | 2.88 | 2.67 | 2.83 | 2.79 |
| Flesh Colour | Yellow | | | | Red | | | | Yellow | | | |
| TSS (ºBrix) | 8 | 7.83 | 8.67 | 8.167 | 9.8 | 9.17 | 8 | 8.99 | 8.71 | 8.17 | 10 | 8.96 |
| PRSV Intensity (%) | 5.82 | 0 | 11.83 | 5.88 | 25.58 | 6.45 | 29.41 | 20.48 | 18.06 | 3.45 | 4.76 | 8.76 |

PS lines (Mahapatro *et al*., 2019), are advocated as vegetable also.

## References


Datar VV, KK Zote, R Verma, S Tripathi and SPS Tomer (2013) Field evaluation of papaya cultivars/lines for Papaya ringspot virus. *J. Mycol. Pl. Pathol.* **43(4)**: 481-483.

Mahapatro GK, K Swati, T Savarni and SK Sharma (2019) Performance of Pune Selection lines of papaya in Pune condition. In: International Conference on Innovative Horticulture and Value Management. 28-31 May 2019. GBPUA&T, Pantnagar, Uttarakhand.

Sharma SK and S Tripathi (2019) Horticultural characterization and disease reactions of *Papaya ringspot virus* tolerant papaya genotype (Pune Selections) under field condition. *Ind. J. Hort.* **76(1)**: 32-37.

Sharma SK, Raj Verma, K Chandrashekar, S Tripathi, Saha S and GK Mahapatro (2017) Potential papaya lines tolerant to Papaya ringspot virus.*Abstracts*. In: 3rd International Conference Biosources and Stress Management. Jaipur, 8-11 November, 2017. pp 15.


# 36. Pune Selection-5 (IC0637025; INGR20114), a Papaya (*Carica papaya*) Germplasm Tolerant to Papaya Ring Spot Virus and Yellow Flesh.


**VV Datar, SJ Singh, VM Chavan, KK Zote, SK Sharma, GK Mahapatro*, Raj Verma, S Tripathi, Swati Saha, SPS Tomer and OP Meena**

*ICAR-IARI Regional Station, Pune-411007, Maharashtra, India*

**Email: head_pune@iari.res.in*


Pune Selection-5 (PS-5) is a near homozygous, yellow fleshed, dioecious papaya (*Carica papaya* L.) line. The line is consistently showing field tolerance to *Papaya Ring Spot Virus* strain papaya (PRSV-P) with good yield (Sharma and Tripathi, 2019). The parental material was a segregating local collection of papaya named 'Madhubala'. PS-5 was selected from the segregating population (Datar *et al*., 2013). Since then, it is developed into a line by sib-mating and selection at IARI, Regional Station and Pune. The PRSV tolerant PS-5 line has good potential in resistance breeding and as target variety for vegetable purpose in Northern States of India (Sharma *et al.,* 2017 b).

**Morpho-agronomic characteristics:** Mean height of the plant is 141 cm, mean stem girth is 31 cm, leaf shape is palmate type and petiole colour is green. Petal colour is yellow. Average fruiting height is 77cm. Average length of the fruiting column is 49 cm. Mean fruit weight is 1280 g. Average yield per plant is 23.63 kg. Shape of the fruit is oblong. Average thickness of flesh is 3.31 cm with yellow colour and average TSS value of 8.11 ºBrix. Average intensity of PRSV infection was 4.34%. The line performed better than both the checks (papaya cv. Red Lady and Pusa Nanha) under severe PRSV-P pressure.

**Associated characters and cultivation practices:** PS-5 is having field tolerance to PRSV-P. It shows late and mild PRSV infection. Growth, fruiting characters and incidence of PRSV-P in PS-5 along with two checks of papaya, namely, Red Lady and Pusa Nanha are given in Table 1. Under Pune conditions, it is recommended to plant seedlings having six to eight leaves in spring season (February-March) since the virus transmitting aphid-vector population is minimal from February to June. Seedlings should be raised in insect-proof polyhouse. Being a dioecious line, two seedlings per hill should be

