*Indian J. Plant Genet. Resour. 36(3): 455-513 (2023)*

# Plant Germplasm Registration Notice*

The Plant Germplasm Registration Committee (PGRC) of ICAR held its XXXXV$^{th}$ meeting on September 21$^{st}$, 2021 in virtual mode. 124 proposals were received and examined at ICAR-NBPGR out of which 71 proposals complete in all respects and reviewed by experts were considered for registration. 64 proposals with unique/novel features belonging to 30 species were finally recommended for registration. The information on registered germplasm is published with the purpose to disseminate the information to respective crop breeders for utilization of these genetic stocks in their crop improvement programmes.

## 1. Wazuhophek (IC639795; INGR21112), a rice (*Oryza sativa* L.) germplasm with tolerance to sheath blight and low soil P tolerance

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Sheath blight (ShB) of rice is one of the major devastating diseases and responsible for 70% of yield losses and quality degradation. It is caused by necrotrophic soil born pathogen *Rhizoctonia solani* AG-1 IA which affects sheath, leaf and panicle. It produces water soaked brown color oval shaped lesions on sheath, irregular lesion on leaf and produces sclerotia during unfavorable conditions and maintains dormant period in soil which can act as a primary source of inoculum.

Screening was done by inoculation of cultured *R. solani* typha bits at maximum tillering stage (Bhaktavatsalam *et al.,*1978) and disease scoring was given based on relative lesion height (RLH) as per (0-9) Standard Evaluation System (SES, IRRI, 2014). Among the entries screened, 'Wazuhophek' a North East Indian landrace was identified as highly tolerant (Table 1) through repeated artificial screening in field condition for the past 6 seasons *viz., Kharif*-2012, *Rabi*-2013, *Kharif*-2013, *Rabi*-2014 and *Kharif*-2014 (Dey *et al.*, 2016; Dey *et al.*, 2020).

To know the tolerance mechanism in Wazuhophek, expression of PR genes, defense enzymes and histo-pathological studies were conducted. The expression transcript s of defense related genes *viz.,* PR-1, PR-2, PR-3, PR-4, PR-5, PR-9, PR-10, PR-13, CHS, LOX, PAL and PPO were studied by using quantitative Real-time PCR (qRT PCR). The expression levels of PR-1, PR-3, PR-9 and PR-10 genes were 56.14, 95.85, 31.48, and 66.1% higher folds in Wazuhophek than IR50 at 72 hours after inoculation with *R. solani* (Roy *et al.*, 2018).

Histopathological studies were conducted between two cultivars *i.e.,* Wazuhophek as tolerant and IR-50 as susceptible by infecting with *R. solani*. Observations were recorded at 24 hours post inoculation (hpi), 48 and 72 hpi. Rate of hyphae branching, density of mycelium was high and most of the area was occupied by infection cushions in susceptible IR-50 when compared to tolerant Wazuhophek (Roy, 2018).

In addition to sheath blight tolerance, Wazuhophek also showed tolerance to low soil P and interestingly we found that it is completely devoid of *Pup1* gene. It performed equally with the tolerant checks Kasalath and Swarna which consists of gene specific *pup-1* gene (Swami *et al.,* 2019). 98 germplasm lines including wazuhophek were screened for low soil P tolerance in the low soil P plot (available p <2 Kg ha$^{-1}$) and with normal soil P condition (available p > 20 Kg ha$^{-1}$) at ICAR- IIRR during *Kharif*-2014 along with the tolerant checks Kasalath and Swarna and susceptible checks Improved Samba Mahsuri (ISM), MTU 1010, and IR-64. A total of fifteen parameters *viz*., days to 50% flowering (DFF), plant height (PH), number of productive tillers per plant (NPT, nos.), flag leaf length (FFL), flag leaf width (FLW), panicle length (PL), shoot length (SL), root length (RL), root volume (RV), dry shoot weight (DSW), dry root weight (DRW), root to shoot ratio (RSR), grain yield per plant (GY), thousand grain weight (TGW) and biomass (BM) were recorded.

Stress indices parameters such as STI (stress tolerance index), YSI (yield stability index), YI (yield index) showed high value for Wazuhophek, revealing its tolerance ability to low soil P while other non *Pup1* genotypes got very low values

*Edited by: Anju Mahendru Singh and Anjali Kak, Division of Germplasm Conservation, ICAR-National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi-110012, India*

*Acknowledgement is due to Mr. Arup Das, YP for providing technical assistance in compilation.*

**Table 1:** Disease reaction among rice germplasm under artificial inoculation during 2012 to 2020

| *S.No* | *K-2012 (F)* | *R-2013 GH)* | *K-2013 (F)* | *R-2014 (GH)* | *K-2014 (F)* | *K-2017 (F)* | *K-2018 (F)* | *K-2019 (F)* | *K-2020 (F)* |
|---|---|---|---|---|---|---|---|---|---|
| Tetep (TC) | 3 | 3 | 3 | 3 | 3 | 3 | 5 | 5 | 3 |
| Wazuhophek | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 5 | 3 |
| IR-50 (SC) | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| Sapetmaso | 5 | 3 | 5 | 7 | 7 | NT | NT | NT | NT |
| 9 (B) | 5 | 5 | 5 | 7 | 7 | NT | NT | NT | NT |
| 16 (B) | 5 | 5 | 5 | 7 | 7 | NT | NT | NT | NT |
| 61 (B) | 5 | 3 | 5 | 5 | 5 | NT | NT | NT | NT |
| APMS 6B | 3 | 5 | 5 | 5 | 7 | NT | NT | NT | NT |
| 495 | 3 | 5 | 5 | 7 | 5 | NT | NT | NT | NT |
| APMS-6B | 3 | 5 | 5 | 5 | 7 | NT | NT | NT | NT |
| MR-1523 | 5 | 5 | 5 | 7 | 9 | NT | NT | NT | NT |
| Meghalaya Lefara | 5 | 3 | 3 | 5 | 7 | NT | NT | NT | NT |

TC-Tolerant check; SC-Susceptible check; NT-Not tested; F-Field; GH-Glass House

**Table 2:** Genotypic status of eighteen low soil P tolerant genotypes for *Pup 1* locus, based on *Pup 1* specific markers

| S. No | Genotypes | Status for Pup 1 specific marker loci | | | | Percent yield reduction under low P condition |
|---|---|---|---|---|---|---|
| | | K 46-1 | K46-K1 | K 46-2 | K 52 | |
| 1 | Nagaram Mahripid | N | N | N | K | 23.4 |
| 2 | Meghalaya R ba Laispah | N | K | K | K | 45.0 |
| 3 | Megalaya Lakang | K | K | K | K | 46.1 |
| 4 | Nungshangphou | K | N | K | K | 46.8 |
| 5 | Kueashu | K | N | K | N | 58.2 |
| 6 | Deserkangbu | K | N | K | K | 61.6 |
| 7 | Wazuhophek | N | N | N | N | 62.1 |
| 8 | Churhchandpur | K | K | K | K | 63.2 |
| 9 | Sumi special | K | K | K | K | 63.8 |
| 10 | Phougak | N | N | K | N | 64.4 |
| 11 | Vishku | K | N | N | N | 66.3 |
| 12 | Chinapati | K | K | K | K | 66.5 |
| 13 | Moirangphou Angovba | N | K | K | K | 69.0 |
| 14 | Zunhiboto | K | K | K | K | 69.2 |
| 15 | Ayamaomaha | N | N | K | K | 69.4 |
| 16 | Yun Yokan Steo | N | N | K | K | 70.7 |
| 17 | Priya | K | N | K | N | 70.8 |
| 18 | China Ching | K | K | K | K | 70.9 |
| 19 | Swarna | K | K | K | K | 66.5 |

'K', Kasalath specific allele for the marker locus; 'N', Nipponbare specific allele for the marker locus [a]Low soil P tolerant check variety ; [b]Low soil P tolerant germplasm line which is completely devoid of Pup 1 locus

and fall into highly sensitive category. Stress susceptibility index of Wazuhophek was less than zero indicating its tolerance while SSI was >1 for other non-*Pup1* genotypes and were highly sensitive to low soil P. Marker assisted characterization of germplasm lines for *Pup1* locus based on *Pup1* specific markers revealed that full set of sequences associated with *Pup1* are present in the tolerant checks (Kasalath and Swarna) respect to all the four *Pup1*- specific markers and absent in the sensitive checks (Improved Samba Mahsuri, IR-64 and MTU 1010). The Wazuhophek possessed 'N' allele (i.e., non-tolerant allele) with respect to all the four *Pup1* specific marker loci but phenotypically tolerant to low soil P (Swami *et al.,* 2019, Table 2). Thus, Wazuhophek possess different mechanisms for low P tolerance and hence could serve as a novel source for low soil P tolerance and could help in diversification breeding programs aimed for low soil P tolerance.

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## 2. Kataribhog (IC640647; INGR21113), a Non-Basmati Aromatic rice (*Oryza sativa* L.) germplasm with low glycemic index (45.72%)


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Glycemic index (GI) helps in estimation of blood glucose response. According to Choi *et al.*, 2012, GI for foods has three categories mentioned as low (55 or less), medium (56-69) and high (70 or more). Frequent intake of rice with high GI is increasingly associated with elevated risk of type II diabetes, obesity, coronary heart disease and other chronic conditions. Northern part of West Bengal is famous for growing popular local indigenous rice landraces known as folk rice as well as many traditional short and medium grain aromatic rice genotypes. These genotypes collected from different parts of Sub-Himalayan region of West Bengal and adjoining states and are being maintained in the rice repository of Uttar Banga Krishi Viswavidyalaya. We have screened those collections of indigenous aromatic rice germplasm for their nutritional attributes and identified an aromatic rice cultivar named 'Kataribhog' with *in-vitro* low glycemic index (GI) value of around 45.72%, which is even lower than the GI of recommended rice varieties for diabetic patients. Kataribhog is photo-period sensitive, with long duration, tall crop, possessing slender type grain, low yield potential (1.5–2.0 t/ha) and having total soluble sugar of 64.77%, reducing sugar content of 1.59%, non-reducing sugar content of 0.77% starch content of 54.57%, amylose content 20.43%, amylopectin content: 34.13%, resistant starch content 2.25%, protein content 6.43% and antioxidant activity ($IC_{50}$) with 1583.68 $\mu$gm/ml (1).

GI of powdered Kataribhog was estimated by using *in vitro* method following Kumar *et al.,* 2018. The absorbance was measured at 510 nm. Maltose (200 mg) was used as standard carbohydrate. Average values were used to plot curves followed by computing the area under the curve (AUC). The Hydrolysis index (HI) for each rice variety was calculated by dividing AUC of sample by that of maltose and expressed in percentage. The predicted glycemic index was calculated using the following formula (PGI) = 39.71 + (0.549 × HI). Among the screened genotypes most of the genotypes showed an average GI value of more than 60% glycemic index. The glycemic index (GI) of the Kataribhog was found to be 45.72% which falls under low glycemic index according to Choi *et al.*, 2012 as 55 or less as low GI foods. GI of Pusa Basmati 1121 has been reported as 58.41%.