**Table 1. Comparison of growth, fruiting characters, yield and PRSV reaction of Pune Selection-5 with local checks (Red Lady and Pusa Nanha)**

| Variety | PS-5 | | | | Red Lady | | | | Pusa Nanha | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Characters | 2016-17 | 2017-18 | 2018-19 | Avg. | 2016-17 | 2017-18 | 2018-19 | Ave. | 2016-17 | 2017-18 | 2018-19 | Avg. |
| Plant Height (cm) | 154 | 139 | 130 | 141 | 148 | 175 | 147 | 157 | 103 | 106 | 91 | 100 |
| Stem girth (cm) | 30 | 35 | 29 | 31 | 35 | 46 | 36 | 39 | 29 | 32 | 27 | 29 |
| Fruiting Height (cm) | 91 | 70 | 71 | 77 | 86 | 90 | 75 | 84 | 45 | 55 | 45 | 48 |
| Fruiting Column Length (cm) | 35 | 59 | 52 | 49 | 31 | 54 | 51 | 45 | 36 | 41 | 39 | 39 |
| Yield (kg/Plant) | 15.73 | 31.01 | 24.16 | 23.63 | 15.47 | 19.13 | 17 | 17.20 | 19 | 13.06 | 16.69 | 16.25 |
| Average fruit weight (g) | 1092 | 1267 | 1481 | 1280 | 1289 | 1677 | 1087 | 1351 | 1215 | 712 | 879 | 935 |
| Flesh Thickness (cm) | 4 | 2.67 | 3.25 | 3.31 | 2.6 | 2.83 | 2.5 | 2.64 | 2.88 | 2.67 | 2.83 | 2.79 |
| Flesh Colour | Yellow | | | | Red | | | | Yellow | | | |
| TSS (ºBrix) | 8 | 7.67 | 8.67 | 8.11 | 9.8 | 9.17 | 8 | 8.99 | 8.71 | 8.17 | 10 | 8.96 |
| PRSV Intensity (%) | 8.33 | 0 | 4.68 | 4.34 | 25.58 | 6.45 | 29.41 | 20.48 | 18.06 | 3.45 | 4.76 | 8.76 |

planted to maintain higher ratio of productive female plants. Per plant space required is 4.3 to 4.4 square meters that can be achieved by maintaining row to row and plant to plant distance of 2.4m × 1.8 m respectively or by square plantation of 2.1 m × 2.1 m. About 2,300 plants can be accommodated per hectare under both spacing. One square foot FYM, 2 kg neem seed cake and 1 kg sterameal should be applied per hill before plantation. Inorganic fertilizers N:P:K at the rate of 300:300:300g/plant should be applied in four split doses at alternate month. Foliar application of a balance mix of all micronutrients (2g/L) at alternate month along with additional spray of boron (2g/L) at the time of fruit setting, and calcium (2g/L) before fruit ripening is recommended.

Papaya is one of the cite-worthy fruit crops of the tropical region with major commercial importance owing to its rich nutritive and medicinal value. However, its true potential has remained under-exploited due to inadequate quality planting materials of right varieties, high pre- and post-harvest losses. This crop is ought to be popularized amongst Indian farmers as a nutrition-rich source for poor; and moreover, the PRSV tolerant PS lines (Mahapatro *et al*., 2019), are advocated as vegetable also.

## References

Datar VV, KK Zote, R Verma, S Tripathi and SPS Tomer (2013) Field evaluation of papaya cultivars/lines for Papaya ringspot virus. *J. Mycol. Pl. Pathol.* **43(4)**: 481-483.

Mahapatro GK, K Swati, T Savarni and SK Sharma (2019) Performance of Pune Selection lines of papaya in Pune condition. In: International Conference on Innovative Horticulture and Value Management. 28-31 May 2019. GBPUA&T, Pantnagar, Uttatakhand.

Sharma SK and S Tripathi (2019) Horticultural characterization and disease reactions of *Papaya ringspot virus* tolerant papaya genotype (Pune Selections) under field condition. *Ind. J. Hort.* **76(1)**: 32-37.

Sharma SK, Raj Verma, K Chandrashekar, S Tripathi, S Saha and GK Mahapatro (2017) Potential papaya lines tolerant to Papaya ringspot virus. *Abstracts*. In: 3rd International Conference Biosources and Stress Management. Jaipur, 8-11 November, 2017 pp 15.

# 37. IPC 126A & IPC 126B (IC635036 &IC635037; INGR20115), a Dark purple (Black) Tropical Carrot (*Daucus carota*) CMS Line.