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## 3. CRR747-12-3-B (IET26337) (IC640651; INGR21114), a rice (*Oryza sativa* L.*)* germplasm with drought tolerant and resistant to blast disease


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The breeding line CRR 747-12-3-B (IET 26337) was derived from the cross Vandana*4/ C101A51//IR84984-83-15-862-B at CRURRS (ICAR-NRRI), Hazaribag following backcross breeding method. This line was evaluated as IET 26337 under direct seeded early group (E-DS) AICRIP trials during 2016 to 2018. It recorded superior yield performance under both severe and moderate drought stress situations with good early vigour, strong culm and good tillering ability. CRR 747-12-3-B is highly tolerant to reproductive stage drought and outperformed all the checks varieties such as Sahbhagi Dhan, Vandana, and Anjali across the locations under severe drought stress conditions by registering yield advantage of 51–102 and 15–292% during 2016 and 2018, respectively. Molecular marker assisted screening confirmed

**Table 1:** DUS characteristics of rice elite line ‘CRR747-12-3-B

| *Characteristics* | *CRR 747-12-3-B* | *Characteristics* | *CRR 747-12-3-B* |
|---|---|---|---|
| Basal Leaf sheath colour | Green | Flag leaf: attitude of blade | Horizontal |
| Leaf: anthocyanin colouration | Absent | Panicle: length of main axis | Medium (22.3cm) |
| Leaf sheath: anthocyanin colouration | Absent | Panicle: curvature of main axis | Semi-straight |
| Leaf: pubescence of blade surface | Weak | Panicle: no. per plant | Medium (15) |
| Leaf: auricles | Present | Spikelet: colour of tip of lemma | Yellowish |
| Leaf: anthocyanin colouration of auricles | Colourless | Lemma and palea: colour | Gold and gold furrows on straw |
| Leaf: collar | Present | Panicle: awns | Absent |
| Leaf: Anthocyanin colouration of collar | Absent | Panicle: attitude of branches | Erect - semi-erect |
| Leaf: shape of ligule | Split | Panicle: exertion | Mostly exerted |
| Leaf: colour of ligule | White | Decorticated grain: length | 6.26 mm |
| Leaf: length of blade | Medium (30.9 cm) | Decorticated grain: width | 2.04 mm |
| Leaf: width of blade | Medium (1.0 cm) | Decorticated grain: shape | Long slender |
| Culm strength | Strong (no lodging) | Decorticated grain: colour | White |
| Culm angle | Intermediate | Decorticated grain: aroma | Absent |
| Time of heading (50% plant with panicles) | Very early (67 days) | Milling recovery | 64.90% |
| Flag leaf: attitude of blade | Horizontal | Head rice recovery | 56.10% |
| Spikelet: density of pubescence of lemma | Weak | Apparent Amylose content | 23.30% |
| Lemma: anthocyanin coloration of area below apex | Absent | Gel consistency | Soft |
| Lemma: anthocyanin coloration of apex | Absent | Maturity duration (days) | 95 |
| Spikelet: colour of stigma | Light green | Yield (t/ha) | 2.3-4.0 (normal); 1.1-2.6 (under stress) |
| Stem: length | Short (97 cm) | Drought score (in SES scale) | 3 |
| Stem: anthocyanin colouration of nodes | Absent | Blast score (in SES scale) | 4.1-5.4 |
| Stem: intensity of anthocyanin colouration of internodes | Absent | | |

that CRR 747-12-3-B possesses three DTY QTLs for grain yield under reproductive stage drought stress (*qDTY*2.3, *qDTY*3.2 and *qDTY*12.1), *Phosphorus starvation tolerance 1* (*PSTOL1*) gene for tolerance to low-Phosphorus, and blast resistance gene *Pi-2*. This line is moderately resistance to rice leaf blast (scored 4.1 - 5.4 in 0-9 scale) based on multi-location screening in NSN1 and NSN2 under AICRIP and has good grain quality (Table 1). This new line can be further exploited to develop multiple tolerant high yielding rice varieties.

## 4. NWGR-13017 (IC637523; INGR21115), a rice (*Oryza sativa* L.) germplasm with resistance to leaf folder

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The rice genotype NWGR-13017 was developed through a cross between SK-20 x IET- 19297 followed by pedigree method of selection at MRRS, AAU, Nawagam. The Geographical Coordinates Latitude and Longitude (22°47′55″N and 72°34′45″E) of MRRS, AAU, Nawagam, Ta and Dist. Kheda, Gujarat. The genotype was tested in state trials during *Kharif,* 2015 as Preliminary Evaluation Trial (PET) and during *Kharif* 2016 as Small Scale Varietal Trial-Late (SSVT-L) at different location of Gujarat state. In addition to this the genotype NWGR-13017 was tested under AICRIP in the multilocation leaf folder screening trials (LFST) during *Kharif,* 2016 and 2017.

### *Morpho-agronomic characteristics*

The progeny of genotype NWGR-13017 was selected from the SK-20 x IET-19297 and cross was made in the year 2006 and F8 Bulk (1-1-1-2-2-2-1) in the year 2013. The donor parent SK-20 was selected from land race of Sukhwel which is early and tall. Another parent, IET- 19297 (DJP-1998-11-1-1-1) was developed by cross between TN-1 x INDCR-1940. The characters of genotype IET 19297 is mid early and long slender grain type. Ultimately, the resistance characters of NWGR 13017 were incorporated from different land races such as SK- 20, Dg Wg, Tsai Yuan Chung and INDCR-1940. Moreover, DNA fingerprinting profile of rice genotype NWGR 13017 was done by AFLP marker at Department of Agricultural Biotechnology, Anand Agricultural University, Anand, Gujarat.

The genotype NWGR-13017 came under late maturity group *i.e.,* seed to seed maturity is 138.5 to 139.5 days. It took 108.5 to 109 days for fifty per cent flowering, plant height between 123.0 to 135.5 cm, panicle length ranged from 26.1 to 27.4 cm, numbers of productive tillers 8.5 to 10.5 per plant, medium slender grain type (length 9.52 to 9.83 and breadth 1.79 to 1.90 mm), 1000 grain weight near about 21.85 to 22.96 g and average grain yield ranges between 3684 to 5228 kg/ha (Table 1).

### *Associate Characteristics*

The field experiments were conducted during *kharif,* 2016 and 2017 for the screening of rice genotypes along with national susceptible check Taichung Native 1 (TN-1) and resistant check (W-1263) against leaf folder. These genotypes were screened with the two rows of 10 hills each genotype and nine rows of test genotype alternating with one row of susceptible check TN-1 with two replications against leaf folder at Main Rice Research Station, Anand Agricultural University, Nawagam as well as different AICRIP centers across the India during 2016 and 2017, respectively (Table 2). The screening was carried out by standard evaluation system (SES) for leaf folder (Anonymous, 2013). At 25 days after transplanting (DAT), the genotypes were covered with nylon net and leaf folder adults were released inside the net collecting from the neighboring fields. Adults were released at 40 and 60 DAT @ 100 adults in each release. Cotton dipped in 20% honey solution was placed inside the net to provide food for adults. Adults were allowed to remain in the net for a week, then the net was removed and observations were recorded at the time of peak infestation on selected ten randomly plants in each genotype. At each observation, total number of leaves and leaf folder damaged leaves were

**Table 1:** Morphological traits and grain yield of NWGR-13017 (Mean ranges of 2015 and 2016)

| *Characters* | *Mean* | *Characters* | *Mean* |
|---|---|---|---|
| DFF (days) | 109.0 (108.5 - 109.0) | Grain breadth (mm) | 1.85 (1.79 - 1.90) |
| Days to Maturity | 139.0 (138.5 - 139.5) | 1000 grain wt. (g) | 22.41 (21.85 - 22.96) |
| Plant height (cm) | 129.0 (123.0 - 135.5) | Grain Yield (kg/ha) | 4456 (3684 - 5228) |
| Panicle length (cm) | 27.0 (26.1 - 27.4) | Grain type | Medium Slender |
| No. of productive tillers/plant | 10.0 (8.5 - 10.5) | Flag leaf attitude of blade | Semi erect |
| Grain length (mm) | 9.18 (9.52 - 9.83) | Length/Width of leaf blade | Short/Medium |

**Table 2:** Performance of NWGR-13017 against leaf folder at different location across the India under LFST trial of AICRIP

| *Year* | *Name of genotypes* | *Per cent damaged leaves of leaf folder at different locations* | | | | | *Mean* |
|---|---|---|---|---|---|---|---|
| | | *PTB (L1)* | *KUL (L2)* | *LDN (L3)* | *NWG (L4)* | *MSD (L5)* | |
| *Kharif*, 2016 | NWGR-13017 | 93.20 | 26.70 | 45.90 | 9.10 | 13.00 | 37.58 |
| | W 1263 (RC) | 92.50 | 12.80 | 26.10 | 8.90 | 1.00 | 28.26 |
| | TN 1 (SC) | 100.00 | 36.50 | 54.50 | 15.90 | 27.20 | 46.82 |

| *Year* | *Name of genotypes* | *Per cent damaged leaves of leaf folder at different locations* | | | | | | | *Mean* |
|---|---|---|---|---|---|---|---|---|---|
| | | *PTB (L1)* | *KUL (L2)* | *CHN (L3)* | *KBP (L4)* | *LDN (L5)* | *NLR (L6)* | *NWG (L7)* | |
| *Kharif*, 2017 | NWGR-13017 | 14.80 | 17.10 | 21.10 | 10.30 | 29.80 | 5.60 | 9.60 | 15.47 |
| | W 1263 (RC) | 12.80 | 15.10 | 26.60 | 13.70 | 17.90 | 6.60 | 13.00 | 15.10 |
| | TN 1 (SC) | 18.90 | 19.80 | 52.20 | 10.90 | 40.80 | 14.40 | 17.30 | 24.90 |

RC- Resistant check, SC- Susceptible check, Locations (L): PTB-Pattambi (Kerala), KUL-Kaul (Haryana), CHN- Chinsurah (West Bengal), KBP-Kurumbapet (Pondicherry), LDN-Ludhiana (Punjab), NLR-Nellore (Andhra Pradesh), NWG- Nawagam (Gujarat) and MSD-Masodhha (Uttar Pradesh)

**Table 3:** Performance of NWGR-13017 against leaf folder at Nawagam and Navsari location under State screening trial in natural condition

| *Year* | *Location* | *Reaction of leaf folder (Damage Score, 0-9)* | | |
|---|---|---|---|---|
| | | *NWGR-13017* | *GR 11 (C)* | *GR 103 (C)* |
| *Kharif*, 2015 | Nawagam | 1 | 3 | 3 |
| | Navsari | 1 | 3 | 1 |
| *Kharif*, 2016 | Nawagam | 1 | 3 | 3 |
| | Navsari | 3 | 3 | 1 |
| Range | | 1-3 (R to MR) | 3 (MR) | 1-3 (R to MR) |

R-Resistant and MR-Moderately Resistant (Anonymous, 2013 SES damage scale (0-9)

recorded to calculate per cent damage in each genotype. The results presented Table 2 on the leaf folder screening trial (LFST) carried out during *kharif,* 2016 and 2017 revealed that the genotype NWGR-13017 was found promising and outstanding perform against leaf folder in five and seven different locations across the India in both the years, respectively. In *kharif* 2016, lowest mean per cent damage leaves 37.58 were recorded in genotype NWGR-13017. While, maximum damaged leaves (46.82%) were recorded in susceptible check TN-1. During *kharif*, 2017 the genotype NWGR-13017 was found promising and recorded 15.47 per cent damaged leaves in all the locations including Nawagam. However, susceptible check TN-1 had maximum per cent damaged leaves (24.90) in *kharif,* 2017. The state screening trial data presented in Table 3 revealed that the genotype NWGR-13017 was found resistant against leaf folder in both Nawagam and Navsari locations during *kharif*, 2015 and 2016. This indicated that the genotype NWGR-13017 showed resistant against leaf folder at most of the locations across the India. Therefore, it can be used as a donor parent in breeding programme for development of leaf folder resistant variety. Moreover, in the 53rd ARGM on 13- 16 April, 2018 at IIRR, Hyderabad, reported that the rice genotype NWGR-13017 developed from Nawagam was identified as promising against leaf folder and recommended for utilization as donor in breeding programme (Anonymous, 2018).

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## 5. Rahaspunjar (IC-575321; AC 42138) (IC575321; INGR21116), a rice (*Oryza sativa* L.) germplasm with tolerance to salinity stress, stagnant flooding (both fresh and saline water) and high anaerobic germination potential

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## Introduction

The genotype 'Rahaspunjar/Rashpanjor' (IC-575321; AC 42138), a landrace from coastal Odisha, was found tolerant to multiple abiotic stresses like salinity at early vegetative stage (Chattopadhyay *et al.* 2014; Singh & Sarkar 2014), stagnant flooding at late vegetative (tillering) and reproductive stages (Panda *et al.* 2019; Prusty *et al.* 2018; Pradhan *et al.* 2018; Chakraborty *et al.* 2021), and germination stage oxygen deficiency (*anaerobic* germination) during germination stage (Senapati *et al.* 2019). It was found to be moderately tolerant to vegetative stage salinity stress (12 dS $m^{-1}$) with an SES score of '5' and $Na^+/K^+$ ratio of 1.29, 1.01 and 1.11 in root, shoot and total plant, respectively (Chattopadhyay *et al.* 2014). Physiological evaluation showed that Rahaspunjar is tolerant to both fresh and saline water flooding at late vegetative to reproductive stage, which means it has a rare ability to withstand the individual stress of stagnant flooding as well as combined stresses of salinity and stagnant flooding (Chakraborty *et al.* 2021).

### *Morpho-agronomic Characteristics*

Rahaspunjar was found to be medium yielder (3.5 t/ha). The average maturity duration was found long (140-150 days). It has tall (145–155 cm) plant type. It has long well exserted panicle with long bold grain type. Multi-locational testing conducted at 11

AICRIP centers in 2019-2020, showed that Rahaspunjar is tolerant to vegetative stage salinity stress (12 dS $m^{-1}$), with <15% reduction in germination percentage and <30% reduction in overall plant dry biomass. This genotype was also found to be tolerant to anaerobic germination (AG) condition with the lowest reduction in germination percentage over control (average of all locations) and <20% reduction in seedling vigour under anaerobic stress imposed as 10 cm of standing water at the time of germination.

### *Associated Characters and Cultivated Practices*

Rahaspunjar is found to possess multiple abiotic stress (salinity, stagnant flooding and anaerobic germination and combined stresses of saline water flooding) tolerance in multi-season and multi-locational testing. Further, global comparative transcriptomic study and morpho-physiological and anatomical evaluation revealed a unique mechanism of tolerance against combined stresses of salinity and stagnant flooding (waterlogging) in Rahaspunjar. We found, the presence of well-developed preformed constitutive aerenchyma due to the coordinated action of *RBOH* (*respiratory burst oxidase homolog*) and MT (*metallothionein*) gene homologs, is the key determining factor towards tolerance to combined stress of salinity and stagnant flooding (Chakraborty *et al.* 2021). This valuable rice germplasm is found to have stable source for multiple abiotic stress tolerance. This genotype is tolerant to individual stresses like salinity (both at early seedling and reproductive stages), stagnant flooding (at tillering and reproductive stages) and combined stresses of salinity and stagnant flooding as encountered during saline water flooding. Additionally, this genotype also possesses considerably high anaerobic germination (AG) potential as over the years and in different locations.

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## 6. Remeni Pokkali (AC 41585) (IC640648; INGR21117), a rice (*Oryza sativa var.* indica) germplasm with tolerance to salinity at vegetative stage (12 dS m-1) and tolerance to salinity at reproductive stage (8 dS m-1)

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## Introduction

Rice grown in the coastal saline areas of Kerala under Pokkali and Kaipad system of cultivation. Pokkali refers to a system of rice cultivation which is characterized by prolonged partial flooding, and farmers alternate rice cultivation with shrimp farming. The rice geramplam and pureline selection from the traditional cultivars and landraces in this region are found to have single or multiple abiotic stress tolerance. Earlier a *Saltol*-QTL for salinity tolerance at seedling stage was identified from one of the accessions of Pokkali and introgressed in high yielding background. But researchers are still searching for donors for the reproductive stage salinity tolerance which can introduce QTLs for substantial reduction in yield penalty under salinity stress. This accession of Pokkali (AC41585) was collected from the Village Kainegeri, Dist. Alappuzha in Kerala. In repeated evaluation under control condition with salinity stress, EC= 12 dSm-1, it was found tolerant (SES score- 3) to salinity at early vegetative stage. Most importantly it was found also tolerant (<25% yield reduction) to salinity stress at reproductive stage.

### *Morpho-agronomic characteristics*

This germplasm has intermediate seedling vigour. Coleoptile is green. Basal leaf sheath colour is green. Leaf blade colour is green. Leaf pubescence is medium. It is medium maturity duration (110-125 days). It is tall (120-135 cm) and having medium tillering ability (6). It has long (28 cm), dropping and well exerted panicle. It has long bold grain with 30 g test weight. Grain yield is around 2 t/ha under moderate (6-8 dSm-1) salinity stress condition.

### *Associated characters and cultivation practices*

Pokklai accession AC 41585 was found tolerant with stable growth both at the seedling and reproductive stages over the years and environments. AC 41585 was found to be a salinity tolerant genotype based on low reduction (<25%) of grain yield and yield component traits under salinity stress (EC= 8 $dSm^{-1}$) at reproductive stage (Chattopadhyay *et al.* 2013a). Higher $K^+$ concentration, lower Na+ concentration and lower $Na^+/K^+$ ratio in flag leaf as compared to susceptible genotypes was observed in reproductive stage salinity tolerance genotype, Pokkali (AC 41585) (Chattopadhyay *et al.* 2018). It was further explained that this genotype, a potential Na+ excluder, managed to sequester higher Na+ load in the roots with little upward transport as evident from greater expression of HKT1 and HKT2 transporters (Chakraborty *et al.* 2019, ICAR-NRRI Annual Report 2018-19). Using mapping population from IR64/AC41585, 9 multi-environmental consistent QTLs for reproductive stage salinity tolerance with 17-42% phenotypic variances were detected (Chattopadhyay *et al.* 2020a). AC 41585 was also detected with salinity (EC= 12 $dSm^{-1}$) tolerant at seedling stage (SES score= 3) and 28 QTLs related to photosynthesis and 2 QTLs for stress susceptibility index for $Na^+/K^+$ ratio were detected for seedling stage salinity tolerance (Chattopadhyay *et al.* 2020b).

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## 7. IET25443 (IC640649; INGR21118), a rice (*Oryza sativa* L.) germplasm with high Zn and Fe concentration in polished grain


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IET 25443 (RP 4993-300-22-18-1-4-1) is an inbred line derived from BPT 5204/ Chittimutyalu. In the studies of Rice Biofortification, IET 25443 was identified as promising line in terms of polished rice grain Fe and Zn content & Protein content. It is a medium duration line with 105-109 days to 50% flowering and possesses short bold (SB) grain

**Table 1:** Agro-morphological, yield and grain micronutrient characters of IET 25443

| *S. No.* | *Trait* | *Value* |
|---|---|---|
| 1 | Plant Height (cm)[a] | 94 |
| 2 | Tiller Number (Per Hill) | 10 |
| 3 | Productive Tiller Number (Per Hill) | 9 |
| 4 | Days to 50% Flowering [a] | 105-108 |
| 5 | Panicles per Square meter [a] | 284-317 |
| 6 | Single Plant Yield (grams) | 14.6 |
| 7 | 1000 grain weight (grams) | 17.2 |
| 8 | Grain Yield (Kg/ha) | 4331 |
| 9 | Grain Fe (ppm) in Polished Rice [a] | 3.36 |
| 10 | Grain Zn (ppm) in Polished Rice [a] | 22.6 |
| 11 | Protein (%) in Polished Rice [a] | 7.96 |
| 12 | Total Ash (%) [b] | 17.8 |
| 13 | Crude Fiber (%) [b] | 43.4 |
| 14 | IVOMD (%) [b] | 45.6 |

a - Based on the data of AICRIP trials; b – Based on the data provided by NIANP, Bengaluru.

type (Table 1). It was evaluated in AICRIP Biofortification trials during 2015, 2016 and 2017 across the locations (IIRR Progress Report, 2016; 2017; 2018). The overall mean grain yield was noted as 4331 Kg. $ha^{-1}$. During, IVT-Biofortification trial (2015), this culture was ranked 2nd in Kerala state with 6837 Kg/ha grain yield. In addition, this culture was ranked 1st in UP (6942 kg/ha) and 5th in Maharashtra (4210 kg/ha) during AVT-1 Biofortification trial, 2016. In the third year of testing *i.e.,* AVT-2 Biofortification trial, the proposed culture, IET 25443 ranked 2nd in Zone III (5197 Kg/ha) and indicated 10% yield advantage over BPT 5204. In West Bengal it was the first ranking entry (5902 Kg/ha) with 22.6% and 17.8% yield gain over IR 64 and BPT 5204 respectively. In Zone VII, it recorded mean grain yield of 4864 kg/ha and state wise it stood at 3rd rank in AP (5584 Kg/ha) with 9.1% and 9.4% yield improvement over IR 64 and BPT 5204 respectively. In addition to the yield advantage, IET25443 has holds the notable grain micronutrient and protein content. The mean grain Fe and Zn concentration was noted as 7.96 ppm and 22.6 ppm respectively [(IIRR Progress Report, 2016; 2017; 2018), (Table 5 of Sanjeeva Rao *et al.* 2020)]. In addition, it has the protein concentration of 7.96%.

The identified genetic stock, IET25443 comprises 22.6 ppm Zn content, 3.36 ppm Fe content and 7.96% Protein in Polished rice grain (Table 2). It can be used as a potential donor in breeding program in rice bio-fortification studies.

**Table 2:** Data of IET 25443 under AICRIP trials during 2015, 2016 and 2017

| | *_Fe (ppm)* | *Zn (ppm)* | *Protein (%)* | *Grain Yield (kg/ha)* | *Days to 50% Flowering* | *Plan Height (cm)* | *Panicles/m2* |
|---|---|---|---|---|---|---|---|
| 2015 (IVT-Biofortification) | 3.6 (14) | 20.4 | 8.14 | 3629 (13) | 109 (18) | 94 (18) | 284 (18) |
| 2016 (AVT 1- Biofortification) | 4.0 (16) | 22.5 (15) | 7.92 (4) | 4660 (12) | 105 (24) | 94 (23) | 317 (23) |
| 2017 (AVT 2- Biofortification) | 2.5 (18) | 25 (18) | 7.83 (8) | 4728 (13) | 108 (24) | 91 (24) | 285 (24) |
| Mean | 3.36 | 22.6 | 7.96 | 4339 | 107 | 93 | 295 |

Values within parenthesis indicates the number locations tested during AICRIP trials. (IIRR Progress Report, 2016; 2017; 2018)

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## 8. DH-1 (IC640653; INGR21119), a wheat (*Triticum aestivum* L.) germplasm with resistance to yellow and brown rust in seedling stage adult plant stage


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DH-1 is wheat (*Triticum aestivum* L.) doubled haploid line resistance against all the prevailing pathotypes of stripe and leaf rust in seedling stage (except for *77-5* race of leaf rust) and is also resistant to both the rust in Adult Plant stage (Table 1 and 2). The material is developed following *Imperata cylindrica* mediated chromosomal elimination technique by crossing wheat F1s (developed by crossing spring wheat genotype HS542 with winter wheat genotype China 84-40022) with *Imperata cylindrica* at ICAR-IARI Regional Station, CHC, Amartara Cottage, Tutikandi Center, Shimla (H.P.). This wheat genetic stock is developed *via Imperata cylindrica* mediated chromosomal elimination technique and have characteristic features of both winter and spring wheat genotypes, thereby increasing the variability in wheat.

DH-1 has semi-spreading growth habit with late maturity (194 days) under Northern Hill conditions. The distinguish features of DH-1 are presence of scurs, green leaves, erect flag leaf attitude, tapering ear shape with white colour during maturity, straight peduncle attitude and thousand grain weight of 36 grams.

The parent HS542 has awns and China 84-40022 is awnless but the developed DH-1 has scurs. The grain colour of DH-1 is similar to HS542 *i.e* amber, while China-84 has reddish grain colour. The genetic stocks namely FLW3 (UP2338*3 /China84-40022) (Datta *et al.*, 2012) and FLW22 (developed through double cross between WH542/*Lr28* and WH542/China84- 40022), developed by ICAR-IIWBR, Regional Station, Flowerdale, Shimla, also contains China 84-40022 as one of the parents (Bhardwaj *et al.*, 2015) and has reported to be resistant to yellow rust and contains *Yr* China 84 genes which has been found to be resistant to all the races of yellow rust till date.
The role of China 84 as resistant sources has been identified

**Table 1:** The seedling resistant response of DH-1, parents and Agra Local to yellow and brown rust and gene postulation

| *Genotypes* | *Seedling screening* | | | | | | | | | *Postulated gene* |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Yellow Rust* | | | | | | | | | |
| | 110S119 | 110S247 | 238S119 | 78S84 | 110S84 | 111S68 | 46S119 | T | P | |
| AL | 3+ | 3+ | 3+ | 3+ | 3+ | 3+ | 3+ | 3+ | 3+ | - |
| HS542 | 3+ | 33+ | 3+ | ; | 3- | ; | ; | 0; | ; | *Yr2+* |
| China84-40022 | 0; | 0; | ;CN | 0; | 0; | 0; | 0; | 0; | 0; | *Yr China+* |
| DH-1(HS 542 / China 84-40022) | 0; | ; | ;- | 0; | ; | 0; | 0; | 0; | 0; | *Yr9+* |

| Genotypes | Leaf Rust | | | | | | | | | | | | | | | | | Postulated gene |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 11 | 12-5 | 12-7 | 12A | 77 | 77-1 | 77-2 | 77-5 | 77-8 | 77-10 | 77A-1 | 104-2 | 107-1 | 108-1 | 162-1 | 77-9 | 104-1 | |
| AL | 3+ | 3 | 3 | 3 | 3 | 3 | 3 | 3+ | 3+ | 3+ | 3+ | 3+ | 3+ | 3+ | 3+ | 3+ | 3+ | - |
| HS542 | 0; | 0; | ;1 | 2 | 3 | ; | 3 | 3+ | ; | 0; | 3+ | 2 | 2 | 2 | 3+ | 3+ | 3+ | *Lr13 +* |
| China84-40022 | ;1 | 3 | 3+ | 33+ | 2 | 3+ | 3+ | 3 | ;1 | ; | 3+ | 2 | 2 | 2 | 3+ | 3+ | 3+ | *Lr13 +* |
| DH-1(HS 542 / China 84-40022) | 0; | ;1 | ; | 0; | 0; | ; | 0; | 3+ | ; | 0; | 0; | 2 | ;1 | ;1 | 0; | ; | 0; | *Lr26 + 23 + 1+* |

**Table 2:** Infection type in DH-1, parents and Agra Local to yellow and brown rust at Adult Plant stage

| *Genotype* | *APR (Yellow Rust) Dhaulakuan* | *APR (Brown Rust) Dhaulakuan* | *APR (Yellow Rust) Bajaura* | *APR (Yellow Rust) Shimla* |
|---|---|---|---|---|
| AL | 30S | 40S | 40S | 20S |
| HS542 | 10S | 10S | 10S | 5S |
| China 84-40022 | R | 5S | R | R |
| DH 1 (HS 542 / China 84-40022) | R | R | R | R |

by many scientists (Datta *et al.*, 2012). The DH-1 also has China 84-40022 as one of the parents and is a resistant source to all the races of yellow and brown rust.