**Pritam Kalia**

*ICAR-Indian Agricultural Research Institute, Pusa Campus-110012, New Delhi, India*
*Email: pritam.kalia@gmail.com*

Black carrot is rich in anthocaynins, which are powerful antioxidants and anticancer bioactive phytochemicals. For developing black coloured anthocyanin rich hybrids in carrot, CMS line is essential. Multinutrient rich multicoloured carrot hybrids will have potential for fresh market as well as industry. For this, a natural petaloid (anthers turn to petal like structures) CMS system found in an already developed variety 'Pusa Rudhira' (IPC-122) at Division of Vegetable Science, ICAR-IARI, New Delhi (Kalia *et al*., 2019), which was used as a source

material for introgression of CMS system into IPC 126 (Pusa Asita) and the maintainer was also searched in this background and CMS line 'IPC 126A' was established which produces black roots with self core colour like that of maintainer.

**Morpho-agronomic characteristics of CMS line IPC 126A:** The CMS line IPC 126A is the first CMS line of tropical black carrot developed indigenously. It is suitable for sowing during main season (*i.e.* October to January). For fresh consumption; 90 days old roots are ready to harvest (Table 1). Leaves are purple green and leaf petiole colour is purple. It produces dark purple or black colour, long roots with self-core character. The average root length was found to be 24.0 cm, root diameter 30.8 cm, core diameter 11.54cm and root weight 95 g. The height of flowering plants was 126.5 cm with profuse flowering umbels and seed setting. The floral traits *i.e.* petal size, petal colour, petaloid (anther converted petals) colour and size and nectaries showed normal development. The marketable root yield at fresh consumption stage was recorded to be 14.6 t/ha which was lower than its maintainer line IPC 126B (17.8t/ha) at harvest (Table 1). The processing industry requirement is bulky roots (120-130 days) which yield around 22.2 t/ha for IPC 126A and 30.1 t/ha for IPC 126B lines. Unlike European type, IPC 126A and IPC 126B does not require vernalization and produce seeds in plains during winter season. The bolting (elongation of flower stalk) occurs during February-March month and produce abundant seeds which are harvested during April-May months in plains of India. The CMS line showed potential in hybrid breeding of black and multicoloured multinutrient rich carrot hybrids, which can be used in commercial hybrid breeding programme.

**IPC 126B: male fertile maintainer line of CMS line IPC 126A:** The 'IPC 126B' or IPC 126 has been released as Pusa Asita, an open-pollinated variety of black colour carrot for main season cultivation in Delhi region. It is a variety of tropical type black carrot and suitable for sowing during September to October months in plains

**Table 1. Important horticultural traits and seed yield of CMS line IPC 126A line as compared to the fertile maintainer line IPC 126B**

| Traits | IPC 126A | IPC 126B |
|---|---|---|
| Maturity traits | | |
| Growing season | Main season | Main season |
| Sowing period | September – October | September – October |
| Harvesting for fresh consumption | December – January | December – January |
| Harvesting for processing* | January – February | January – 1st Fortnight February |
| Plant and root traits | | |
| Root skin colour | Dark purple | Dark purple |
| Root core colour | Dark purple (self-core) | Dark purple (self-core) |
| Plant height (cm) | 68.4 | 87.5 |
| Gross plant weight (cm) | 185 | 215.0 |
| Root length (cm) | 24.0 | 25.6 |
| Root diameter (mm) | 30.8 | 37.4 |
| Core diameter (mm) | 11.54 | 10.8 |
| Root weight for fresh consumption (g) | 95.0 | 115.0 |
| Root yield for fresh consumption (t/ha) | 14.6 | 17.8 |
| Root weight (g) | 195.0 | 200.7 |
| Root yield for processing purple (t/ha) | 22.2 | 30.1 |
| Floral traits | | |
| Petal colour | Light purple | Light purple |
| Petal length (cm) | 1.5 | 1.11 |
| Petaloid colour | Light purple | - |
| Petaloid length (cm) | 1.30 | - |
| Petaloid width (cm) | 0.47 | - |
| Style length (cm) | 1.57 | 1.16 |
| Petaloid shape | Spoon | - |
| Nectary development | Prominent | Prominent |
| Observation on natural seed setting | Abundant | Abundant |

*Require more time for bulkiness and colour accumulation.

of north India. It matures in 90 days after sowing during December to January months. Plants vigorous, erect, medium to large in spread and leaves are purple green with purple petiole. It produces dark purple or black roots with self core colour (Table 1).