The molecular screening with gene specific markers highlighted the presence of adult plant leaf rust resistant gene *Lr34* along with *Lr26 and Lr32* genes. The rust resistance gene pool present in DH-1 would prove to be an important source for developing potential rust resistant genotypes and/ or serve as potent donor for creating new usable variability against different pathotypes of rust in wheat improvement programme of India having characteristics from winter gene pool also.

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## 9. QLD121 (IC640670; INGR21120), a wheat (*Triticum aestivum* L.) germplasm with low grain hardness index and low sedimentation value

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Grain hardness is an important trait in wheat quality with a profound effect on milling, baking and end-use qualities of wheat. It is common to differentiate soft and hard wheat in the world trade for product specific utility. Soft wheat is more friable, requires less energy to mill, and produces flours and meals with finer particles and lower starch damage, which are suitable for cake and biscuit production. Soft grain textured wheat produces tender and larger biscuits. QLD 121 was developed at ICAR-Indian Institute of Wheat and Barley Research (ICAR-IIWBR) by crossing DPW621-50 / PBW550. The genotype was evaluated at 15 different locations across the country for different agro- morphological traits in Quality Component and Wheat Bio-fortification Nursery (QCWBN) and the results are presented in Table 2. However, due to high heritability of grain hardness index, only 06 centres comprising all the major wheat growing zones of the country has been analysed for grain hardness index. QLD 121 was found to be superior with 21 grain hardness index over the locations to all the tested genotypes and checks including soft grain check variety HS 490 (Table 1). Although, grain hardness of parentage of QLD 121 was hard, transgressive sergeants were appeared for soft grain. QLD 121 recorded the lowest grain hardness index in all the tested centres compared to the best check variety (HS 490) for low grain index. QLD 121 recorded lowest grain hardness index of 24, 14, 17, 18, 22, and 27 respectively at Karnal, Delhi, Kanpur, Indore, Vijapur, and Pune centres, whereas, the soft grain check variety HS 490 reported 37, 29, 23, 39, 40, and 37. The QCWBN nursery was also tested for rust reaction in Initial Plant Pathological Nursery (IPPSN) and the results are presented in (Table 2). The genotype is resistant to all the three rusts (stripe, leaf and stem). QLD 121 also has the lowest sedimentation value compared to all the checks. Low grain hardness index and sedimentation value are very important factors to obtain high spread factor of biscuit and better biscuit quality. Thus, QLD 121 would be a potential source to be utilized in future breeding programs to develop high yielding, disease resistant bread wheat varieties suitable for better biscuit making.

**Table 1:** Grain hardness index of QLD121 at 6 locations during 2020-21

| Zone | Location | *Genotype* | *Check Varieties* | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *QLD 121* | *HS490 (Soft Check)* | *WB02* | *DBW187* | *HD3226* | *GW322* | *DDW47* |
| NWPZ | Karnal | 24 | 37 | 79 | 79 | 85 | 83 | 91 |
| | Delhi | 14 | 29 | 70 | 79 | 83 | 80 | 85 |
| NEPZ | Kanpur | 17 | 23 | 80 | 75 | 78 | 70 | 81 |
| CZ | Indore | 18 | 39 | 69 | 75 | 80 | 88 | 88 |
| | Vijapur | 22 | 40 | 76 | 78 | 84 | 86 | 90 |
| PZ | Pune | 27 | 37 | 75 | 73 | 76 | 87 | 89 |
| Mean (National) | | 21 | 35 | 75 | 77 | 81 | 82 | 87 |

**Table 2:** Agro-morphological, disease and quality traits of QLD 121 at 15 locations during 2020-21

| *Trait_Genotype* | *QLD 121* | *HS490 (Soft Check)* | *WB02* | *DBW187* | *HD3226* | *GW322* | *DDW47* |
|---|---|---|---|---|---|---|---|
| Agro-Morphological Traits | | | | | | | |
| Grain yield (q/ha) | 53.3 | 45.9 | 45.8 | 54.6 | 56.7 | 51.4 | 45.8 |
| Plant Height (cm) | 93 | 101 | 86 | 93 | 98 | 92 | 91 |
| Heading (days) | 81 | 79 | 72 | 75 | 80 | 76 | 80 |
| Thousand Kernel weight (gm) | 41 | 41 | 39 | 44 | 40 | 40 | 39 |
| Disease Reaction (IPPSN) | | | | | | | |
| Stripe Rust (ACI) | 11.7 | 6.4 | - | 3.2 | - | 36 | 3.8 |
| Leaf Rust-North (ACI) | 3.5 | 3.6 | - | 5.9 | - | 8.6 | 3.4 |
| Leaf Rust-South(ACI) | 5.2 | 4.1 | - | 9.5 | - | 7.3 | 7.7 |
| Stem Rust (ACI) | 1.8 | 11.8 | - | 12 | - | 8.3 | 3.5 |
| Quality Traits | | | | | | | |
| Grain Iron (ppm) | 36.8 | 37.0 | 40.7 | 39.6 | 39.5 | 36.6 | 38.1 |
| Grain Zinc (ppm) | 42.7 | 41.0 | 44.3 | 37.0 | 41.3 | 41.4 | 43.8 |
| Grain Protein Content (%) | 12.4 | 11.5 | 13.9 | 12.1 | 12.9 | 10.9 | 12.1 |
| Sedimentation Value (ml) | 38.8 | 39.7 | 60.7 | 57.3 | 59.6 | 38.6 | 32.5 |
| Hectolitre Weight (Kg/hl) | 75.7 | 74.7 | 77.3 | 78.6 | 78.3 | 76.8 | 78.1 |

## 10. QLD120 (IC640671; INGR21121), a wheat (*Triticum aestivum* L.) germplasm with low grain hardness index and high nutritional value

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Grain hardness is an important trait in wheat quality with a profound effect on milling, baking and end-use qualities of wheat. It is common to differentiate soft and hard wheat in the world trade for product specific utility. Soft wheat is more friable, requires less energy to mill, and produces flours and meals with finer particles and lower starch damage, which are suitable for cake and biscuit production. Soft grain textured wheat produces tender and larger biscuits. QLD 120 was developed at ICAR-Indian Institute of Wheat and Barley Research (ICAR-IIWBR) by crossing PBW343/VL738//PBW611/3/39$^{th}$ IBWSN1108 (SUNSU/CHIBIA)/DBW17. The genotype was evaluated at 15 different locations across the country for different agro-morphological traits in Quality

**Table 1:** Grain hardness index of QLD 120 and check varieties at 6 locations during 2020-21

| *Zone* | *Location* | *Genotype* | *Check Varieties* | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *QLD 120* | *HS490 (Soft Check)* | *WB02* | *DBW187* | *HD3226* | *GW322* | *DDW47* |
| NWPZ | Karnal | 44 | 37 | 79 | 79 | 85 | 83 | 91 |
| | Delhi | 19 | 29 | 70 | 79 | 83 | 80 | 85 |
| NEPZ | Kanpur | 24 | 23 | 80 | 75 | 78 | 70 | 81 |
| CZ | Indore | 30 | 39 | 69 | 75 | 80 | 88 | 88 |
| | Vijapur | 29 | 40 | 76 | 78 | 84 | 86 | 90 |
| PZ | Pune | 28 | 37 | 75 | 73 | 76 | 87 | 89 |
| Mean (National) | | 29 | 35 | 75 | 77 | 81 | 82 | 87 |

**Table 2:** Agro-morphological, disease and quality traits of QLD 120 and check varieties during 2020-21

| *Trait* | *Genotype* | *Check Varieties* | | | | | |
|---|---|---|---|---|---|---|---|
| | *QLD 120* | *HS490 (Soft Check)* | *WB02* | *DBW 187* | *HD 3226* | *GW 322* | *DDW 47* |
| Agro-Morphological Traits | | | | | | | |
| Grain yield (q/ha) | 52.1 | 45.9 | 45.8 | 54.6 | 56.7 | 51.4 | 45.8 |
| Plant Height (cm) | 90 | 101 | 86 | 93 | 98 | 92 | 91 |
| Heading (days) | 78 | 79 | 72 | 75 | 80 | 76 | 80 |
| Thousand Kernel weight (gm) | 42 | 41 | 39 | 44 | 40 | 40 | 39 |
| Disease Reaction (IPPSN) | | | | | | | |
| Stripe Rust (ACI) | 6.4 | 6.4 | - | 3.2 | - | 36 | 3.8 |
| Leaf Rust-North (ACI) | 2.6 | 3.6 | - | 5.9 | - | 8.6 | 3.4 |
| Leaf Rust-South(ACI) | 6.0 | 4.1 | - | 9.5 | - | 7.3 | 7.7 |
| Stem Rust (ACI) | 3.6 | 11.8 | - | 12 | - | 8.3 | 3.5 |
| Quality Traits | | | | | | | |
| Grain Iron (ppm) | 41.2 | 37.0 | 40.7 | 39.6 | 39.5 | 36.6 | 38.1 |
| Grain Zinc (ppm) | 47.2 | 41.0 | 44.3 | 37.0 | 41.3 | 41.4 | 43.8 |
| Grain Protein Content (%) | 13.1 | 11.5 | 13.9 | 12.1 | 12.9 | 10.9 | 12.1 |
| Sedimentation Value (ml) | 42.1 | 39.7 | 60.7 | 57.3 | 59.6 | 38.6 | 32.5 |
| Hectolitre Weight (Kg/hl) | 77.6 | 74.7 | 77.3 | 78.6 | 78.3 | 76.8 | 78.1 |

Component and Wheat Bio-fortification Nursery (QCWBN) and the results are presented in Table 2. However, due to high heritability of grain hardness index, only 06 centres comprising all the major wheat growing zones of the country has been analyzed for grain hardness index. QLD 120 was found to be superior with 29 grain hardness index over the locations to all the check varieties including soft grain check variety HS 490 (Table 1). QLD 120 recorded the lowest grain hardness index in all the tested centres compared to the best check variety (HS 490) for low grain index. QLD 120 recorded lowest grain hardness index of 44, 19, 24, 30, 29, and 28 respectively at Karnal, Delhi, Kanpur, Indore, Vijapur, and Pune centres, whereas, the soft grain check variety HS 490 reported 37, 29, 23, 39, 40, and 37. The QCWBN was also tested for rust reaction in Initial Plant Pathological Nursery (IPPSN) and the results are presented in Table 2. The genotype is highly resistant to all the three rusts (stripe, leaf and stem). QLD 120 is also having lowest sedimentation value compared to all the checks. Low grain hardness index and sedimentation value are very important factors to obtain high spread factor of biscuit and better biscuit quality. Thus, QLD 120 would be a potential source to be utilized in future breeding programs to develop bread wheat varieties suitable for better biscuit making.

## 11. QLD118 (IC640672; INGR21122), a wheat (*Triticum aestivum* L.) germplasm with very high grain zinc and high grain yield

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Worldwide over 2 billion people suffer from iron (Fe), zinc (Zn) and/or other (multiple) micronutrient deficiencies. In India, 48% of children under the age of 5–10 years have zinc/iron or some other micronutrient deficiency. Zinc is one of the important micronutrient for normal growth and development. QLD 118 was developed at ICAR-Indian Institute of Wheat and Barley Research (ICAR-IIWBR) by crossing 43rd IBWSN1137 (MINO/898.97)/43rd IBWSN1049 (WHEAR/SOKOLL). The genotype was evaluated at 15 different locations across the country for different agro-morphological traits in Quality Component and Wheat Bio-fortification Nursery (QCWBN) and the results are presented in Table 2. However, the hand threshed grains of 10 centres in QCWBN comprising all the major wheat growing zones

**Table 1:** Grain iron and zinc concentration of QLD 118 and check varieties at 10 locations during 2020-21

| Zone | Location | *Genotype* | | *Check Varieties* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *QLD 118* | | *HS490* | | *WB02* | | *DBW187* | | *HD3226* | | *GW322* | | *DDW47* | |
| | | *Zn* | *Fe* | *Zn* | *Fe* | *Zn* | *Fe* | *Zn* | *Fe* | *Zn* | *Fe* | *Zn* | *Fe* | *Zn* | *38.3* |
| NWPZ | Karnal | 33.5 | 37.3 | 32.3 | 35.4 | 35.1 | 36.9 | 31.0 | 35.7 | 32.5 | 35.0 | 33.6 | 34.6 | 35.0 | 38.7 |
| | Hisar | 45.3 | 46.0 | 43.13 | 37.3 | 44.4 | 42.8 | 35.8 | 40.9 | 42.1 | 40.5 | 40.1 | 35.1 | 48.2 | 37.4 |
| | Delhi | 70.3 | 46.2 | 57.6 | 37.5 | 59.1 | 39.9 | 48.7 | 39.3 | 53.3 | 40.0 | 52.4 | 37.1 | 59.9 | 41.9 |
| | Ludhiana | 49.3 | 35.5 | 35.8 | 38.1 | 37.4 | 41.6 | 33.7 | 44.0 | 34.4 | 37.5 | 35.5 | 37.0 | 38.0 | 32.8 |
| NEPZ | Kanpur | 40.5 | 35.1 | 37.8 | 32.4 | 38.0 | 34.0 | 32.3 | 32.0 | 40.6 | 35.2 | 38.4 | 31.3 | 42.0 | 35.9 |
| | Varanasi | 39.3 | 35.5 | 33.3 | 34.0 | 34.6 | 38.0 | 29.2 | 37.0 | 33.2 | 37.9 | 34.2 | 34.9 | 36.9 | 39.3 |
| CZ | Indore | 55.1 | 43.8 | 46.1 | 37.0 | 51.1 | 40.2 | 42.8 | 41.3 | 50.7 | 42.7 | 47.4 | 38.0 | 46.6 | 39.7 |
| | Vijapur | 52.2 | 42.0 | 48.0 | 41.0 | 56.1 | 46.5 | 44.1 | 43.3 | 49.6 | 45.5 | 49.5 | 42.4 | 50.4 | 39.3 |
| PZ | Pune | 57.6 | 44.6 | 45.1 | 40.2 | 50.0 | 44.2 | 42.4 | 40.6 | 46.7 | 40.6 | 47.8 | 38.0 | 47.4 | 38.3 |
| | Dharwad | 39.5 | 44.1 | 31.3 | 37.1 | 37.6 | 43.1 | 29.9 | 41.7 | 31.2 | 39.8 | 34.9 | 37.7 | 33.9 | 38.3 |
| Mean (National) | | 48.3 | 41.0 | 41.0 | 37.0 | 44.3 | 40.7 | 37.0 | 39.6 | 41.3 | 39.5 | 41.4 | 36.6 | 43.8 | 38.1 |

**Table 2:** Agro-morphological, disease, and quality traits of QLD 118 and check varieties during 2020-21

| *Trait* | *Test Genotype* | *Check Varieties* | | | | | |
|---|---|---|---|---|---|---|---|
| | *QLD 118* | *HS490* | *WB02* | *DBW187* | *HD3226* | *GW322* | *DDW47* |
| Agro-Morphological Traits | | | | | | | |
| Grain yield (q/ha) | 56.4 | 45.9 | 45.8 | 54.6 | 56.7 | 51.4 | 45.8 |
| Plant Height (cm) | 97 | 101 | 86 | 93 | 98 | 92 | 91 |
| Heading (days) | 78 | 79 | 72 | 75 | 80 | 76 | 80 |
| Thousand Kernel weight (gm) | 41 | 41 | 39 | 44 | 40 | 40 | 39 |
| Disease Reaction (IPPSN) | | | | | | | |
| Stripe Rust (ACI) | 10.8 | 6.4 | - | 3.2 | - | 36 | 3.8 |
| Leaf Rust-North (ACI) | 6.0 | 3.6 | - | 5.9 | - | 8.6 | 3.4 |
| Leaf Rust-South(ACI) | 12.2 | 4.1 | - | 9.5 | - | 7.3 | 7.7 |
| Quality Traits | | | | | | | |
| Grain Protein Content (%) | 12.5 | 11.5 | 13.9 | 12.1 | 12.9 | 10.9 | 12.1 |
| Sedimentation Value (ml) | 59.0 | 39.7 | 60.7 | 57.3 | 59.6 | 38.6 | 32.5 |
| Hectolitre Weight (Kg/hl) | 78.4 | 74.7 | 77.3 | 78.6 | 78.3 | 76.8 | 78.1 |

of the country has been analysed for grain iron and zinc concentration. QLD 118 was found to be superior for grain zinc concentration (48.3 ppm) over the locations to all the check varieties (Table 1). High grain zinc has been incorporated in to the high yielding genetic background through conventional breeding. The QCWBN nursery was also tested for rust reaction in Initial Plant Pathological Nursery (IPPSN) 2020-21 and the results are presented in Table 2. QLD 118 was also resistant to both stripe and leaf rust. Thus, QLD 118 would be a potential source to be utilized in future breeding programs to develop high yielding, disease resistant bread wheat varieties with enhanced grain zinc concentration.

## 12. QLD122 (IC640673; INGR21123), a wheat (*Triticum aestivum* L.) germplasm with high grain iron and zinc content

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Worldwide over 2 billion people suffer from iron (Fe), zinc (Zn) and/or other (multiple) micronutrient deficiencies. In India, 48% of children under the age of 5-10 years have zinc/iron or some other micronutrient deficiency. Zinc is one of the important micronutrient for normal growth and development. QLD 122 was developed at ICAR-Indian

**Table 1:** Grain iron and zinc concentration of QLD 122 at 11 locations during 2020-21

| Zone | Location | *Genotype* | | *Check Varieties* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *QLD 122* | | *HS490* | | *WB02* | | *DBW187* | | *HD3226* | | *GW322* | | *DDW47* | |
| | | *Fe* | *Zn* | *Fe* | *Zn* | *Fe* | *Zn* | *Fe* | *Zn* | *Fe* | *Zn* | *Fe* | *Zn* | *Fe* | *Zn* |
| NWPZ | Karnal | 55.5 | 36.2 | 35.4 | 32.3 | 36.9 | 35.1 | 35.7 | 31.0 | 35.0 | 32.5 | 34.6 | 33.6 | 38.3 | 35.0 |
| | Hisar | 41.1 | 43.6 | 37.3 | 43.13 | 42.8 | 44.4 | 40.9 | 35.8 | 40.5 | 42.1 | 35.1 | 40.1 | 38.7 | 48.2 |
| | Delhi | 40.0 | 63.5 | 37.5 | 57.6 | 39.9 | 59.1 | 39.3 | 48.7 | 40.0 | 53.3 | 37.1 | 52.4 | 37.4 | 59.9 |
| | Ludhiana | 39.4 | 32.9 | 38.1 | 35.8 | 41.6 | 37.4 | 44.0 | 33.7 | 37.5 | 34.4 | 37.0 | 35.5 | 41.9 | 38.0 |
| NEPZ | Kanpur | 34.6 | 40.1 | 32.4 | 37.8 | 34.0 | 38.0 | 32.0 | 32.3 | 35.2 | 40.6 | 31.3 | 38.4 | 32.8 | 42.0 |
| | Varanasi | 37.8 | 34.8 | 34.0 | 33.3 | 38.0 | 34.6 | 37.0 | 29.2 | 37.9 | 33.2 | 34.9 | 34.2 | 35.9 | 36.9 |
| CZ | Indore | 47.3 | 61.1 | 37.0 | 46.1 | 40.2 | 51.1 | 41.3 | 42.8 | 42.7 | 50.7 | 38.0 | 47.4 | 39.3 | 46.6 |
| | Vijapur | 47.3 | 50.1 | 41.0 | 48.0 | 46.5 | 56.1 | 43.3 | 44.1 | 45.5 | 49.6 | 42.4 | 49.5 | 39.7 | 50.4 |
| PZ | Pune | 46.6 | 57.1 | 40.2 | 45.1 | 44.2 | 50.0 | 40.6 | 42.4 | 40.6 | 46.7 | 38.0 | 47.8 | 39.3 | 47.4 |
| | Dharwad | 50.4 | 37.6 | 37.1 | 31.3 | 43.1 | 37.6 | 41.7 | 29.9 | 39.8 | 31.2 | 37.7 | 34.9 | 38.3 | 33.9 |
| Mean (National) | | 44.0 | 45.7 | 37.0 | 41.0 | 40.7 | 44.3 | 39.6 | 37.0 | 39.5 | 41.3 | 36.6 | 41.4 | 38.1 | 43.8 |

**Table 2:** Agro-morphological, disease and quality traits of QLD 122 at 15 locations during 2020-21

| *Trait* | *Test Genotype* | *Check Varieties* | | | | | |
|---|---|---|---|---|---|---|---|
| | *QLD 122* | *HS490* | *WB02* | *DBW187* | *HD3226* | *GW322* | *DDW47* |
| Agro-Morphological Traits | | | | | | | |
| Grain yield (q/ha) | 49.5 | 45.9 | 45.8 | 54.6 | 56.7 | 51.4 | 45.8 |
| Plant Height (cm) | 95 | 101 | 86 | 93 | 98 | 92 | 91 |
| Heading (days) | 83 | 79 | 72 | 75 | 80 | 76 | 80 |
| Thousand Kernel weight (gm) | 44 | 41 | 39 | 44 | 40 | 40 | 39 |
| Disease Reaction | | | | | | | |
| Stripe Rust (ACI) | 4.9 | 6.4 | - | 3.2 | - | 36 | 3.8 |
| Leaf Rust-North (ACI) | 2.7 | 3.6 | - | 5.9 | - | 8.6 | 3.4 |
| Leaf Rust-South(ACI) | 4.9 | 4.1 | - | 9.5 | - | 7.3 | 7.7 |
| Stem Rust (ACI) | 3.2 | 11.8 | - | 12 | - | 8.3 | 3.5 |
| Quality Traits | | | | | | | |
| Grain Protein Content (%) | 13.0 | 11.5 | 13.9 | 12.1 | 12.9 | 10.9 | 12.1 |
| Sedimentation Value (ml) | 47.1 | 39.7 | 60.7 | 57.3 | 59.6 | 38.6 | 32.5 |
| Hectolitre Weight (Kg/hl) | 76.3 | 74.7 | 77.3 | 78.6 | 78.3 | 76.8 | 78.1 |

Institute of Wheat and Barley Research (ICAR-IIWBR) by crossing 15th HRWSN286 (MILAN/3/PAT24/ALD//DOVE/BUC)/CIMMYT165. The genotype was evaluated at 11 centres in Quality Component Screening Nursery (QCSN) comprising all the major wheat growing zones of the country. QLD 122 was found to be superior for grain iron (44 ppm) and zinc (45.7 ppm) over the locations to all the check varieties (Table 1). High grain iron and zinc has been incorporated in to the improved genetic background through conventional breeding. QCWBN nursery has been evaluated at 15 different locations across the country for agro-morphological traits and the results are presented in Table 2. The QCWBN nursery was also tested for rust reaction in Initial Plant Pathological Nursery (IPPSN) and the results are presented in Table 2. QLD 122 is also resistant to all the three rusts (stripe, leaf and stem rust). Thus, QLD 122 would be a potential source to be utilized in future breeding programs to develop high yielding, disease resistant bread wheat varieties with enhanced grain iron and zinc concentration.