## References

Kalia P, M Mangal, S Singh, C Chugh, M Mishra and S Chaudhary (2019) Morphological and molecular changes on cytoplasmic male sterility (CMS) introgression in Asiatic carrot (*Daucus carota* L.). *Planta*, https://doi.org/10.1007/s00425-019-03185-4.

# 38. IPC 98A & IPC 98B (IC0598343 & IC0637028; INGR20116), a Red Colour Tropical Carrot CMS Line (*Daucus carota*)

**Pritam Kalia**
*ICAR-Indian Agricultural Research Institute, Pusa Campus-110012, New Delhi, India*
*Email: pritam.kalia@gmail.com*

Carrot (*Daucus carota* L.; 2n= 2x=18) is an important root vegetable crop being grown worldwide. Tropical red colour carrot is rich in lycopene, a powerful anticancer antioxidant. In India, carrot is grown on 86,200 ha area and production is 1,379,031 MT with productivity of 15.9 t/ha (NHB Database 2017). Hybrids are superior for uniformity, higher yield, earliness and have higher recovery of marketable roots per unit area. But, lack of cytoplasmic male sterile (CMS) lines in tropical types having red colour was major reason which hampered the progress of hybrid breeding in India. Fortunately, a 'petaloid' type sterile cytoplasm was found as a natural mutant in tropical red carrot genotype 'IPC-122' at Division of Vegetable Science, ICAR-IARI, New Delhi which was tapped and introgressed into different elite genotypes. It was introgressed into 'IPC 98', an elite genotype of tropical red carrot by backcross breeding (Kalia *et al.,* 2019) and used in development of only tropical carrot hybrid 'Pusa Vasuda' as female parent. This CMS line is expected to play a key role in establishment of indigenous hybrid seed industry of tropical carrot.

**Morpho-agronomic characteristics of CMS line IPC 98A:** The 'IPC 98A'is the first CMS line of tropical carrot having red coloured self-core roots developed indigenously. It is suitable for sowing during main crop season in north Indian plains (*i.e.* September to October) and roots gets ready for harvest in 90-100 days (Table 1). The height of flowering plants was 100.5 cm with profuse flowering and seed setting. The floral traits *i.e.* petal size, petal colour, petaloid (anther converted petals) colour, size and nectaries showed normal development. It produces red colour, long roots with self-core character.

**Table 1. Important horticultural traits and seed yield of CMS line IPC 98A line as compared to the fertile maintainer line IPC 98B**

| Traits | IPC 98A | IPC 98B |
|---|---|---|
| Maturity traits | | |
| Growing season | Main season | Main season |
| Sowing period | September – October | September – October |
| Harvesting period | December – January | December – January |
| Plant and root traits | | |
| Plant height (cm) | 87.4 | 89.1 |
| Gross plant weight (cm) | 185.0 | 254.7 |
| Root colour | Red | Red |
| Root core colour | Red | Red |
| Root length (cm) | 24.4 | 24.8 |
| Root diameter (mm) | 31.0 | 38.5 |
| Core diameter (mm) | 9.4 | 11.2 |
| Root weight (g) | 151.0 | 164.5 |
| Root yield (t/ha) | 30.0 | 29.25 |
| Floral traits | | |
| Petal colour | White | Green |
| Petal length (cm) | 1.49 | 1.01 |
| Petaloid colour | Light purple | - |
| Petaloid length (cm) | 1.86 | - |
| Style length (cm) | 0.94 | 0.61 |
| Petaloid width (cm) | 0.90 | - |
| Petaloid shape | Trident | - |
| Nectary development | Prominent | Prominent |
| Honey bee visit | Abundant | Abundant |

Average root length of IPC 98A was found to be 24.4 cm, root diameter 31.0 mm, small core diameter 9.4 mm and root weight 151.0 g (Fig. 3A-B). The marketable root yield was recorded to be 30.0 t/ha which was at par with its maintainer line IPC 98B (29.25t/ha) (Table 1). The bolting (elongation of flower stalk) occurs during February–March months and produce seeds profusely which are harvested during April-May months in plains. This CMS line has been used in breeding 'Pusa Vasuda'

red root hybrid for the main season. The IPC 98A performed well in different hybrid combinations showing potential, thereby, in commercial hybrid breeding of indigenous tropical hybrids.