## 13. HD3304 (IC640683; INGR21124), a wheat (*Triticum aestivum* L.) germplasm with very high sedimentation value for greater gluten strength

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Indian wheat varieties have moderately strong gluten, whereas the bread baking industry desires flour with stronger gluten. In the absence of this criteria being met, chemicals for improving the gas retention capacity and gluten strengthening are used in large quantities. Some of the common chemicals used in baking industry are potassium bichromate, calcium peroxide, ascorbic acid etc. Indiscriminate use of these strong oxidizing agents can be harmful for consumer health in the long run. Therefore, donors with these quality traits are required to be identified/developed and used in breeding programmes. HD3304 is one such germplasm. HD3304 based on its high sedimentation value in station trial was promoted to Quality Component & Wheat Biofortification Nursery where it was evaluated in 12 locations encompassing all the four zones. It gave a mean value of 75 ml which is the highest recorded so far in any year of testing for any genotype (Table 1 & 2). Wheat with high sedimentation value has strong gluten

**Table 1:** Mean values of four quality traits in the genotype HD3304 tested over12 locations for three years in the Quality Component& Wheat Biofortification Nursery, 2018-19 to 2020-21

| *Genotype* | *Mean Sedimentation value (ml) NWPZ* | *Mean Sed value (ml) NEPZ* | *Mean Sed value (ml) CZ* | *Mean Sed value (ml) PZ* | *Mean Sed value (ml) all locations mean* |
|---|---|---|---|---|---|
| HD3304 | 69 | 78 | 76 | 78 | 75 |
| HD3086 | 62 | 55 | 57 | 66 | 60 |
| WB02 | 70 | 75 | 68 | 76 | 72 |

**Table 2:** Promising genotypes identified in QCSN 2018-19 for individual quality parameters

| *Component* | *Genotypes* | *Range* | | *Best Check* |
|---|---|---|---|---|
| Protein content (%) | GW20171-596, UP2994 | 13.8 | - 14.6 | WB2 (13.5) |
| Sedimentation value (ml) | HD3304, HD3241, HD3215 | 73 | - 75 | WB2 (72) |
| Grain hardness index (hard wheat) | DBP-17-05 ( D ), NIAW3284, QLD109 | 87 | - 89 | GW 322 & HD 3086 (84) |
| Grain hardness index (soft wheat) | QLD112 | 15.0 | | HS 490 (30) |
| Hectolitre weight (Kg/hl) | RAJ-4541, QLD109, QBP-18-8, QBP-18-10, KA-1805, UP2994 | 80.2- 82.5 | | HD 3086 (78.2) |
| Grain appearance score (Max. score 10) | RAJ-4541, UP2994, QBP-18-10, QBP-18-19 | 7.0 | - 7.2 | MACS 6222 (6.7) |
| Iron content (ppm) | UP2994, BWL-7800, QBP-17-7 | 48.1 – 49.0 | | WB2 (44.8) |
| Zinc content (ppm) | BWL-7805, Raj-4541, BWL-7800, UP2994 | 43.5 – 46.9 | | UP 2672 (39.8) |

which is highly desirable for making products such as bread, buns, pizza base etc. HD3304 is additionally, hard grained, has hectoliter weight of 78 Kg/hl and has good yield. In nutshell, HD3304 is suitable for industrial quality and can be used as an elite donor in breeding for superior industrial quality.

## 14. BHS 481 (BBM 815) (IC640685; INGR21125), a barley (*Hordeum vulgare* L.) germplasm with resistance to seedling resistance to leaf and stripe black rust as well as adult plant resistance to yellow rust

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BHS 481 (BBM 815) is a barley (*Hordeum vulgare* L.) line resistant against stripe, leaf and stem rust. It has shown highest degree of resistance against all the prevailing pathotypes of stripe, leaf and stem rust at seedling stage (except moderately resistant to *117-6* race of stem rust) and is also resistant to all the three rusts at adult plant stage. This line is developed following pedigree method of breeding involving crosses between registered barley genetic stock BHS 369 and HBL 113 at ICAR-IARI, Regional Station, CHC, Amartara Cottage, Tutikandi Center, Shimla (H.P.)

BHS 481 (BBM 815) has semi erect growth habit with medium maturity (171 days) under Northern Hill condition. The average yield is 3.63 t/ha under rainfed condition of Northern Hill Zone of All India Co-ordinated trials. For grain yield, BHS 481 (BBM 815) ranked third and was in the 1st Non-Significant Group with average yield of 36.3 q/ha (check variety BHS 400 yield was 36.5 q/ha) when tested in co-ordinated trials under All India Co- ordinated Wheat & Barley Improvement Project during 2019-20. The distinguish features of BHS 481 are six-rowed; hulled; semi-erect growth habit; green leaves; white colour of ear at maturity and thousand grain weight of 41 grams.

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**Table 1:** Reaction to major diseases

| *Diseases* | *Condition* | *Year* | *Response of Proposed Genetic stock 481 (BBM 815)* | *Page No.* |
|---|---|---|---|---|
| Stripe Rust (Resistant toyellow rust) | IBDSN (APR) | 2018-19 | ACI = 0.2 | 3.8 of Reference (i) |
| | | | HS = TMS | |
| | NBDSN (APR) | 2019-20 | ACI = 6.9 | 3.14 of Reference (ii) |
| | NBDSN (Seedling) | 2019-20 | R (Resistant to all races) | 3.28 of Reference (ii) |
| Leaf Rust (Resistant to brown rust) | NBDSN (APR) | 2019-20 | HS = 0 | 3.14 of Reference (ii) |
| | NBDSN (Seedling) | 2019-20 | R (Resistant to all races) | 3.28 of Reference (ii) |
| Stem Rust (Resistant toblack rust) | NBDSN (APR) | 2019-20 | 5 MS | 3.14 of Reference (ii) |
| | NBDSN (Seedling) | 2019-20 | R (Resistant to all races) (Except for *117-6* race showing moderately resistant response) | 3.28 of Reference (ii) |

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

# 15. IML 11 (IC640687; INGR21126), a maize (*Zea mays* L.) germplasm with resistance to *Turcicum* Leaf Blight

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## Introduction

Maize (*Zea mays* L.) is one of the most versatile emerging crops with its highest genetic yield potential among the cereals. The major reason for low productivity of maize in India is losses caused by various biotic and abiotic stresses. Among the various biotic stresses, foliar diseases namely, turcicum leaf blight (TLB) also called northern corn leaf blight caused by *Exserohilum turcicum* (Pass.) Leonard and Suggs. (syn. *Heliminthosporium turcicum* Pass.) is of worldwide importance and one of the most important diseases in India. This foliar disease occurs in high humidity and moderate temperature areas. It also results upto 70% loss in the yield. The fungus *E. turcicum* is known to be highly variable in nature (Reddy *et al.* 2013; De-Rossi *et al.*, 2015). Host plant resistance is considered as most practical and economically viable method of plant disease management (Wathaneeyawech *et al,* 2015: Hooda *et al*, 2018). The inbred IML 11 is developed at Regional Maize Research and Seed Production Centre (ICAR-IIMR), Begusarai following pedigree method using commercial maize hybris as source material. Under hot spot locations (Dharwad, Mandya, Almora and Bajaura) for TLB, the line IML 11 (IMLSB 334B-1) displayed a mean disease score of 2.6 at par with the resistant check i.e. 2.4 while the susceptible check 7.9.

A set of 237 newly developed maize inbred lines along with resistant (LM 13, CL 4, NAH 1137) and local susceptible (CM 202, CM 600) inbred line as check were evaluated against TLB under artificial epiphytotic conditions. The trial was conducted during kharif season of 2017 and 2018 at TLB hot-spot locations, *viz*., Dharwad, Mandya, Almora and Bajaura. In 2017, the trial was conducted in randomized complete block design whereas in 2018 it was conducted in alpha design. Spore suspension of *E. turcicum* isolates was prepared in lab and sprayed by using atomizer at three to four leaf stage of each and every maize plants twice in an interval of two days to ensure proper inoculation. The disease reaction was recorded by using 1 to 9 scales as suggested by Hooda *et al*. (2018). Disease scoring was commenced from six-eight leaves stage (approximately 45 days after planting) and continued on weekly basis for 6 weeks. The genotypes showing disease score between 0.0–3.0 were considered as resistant (R), 3.1-5.0 as moderately resistant (MR), 5.1- 7.0 as moderately susceptible (MS), >7.0 as susceptible (S). The disease reaction was recorded on five plants in the middle of the row and it was averaged to calculate TLB overall mean disease score of each line. The overall mean TLB score calculated across locations over two years was considered to classify inbred lines into resistant, moderately resistant, moderately susceptible and susceptible inbred lines. Out of 237 inbred lines, 41 inbred lines were resistant with TLB score <3.0, 181 lines were moderately resistance with TLB score 3.1-5.0 and 15 inbred lines were moderately susceptible with TLB score 5.1 to 7.0 (Singh *et al*. 2018). The Inbred lines were also evaluated for maturity and yield traits during rabi-2017-18 and 2018-19 and RMR&SPC, Begusarai. Out of the 41 resistant inbred lines, four best TLB resistant lines along with high yield per se performance as mentioned in Table 1 were identified for registration.

### *Morpho-agronomic characteristics*

IML 11 is a late maturing high yielding line resistant to Turcicum Leaf Blight (disease mean score on the scale of 1-9), short height, medium ear placement, straight attitude of lateral tassel branches, sparse spikelets of tassel, yellow round shaped and flint kernels. It is derived from normal maize segregating progeny by continuous selfing following pedigree breeding method using commercial hybrid as source material.

### *Associated-agronomic Characteristics*

IML 11 is high yielding maize inbred line with yield potential of 28.2 q/ha. This inbred is suitable for cultivation during rabi season. It also has good seed setting to be used as seed parent under commercial seed production. The inbred has straight kernel rows and semi-flint kernels.

**Table 1:** Disease score for TLB (kharif-2017 &2018), maturity and yield (rabi-2017-18 & 2018-19) of identified newly developed maize inbred lines

| *S. No* | *Name of inbred* | *Another name* | *TLB score* | *Reaction* | *Days to 50% anthesis (rabi)* | *Days to 75 % dry husk maturity (rabi)* | *Grain yield (q/ha)* | *Maturity group* |
|---|---|---|---|---|---|---|---|---|
| 1 | IML 11 | IMLSB-334B-1 | 2.6 | R | 122 | 158 | 28.2 | Late |
| 2 | IML 13 | IMLSB-1041-4-1 | 2.4 | R | 112 | 155 | 36.4 | Medium |
| 3 | IML 12 | IMLSB-446-2 | 2.5 | R | 107 | 147 | 31.9 | Medium |
| 4 | IML 21 | IMLSB-343-2 | 2.6 | R | 125 | 163 | 33.1 | Late |
| | | Resistant Check (CL 4/ NAH 1137 | 2.4 | R | -- | -- | -- | -- |
| | | Susceptible check (CM 200) | 7.9 | S | -- | -- | -- | -- |

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## 16. PRB 903 (IC640691; INGR21127), a barnyard millet (*Echinochloa esculenta (*A. Braun) H.Scholz ) germplasm highly resistant to grain smut disease.


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Barnyard millet (*Echinochloa* spp.) is one of the oldest domesticated small millets in the semi-arid tropics of Asia and Africa (Sood *et al.,* 2020). The potential of this important small millet crop in addressing food and nutritional insecurities has been well recognized (Joshi *et al.,* 2020). However, compared to the efforts invested to improving major cereals, barnyard millet has received little research attention. The productivity of barnyard millet is reduced by a number of biotic constraints, among which grain smut caused by *Ustilago panici frumentacei* Bref. is potentially the most destructive and reported to cause nearly 60 % losses in grain yield (Jain *et al.,* 1997).

The presently grown cultivars of Indian barnyard millet are reported to have moderately resistant to susceptible and highly susceptible reaction against grain smut in multi- location trials. However, strong resistance against grain smut is reported neither in commercial cultivars nor in germplasm collections (Sood *et al.,* 2015). PRB 903 belonging to *E. esculenta* (Japanese type) is indigenously developed pure line selection from PRB 401 is an early maturing (mean duration 80 days) genetic stock with semi compact and purple colour inflorescence. It was observed to be highly resistant compared to the national checks and high yielding cultivars (VL 172, VL 207 and DHBM 93-3) in All India Coordinated Research Trials on Small Millets conducted over 22 locations in 6 years (Table 1).

The mean percent disease incidence over the years and locations (Table 1) due to grain smut in PRB 903 was very low (0.38%) and fell in highly resistant (HR) disease scale category compared to the national checks VL 172 (12.67%), VL 207 (11.70%) and DHBM 93-3 (5.72%). In disease screening nurseries of barnyard millet, resistant check is yet not available for grain smut. Therefore, the proposed genetic stock PRB 903 was used as a resistant check since 2018 to 2020 in national disease screening nurseries of barnyard millet. Interestingly, PRB 903 was reported to be

**Table 1:** Mean reaction of PRB 903 to grain smut disease (%) in coordinated trials

| *Item* | *Locations* | *PRB 903 (PGS)* | *VL 172 (C1)* | *VL 207 (C2)* | *DHBM93-3 (C3)* |
|---|---|---|---|---|---|
| Mean of year 2010 | 4 | 0.00 | 15.44 | 12.55 | - |
| Mean of year 2011 | 4 | 0.00 | 10.48 | 11.45 | - |
| Mean of year 2012 | 4 | 0.00 | 12.10 | 24.40 | - |
| Mean of year 2018 | 3 | 0.86 | - | 7.78 | 6.12 |
| Mean of year 2019 | 4 | 0.52 | - | 7.05 | 4.39 |
| Mean of year 2020 | 3 | 0.90 | - | 7.00 | 6.34 |
| Mean over the years | - | 0.38 | 12.67 | 11.70 | 5.72 |

PGS: Proposed Genetic stock; C1: Check 1; C2: Check 2; C3: Check 3

highly resistant by maintaining first rank among all the tested genotypes at different grain smut hot spot locations. Availability of highly resistant genetic stocks with minor grain smut incidence in different origin groups provides opportunity to significantly enhance the resistant level in commercial cultivars through hybridization and selection.

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## 17. VL 386 (IC640692; INGR21128), a finger millet (*Eleusine coracana* L. Gaertn.) germplasm with resistance to foot rot, leaf blast, neck blast, finger blast, high harvest index and high grain yield


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Finger millet is an annual self-pollinated crop grown in Asia and Africa. Depending upon the severity, blast disease can cause yield loss to the tune of 50–90% whereas foot rot causes

considerable losses to the crop (Rao 2020). Blast affects finger millet at all stages of growth whereas symptoms of foot rot could be noticed 25-30 days after transplanting. Most of the landraces and a number of varieties are susceptible to highly susceptible to both the diseases (Sood *et al.*, 2019). Till date no genotype is reported in finger millet conferring resistance to both blast (leaf, finger and neck blast) and foot rot.

VL 386 has been indigenously developed from a cross between GE 440 **(**Early maturing core collection germplasm line belonging to Andhra Pradesh**)** and VL *Ragi* 149 (Blast resistant, High yielding old national variety). It was found resistant to foot rot (6.04%) in all Indian coordinated trials conducted during *kharif* 2015-2017 (Table 1). Likewise, the grade for leaf blast (2.5) and mean percent damage for finger blast (6.49%) and neck blast (8.02%) in coordinated trials (2015-2017) fell in the resistant category for VL 386 (Table 1). In addition to multiple disease resistance, VL 386 is reported to have high harvest index (31.75%) compared to both the national checks VL 352 (30.33%) and GPU 45 (28.52%). Based on the yield evaluation trials conducted over ten locations from 2015-2017, VL 386 reported to have 9.58% superiority in grain yield compared to the best check (VL 352). Identification of a genetic stock conferring resistance to the severe diseases and possessing desirable agronomic traits in the common genetic background will be highly useful in breeding for durable resistance and high yield in finger millet.

**Table 1:** Mean reaction of VL 386 against foot rot, leaf blast, finger blast and neck blast

| *Disease* | *Year* | *Locations* | *VL 386* | *GPU 45 ($C_1$)* | *VL 352 ($C_2$)* | *GPU 67 (C3)* | *VR 708 (C4)* | *PR 202 (C5)* |
|---|---|---|---|---|---|---|---|---|
| Foot rot (%) | 2015 | 2 | 2.2 | 0.0 | 0.7 | 1.0 | 1.7 | 0.0 |
| | 2016 | 4 | 7 | 7 | 9 | - | - | - |
| | 2017 | 2 | 8.93 | 13.3 | 6.68 | 8.63 | - | 10.30 |
| | Mean | | 6.04 | 6.76 | 5.46 | 4.81 | 1.7 | 5.15 |
| Leaf blast (G) | 2015 | 9 | 1.5 | 1.3 | 2.0 | 2.1 | 2.5 | 2.6 |
| | 2016 | 11 | 3 | 4 | 3 | - | 4 | - |
| | 2017 | 3 | 2.8 | 3.1 | 3.3 | 4.0 | - | 4.22 |
| | Mean | | 2.9 | 3.0 | 3.2 | | | |
| Neck blast (%) | 2015 (9) | 9 | 6.70 | 3.80 | 9.40 | 10.7 | 16.0 | 10.6 |
| | 2016 | 11 | 11 | 5 | 14 | - | 21 | - |
| | 2017 | 3 | 6.36 | 6.86 | 10.33 | 8.93 | - | 7.43 |
| | Mean | | 8.02 | 5.22 | 11.25 | 9.82 | 18.50 | 9.02 |
| Finger blast (%) | 2015 | 9 | 6.60 | 3.70 | 5.80 | 10.7 | 16.6 | 14.0 |
| | 2016 | 11 | 10 | 6 | 10 | - | 22 | - |
| | 2017 | 3 | 2.89 | 3.2 | 3.2 | 4.00 | - | 4.22 |
| | Mean | - | 6.49 | 4.30 | 6.33 | 7.35 | 19.30 | 9.11 |

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# 18. VL 399 (IC640693; INGR21129), a finger millet (*Eleusine coracana* L. Gaertn.) germplasm with broad resistance to finger blast and neck blast.


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Finger millet (*Eleusine coracana* L. Gaertn.) is a crop of antiquity with great historical, cultural and nutritional importance, particularly in Asia and Africa (Sood *et al.*, 2019). Among the various biotic constraints, blast is the major disease, which severely affects the finger millet production. Similar to rice, finger millet blast caused by *P. grisea* (Cke.) Sacc. is both economically significant and very destructive, causing over 50% yield loss (Joshi *et al.*, 2021). The use of blast-resistant finger millet varieties is an effective blast control strategy in the crop as it is compatible with low-cost input requirements of small-scale farmers who are the main growers of finger millet. Blast affects finger millet at all stages of growth and most of the landraces and a number of varieties are highly susceptible.

The proposed genetic stock VL 399 is indigenously developed from a cross between GPU 28 (High yielding, blast resistant late maturing cultivar) and VL 324 (high yielding, medium maturing locally adapted cultivar). It has mean maturity duration of 116 days in coordinated trials. In the coordinated trials conducted across 9 diverse locations, the percent damage due to finger blast in VL 399 was very low (7.90%) compared to the susceptible check *Uduru Malige* (29.09%) and fell in the same disease scale category (resistant reaction) of 5-10% with the resistant check GE 4449 (6.75%) (Table 1). Likewise, the percent damage due to neck blast in VL 399 was very low (9.9%) compared to the susceptible check *Uduru Malige* (37.47%) and fell in the same disease scale category (resistant reaction) of 5-10%

**Table 1:** Reaction of VL 399 against finger and neck blast

| *Disease* | *Year* | *Locations* | *Percent damage* | | |
|---|---|---|---|---|---|
| | | | VL 399 | GE449 (RC) | Uduru Malige (SC) |
| Finger blast | 2019 | 9 | 7.90 | 6.75 | 29.09 |
| Neck blast | 2019 | 8 | 9.93 | 8.36 | 37.47 |

*RC: Resistant check; SC: Susceptible check

with the resistant check GE 4449 (8.36%) (Table 1). Overall, VL 399 has broad resistance and had 2nd and 3rd rank for finger and neck blast resistance, respectively at all India level. Identification of a genetic stock conferring broad resistance to the severe diseases like neck and finger blast will be highly useful in breeding for durable resistance and high yield in finger millet.

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## 19. AKGMR 118 (IC640695; INGR21130), a sorghum (*Sorghum bicolor* L.) germplasm with resistance to grain mold, thresh grade


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Sorghum (*Sorghum bicolor*) is the fourth most important cereal following rice, wheat and maize and staple food in the semi-arid parts of the world. Grain mold is the major biotic constrain in the way of production, marketing and utilization of kharif grain sorghum. It is one of the most important diseased of sorghum in many countries in Asia, Africa, North America, South America. The term Grain Mold Disease Complex (GDMC) has been used in few instances to describe this disease conditions (Prom *et al*. 2003). The disease is particularly important on improved, short- and medium-duration sorghum cultivars that mature during the rainy season in humid, tropical and subtropical climates. Several fungal species of the genera *Fusarium, Curvularia, Alternaria, Phoma, Bipolaris* and *Colletotrichum* have been reported to be associated with grain mold (Audilakshmi *et al*. 1999). *Curvularia lunata* and *Fusarium monoliforme* secrete amylase, cellulose and pectinases resulting in the disintegration of endosperm and germ tissues. These fungi also interfere with carbohydrate translocation to developing kernels causing reduction in size and weight of the kernels and ultimately germination of these grains. Therefore, identification of the resistant sources of grain mold in kharif sorghum is if prime importance. Considering this, a multilocation and multiseason grain mold screening trial entitled "National Grain Mold Nursery (NGN)" was formulated at national level by Indian Institute of Millets Research (IIMR), Hyderabad.

A national level trial was formulated by Indian Institute of Millets Research (IIMR), Hyderabad consisting of the entries contributed by the all the major centers of the AICSIP (All India Coordinated Sorghum Improvement Project) and conducted during the three years of 2016, 2017 and 2018 at the hot spot centers for grain mold i.e. Akola, Parbhani and Dharwad. In this connection, massive breeding programme for grain mold resistance has been continued at AICSIP Akola center and by utilizing the resistance sources identified in the programme, grain mold resistant lines have been developed at Akola center. AKGMR 118 contributed by Sorghum Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashta) was tested for three years in the "National Grain Mold Nursery (NGN)" trial formulated at national level by Indian Institute of Millets Research (IIMR), Hyderabad. Trial consisted of the testing entries along with one resistant check for grain mold (B 58586) in loose panicle background and one susceptible check (Bulky yellow). The experiments were sown in randomized block design with three replications.

For the character grain mold field grade the resistant check B 58586 recorded the lowest grain mold infestation of 2.29, while the susceptible check exhibited the highest grain mold field grade of 6.66. The best promising entry was AKGMR 118 (3.50) followed by AKGMR 119 (3.65). For the character grain mold threshed grade the resistant check B 58586 recorded the lowest grain mold infestation of 1.83, while the susceptible check exhibited the highest grain mold field grade of 6.83. The best promising entry was AKGMR118 with the grain mold threshed grade of 3.45 followed by AKGMR 119 (4.08).

The promising genotype AKGMR 118 and the resistant check B 58586 exhibited resistant reaction towards both field grade mold rating and threshed grain mold rating. This resistant reaction can be attributed to the lower percentage of both the fungi i.e. *Fusarium* and *Curvularia*.

Thus it was concluded form the present study that considering the resistant reaction as confirmed by AICSIP three years report against the grain mold disease, the promising genotype AKGMR 118 showing resistant reaction need to be exploited in breeding for grain mold resistance in sorghum as the donor parent in the crossing programme.

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## 20. VS 25 (IC640696; INGR21131), a little millet (*Panicum sumatrense* L.) germplasm with early flowering and early maturity

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Little millet (*Panicum sumatrense* (L.)) is one among the seven small millets which is gaining popularity in modern days because of its triple security for food, fodder and nutrition. Early maturity in little millets is an important criterion to fit into double or triple cropping system and also to serve as contingent crop. Little millet genotype, VS 25 is a promising line for early flowering and early maturity. It is a pure line selection obtained from the germplasm collected from Gummalakshmipuram (GMPLSM 9), Andhra Pradesh.

The entry, VS 25 along with other test entries were tested at 6 locations under field conditions in states of Chhattisgarh, Jharkhand, Madhya Pradesh, Maharashtra and Orissa during 2019. VS 25 recorded earliness with respect to days to 50 % flowering (47 days) and maturity (71 days). Moreover, VS 25 has recorded significantly higher grain yield (1110 kg/ha) compared to check entries, DHLM 36-3(865 kg/ha), OLM 203(863 kg/ha) and BL 6(980 kg/ha). It was tested in station trials during 2017 to 2019 and in Coordinated trials during 2019 to 2020. It belongs to early maturity with medium plant height and medium number of productive tillers/plant. It is high yielding compared to late duration checks, DHLM 36-3, OLM 203 and BL 6 for grain yield. Little millet genotype, VS 25 is unique in terms of higher grain yield with earliness and hence can be used directly as a source for development of earliness with high yielding variety.

## 21. VR 1070 (IC640697; INGR21132), a finger Millet (*Eleusine coracana* L. Gaertn.) germplasm with resistance to neck blast and finger blast

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Finger millet is one of the drought resistant small millet valued for its nutrient content in grains. It is a crop of both food and nutritional security. Blast is a major problem in finger millet crop which can hamper the production up to 70% in severe cases. Hence, finger millet improvement is oriented towards development of blast resistant high yielding varieties. Finger millet, VR1070 is finger and neck blast resistant line developed from pure line selection of IE No.2043. It belongs to medium maturity with medium plant height and medium number of productive tillers/plant.

The entry, VR 1070 recorded 16.2% less incidence of neck blast and 27.8% less incidence of finger blast compared to resistant check, Sri Chaitanya (VR 847) and 96.9% less incidence of neck blast and 97.3% less incidence of finger blast compared to susceptible check Champavathi (VR 708). The proposed entry along with other test entries and two checks were tested under high disease pressure under field conditions for consecutive five years from 2014 to 2018. It recorded less incidence of Finger blast (2.5%) among all the 3000 entries tested for finger blast resistance and also showed resistance to neck blast (3.5% Pooled data). Hence, VR 1070 is unique in terms of finger and neck blast resistance and hence can be used directly as a source for development of high yielding, finger and neck blast resistant varieties.