**IPC 98B: male fertile maintainer line of CMS line IPC 98A:** The 'IPC 98B' is an elite genotype of main season tropical carrot. It is suitable for sowing in September to October in plains of north India. It matures during December to January months in 90-100 days after sowing. Plants are medium, vigorous, semi-erect, medium in spread and leaves are green. It produces red root with self-core colour (Table 1).

## References

NHB Database (2017) Horticultural Statistics at a Glance. National Horticulture Board, Government of India, Gurugram, India.

Kalia P, M Mangal, S Singh, C Chugh, M Mishra and S Chaudhary (2019) Morphological and molecular changes on cytoplasmic male sterility (CMS) introgression in Asiatic carrot (*Daucus carota* L.). *Planta*, https://doi.org/10.1007/s00425-019-03185-4.

# 39. YF 5-2-7 (IC-633085) (IC0633085; INGR20117), a Watermelon (*Citrullus lanatus*) Germplasm with Saffron Coloured Flesh and High Carotenoid Content. Non-Lobed (Entire) Leaves

**BR Choudhary*, MK Berwal and PL Saroj**

*ICAR-Central Institute for Arid Horticulture, Bikaner-334 006, Rajasthan, India*

**Email: choudharybr71@gmail.com*

Watermelon [*Citrulluslanatus* (Thunb.) Mansf.] is an important crop grown in different parts of country. It is one of the most widely cultivated crops in the world and its global consumption is greater than that of any other cucurbit. Presently the red fleshed varieties are widely cultivated in India. The major nutritional components in watermelon consist of carbohydrates (6.4 g/ 100g), vitamin A (590 IU) and lycopene (4100 µg/ 100g) in red flesh varieties. Presently the red fleshed varieties are widely cultivated in India which contain low amount of carotenoid content. Now a day's people are very conscious to health issues and there is demand of varieties rich in carotenoids. Therefore, breeding for specific flesh coloured varieties having high nutritive value are often a challenge to attract consumers.

Watermelon showed a wide range of genetic variability in quantitative and qualitative traits (Choudhary *et al*., 2016). Watermelon being highly cross pollinated crop possess varying flesh colour *viz*., red, white, yellow and saffron having different profile of nutrients. Keeping in view, identified and homogenized a saffron flesh coloured genotype of watermelon (YF 5-2-7) having high carotenoid content. YF 5-2-7 is high in carotenoid content (7.10-9.18 µg/ g FW) in comparison to popular red fleshed varieties which have 3.92-4.14 µg /g FW carotenoid content. It is characterized by non-lobed (entire) leaves, round fruits having dark green rind with very narrow stripes, saffron flesh and blackish brown seeds. YF 5-2-7 produced round fruits weighing 2.5-3 kg, rind thickness (1.0-1.3 cm), TSS (10-11%) and bear 3-4 fruits/plant. Fruits ready for harvesting in 80-85 days after sowing. The analysis of carotenoid content was done using the biochemical method as suggested by Hartmut and Alan, 1983.

**Table 1. Salient characteristics of YF 5-2-7 (IC-0633085)**

| Trait | Description |
|---|---|
| Days to first fruit harvest after sowing | 80-85 days |
| Number of fruit/ plant | 3-4 |
| Fruit weight | 2.5-3.0 kg |
| Fruit diameter | 14.8-18.0 cm |
| Rind thickness | 1.0-1.3 cm |
| TSS | 10.0-11.0% |
| Carotenoid content | 7.10-9.18 µg/ g FW |
| Sex form | Monoecious |
| Leaf shape | Non-lobed (Entire) |
| Fruit shape | Round |
| Rind colour | Dark green with very narrow stripes |
| Flesh colour | Saffron |

## References

Choudhary BR, S Pandey, ES Rao, D Singh and BD Sharma (2016) Characterization of variability in watermelon for DUS testing.*Current Horticulture,* **4(2)**: 30-34.

Hartmut K Lichtenthaler and Alan R Wellburn (1983) Determinations of total carotenoids and chlorophylls a and b of leaf extracts in different solvents. *Biochem. Soc. Trans.* **11(5)**: 591-592.