## 22. VR 1087 (IC640698; INGR21133), a (*Eleusine coracana* L. Gaertn.) germplasm with resistance to neck blast and finger blast.

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Finger millet is one of the climate resilient small millet which serves both food and nutritional security. Blast is a major problem in finger millet crop which can hamper the production upto 70% in severe cases. Hence, finger millet improvement is oriented towards development of blast resistant high yielding varieties. Finger millet, VR 1087 is neck and finger blast resistant line developed by crossing VL 330 x GE 532. The cross was performed in 2006 for developing blast resistant high yielding variety and subsequent selections were made through pedigree method from F2 to F6. It was promoted at F7 stage to Preliminary Yield Trial in 2013. It belongs to medium maturity with medium plant height medium number of productive tillers/plant. It is comparable with the check, Sri Chaitanya (VR 847) for grain yield.

The entry, VR 1087 recorded 3.2% less incidence of neck blast and 34.8% less incidence of finger blast compared to resistant check, Sri Chaitanya and 96.2% less incidence of neck blast and 97.5% less incidence of finger blast compared to susceptible check, Champavathi. VR 1081 along with other test entries and two checks were tested under high disease pressure under field conditions at All India Coordinated Research Project on Small Millets, Vizianagaram for consecutive five years from 2014 to 2018. It recorded 2.6% incidence of Finger blast among all the 3000 entries tested for finger blast resistance and also showed resistance to neck blast (3.8 % Pooled data). Hence, VR 1087 is unique in terms of neck and finger blast resistance and moreover it is a breeding line and hence it can be directly used as a source for development of high yielding, neck and finger blast resistant varieties.

## 23. SPV2591 (IC640645; INGR21134), a sorghum (*Sorghum bicolor* L. Moench.) germplasm with high total soluble sugar

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In any agriculture based economy livestock plays important role in agriculture development. Fodder demand and supply gap is increasing day by day in the country and to bridge this gap there is essential requirement of good quality and insect pest and foliar disease resistant germplasm stock which can be used in breeding programme to develop improved varieties/hybrids. Forage sorghum [*Sorghum bicolor* (L.) Moench] is an important fodder crop of India and mainly grown during summer and *kharif* seasons in the states of western UP, Haryana, Punjab, Rajasthan and Delhi due to its greater adaptability, high fodder yield, better palatability. Which fulfills over two third of the fodder demand during summer and *kharif* season. But in addition to quantity, quality of feed also is a matter of concern because good quality feed provides better nutrition to the livestock and intern also affect quality of byproducts. Sorghum feed quality is mainly determined by TSS%, CP% and IVDMD%. There are some morphological markers which indicate sorghum feed quality like green and brown midrib, juiciness etc.

Major breeding objectives for forage sorghum improvement include its quality and resistance to insect pest and foliar diseases. This genotype SH1514/SPV2591 genotype is genotype is tall having 9.14% TSS and is also resistant to stem borer, shoot fly, anthracnose, zonate leaf spots, leaf blight, grey leaf spot. It is developed by pedigree breeding and tested in AICRP Trials, AVHT SC Trial *Kharif* 2019. In addition to this genotype is having crude protein content & IVDMD% statistically on par with checks and plant height more than checks.

## Acknowledgement

Help and cooperation received from Dr. Vilas Tonapi, Director IIMR and his team working in IIMR, Hyderabad is thankfully acknowledged. We also thank Dr. M Elangovan who has helped in preparation of document. Cooperation and support received from HOD, Genetics and Plant Breeding and Director of Research, CCS HAU, Hisar is also duly acknowledged.

## 24. SPV2671 (IC640646; INGR21135), a sorghum (*Sorghum bicolor* L. Moench.) germplasm with resistance to anthracnose.

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In any agriculture based economy livestock plays important role in agriculture development. Fodder demand and supply gap is increasing day by day in the country and to bridge this gap there is essential requirement of good quality and insect pest and foliar disease resistant germplasm stock which can be used in breeding programme to develop improved varieties/hybrids. Forage sorghum [*Sorghum bicolor* (L.) Moench] is an important fodder crop of India and mainly grown during summer and *kharif* seasons in the states of western UP, Haryana, Punjab, Rajasthan and Delhi due to its greater adaptability, high fodder yield, better palatability. Which fulfills over two third of the fodder demand during summer and *kharif* season. But in addition to quantity, quality of feed also is a matter of concern because good quality feed provides better nutrition to the livestock and intern also affect quality of byproducts. Sorghum feed quality is mainly determined by TSS%, CP% and IVDMD%. There are some morphological markers which indicate sorghum feed quality like green and brown midrib, juiciness *etc*.

Major breeding objectives for forage sorghum improvement include its quality and resistance to insect pest and foliar diseases. This genotype SH1488/SPV2671 genotype is having high TSS% and low HCN and is also statistically on par for shoot fly and anthracnose resistance. It is developed by pedigree breeding and tested in AICRP Trials, IAVHT MC Trial *Kharif* 2019. In addition to this genotype is juicy, having good crude protein content & IVDMD% statistically on par with checks and leaf breadth more than checks.

## Acknowledgement

Help and cooperation received from Dr. Vilas Tonapi, Director IIMR and his team working in IIMR, Hyderabad is thankfully acknowledged. We also thank Dr. M Elangovan who has helped in preparation of document. Cooperation and support received from HOD, Genetics and Plant Breeding and Director of Research, CCS HAU, Hisar is also duly acknowledged.

## 25. IC360831 (IC0360831; INGR21136), a French bean (*Phaseolus vulgaris* L.) germplasm with resistance to BCMV disease

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### Introduction

Rajmash/Common bean (*Phaseolus vulgaris* L.; $2n = 2x = 22$) is also known by kidney bean, French bean, Snap bean and dry bean etc. It is one of the most vital and highly relished pulse crop used for direct human consumption globally and is an important component of subsistence agriculture (Broughton *et al.,* 2003). Therefore, rajmash is regarded as “Grain of hope”. In India, rajmash mainly produced by resource-poor farmers, small and marginal land holding farmers in the traditional production system that include rotation with vegetables and intercropping of climbing/pole type varieties with grain amaranth, potato and maize during *Kharif* season in North Eastern Hilly (NEH) region. While, it grown as a sole crop by using bush types varieties during *rabi* season in northern plain and central India. It is growing under diverse geographical location in which crop may expose to varied climatic condition. However, crop was prone to many diseases, among them Bean common mosaic virus (BCMV) is one of the most destructive diseases of common bean, it is mainly transmitted by vector Aphid and having seed borne nature. The virus belongs to genus *Potyvirus* of family *Potyviridae* and in India, BCMV is of regular recurrence in North- western Himalayas with disease incidence ranging from 0.5 to 77.0 % (Sharma *et al.* 1998; Kapil *et al.* (2011)). Thus, the prevalence of BCMV disease has posed a serious threat for dry bean production in rajmash growing areas of Himachal Pradesh, Jammu & Kashmir, Sikkim, Uttar Pradesh and Uttarkhand. Hence, Identification of stable BCMV resistant donors is crucial in Rajmash/Common bean improvement programme.

#### *Pedigree*

During *rabi* 2015-16, 2016-17, 2017-18 and 2018-19 a set of 300 germplasm accessions were evaluated for agronomic traits and BCMV disease screening under natural epiphytotic condition at IIPR, Kanpur by using BCMV resistant checks as Arun & Amber while, susceptible check as Jawala, Uday and IC341339. Disease scoring was done at three stages of crop growth *viz*., 45 DAS, 65 DAS and 90 DAS (Pathologist assistance involved). In these experiments, both agronomic and morphological data were recorded and based on BCMV percent disease incidence (PDI) data revealed that germplasm accession *viz.,* IC340947 and IC360831 were highly resistant against BCMV disease as they recorded 0.00% PDI over four consecutive seasons and *Kharif* rajmash is a highly remunerative pulse crop in hilly tract of Himachal Pradesh but BCMV disease is a major obstacle for grain production. During *Kharif* 2017 and 2018, a set of selected promising germplasm accession were screened against BCMV disease under natural field condition at NBPGR, Regional station, Shimla by using BCMV resistant checks as Arun & Amber while, susceptible check as Jawala and Uday. Based on agronomic traits and BCMV disease reaction scale the germplasm accession *viz.,* IC340947 and IC360831 were superior to check varieties and highly resistant against BCMV disease as they recorded 0.00% PDI. In addition to that, during *rabi* 2019-20 a set of selected promising germplasm accessions were screened against BCMV disease both under field and lab condition through sap inoculation method, similarly above experiments both agronomic and BCMV disease reaction was recorded at three different stages of crop growth. Likewise, previous experiments the germplasm accessions such as IC340947 and IC360831 were highly consistent and noticed highly resistant aganist BCMV disease and stable across the location and seasons. Thus, these donors being already utilized in disease breeding programme of Common bean. The germplasm identification committee under the chairmanship of Director, ICAR-IIPR visited the field on 09.03.2020 and examined the BCMV resistant donor in all aspects and GIC committee recommended for submission of germplasm registration proposal for unique germplasm identification.

### *Morpho-agronomic Characteristics*

IC360831: It is having very good plant vigour at early plant stages of crop growth and It has adventitious root system, plant growth habit is pole (semi indeterminate) type, green stem pigmentation, the green leaves grow alternately on the stems, days to 50% flowering attaining at 70 days, flower colour bears light pink, leaflet shape is ovate, pod colour is pale green and pod shape is straight, pod length is 12.29 cm and physiological maturity attaining at 125 days and it produces yield about 20 quintals /ha.

### *Associated characters and cultivated practices*

Rajmash grows well in areas where medium rainfall occurs, but not suited to the humid condition. Soil pH should be in the range of 5.5 - 6.0 to obtain maximum yield. The rajmash+ potato intercropping found quite profitable and efficient in irrigated areas. In hills, it is grown as a *Kharif* crop where as in plain grown as *rabi* crop. Seed rate varies with seed size. Bold seeded varieties with a test weight of 350-450 g need 120-140 kg seed/ha, while in small seeded varieties, it varies from 70-100 kg/ha and spacing for *Kharif* (Hills) - 45-50 cm x 8-10 cm while, Rabi & Spring - 40 cm x 10 cm (irrigated); 30 cm x 10 cm (Rain fed). For enhanced productivity, application of 90-120 kg N ha-1 has been found optimum. Half of the nitrogen should be applied as basal during sowing and rest half as top dressing after first irrigation and application of 60-80 kg $P_2O_5$/ha will give better yield. It requires 2 to 3 irrigations in NEPZ, Irrigation at 25 days after sowing is most critical followed by irrigation at 75 days after sowing. The crop matures in 125-130 days. A well-managed crop can easily give 20-25qtls/ha yields.

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## 26. EC267301 (EC267301; INGR21137), a chickpea (*Cicer arietinum* L.) germplasm with ascochyta blight resistance


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## Introduction

EC267301 is resistant to Ascochyta blight caused by *Ascochyta rabiei* (Pass.) Labr. The pathogen *A. rabiei* is highly variable. Total 1970 chickpea accessions were screened at two hotspot locations viz. PAU, Ludhiana and HAREC, CSK HPKV, Dhaulakuan. The chickpea germplasm was screened and promising accessions were validated against the disease for over the six years under artificial epiphytotic conditions in two locations i.e. PAU, Ludhiana and CSK HPKV, Dhaulakuan. An artificial standard inoculation procedure was followed for uniform spread of the pathogen (Gayacharan *et al.*, 2020). The disease reaction: 0 (immune) to 9 (highly susceptible) is as given below:

Screening of EC267301 for Ascochyta blight resistantance

| Genebank I.D. | Ludhiana | | | HAREC, CSK HPKV, Dhaulakuan |
|---|---|---|---|---|
| | 2016-17 | 2018-19 | 2019-20 | 2015-16 |
| EC267301 | 3 | 3 | 3 | 1 |
| L550(susceptible check) | 9 | 9 | 9 | 9 |
| JG62 (susceptible check) | 9 | 9 | 9 | 9 |

### *Morpho-agronomic Characteristics*

| | | | |
|---|---|---|---|
| Flower Color: White | Seed shape | Angular shape |
| Seed surface: Rough | Seed color | Beige |
| 100 seed weight: 21.3 | | |

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# 27. IC248147 (IC248147; INGR21138), a chickpea (*Cicer arietinum* L.) germplasm with ascochyta blight resistance

**Gayacharan[1*], Upasana Rani[2], Sarvjeet Singh[2], Ashwani K Basandrai[3], Virender K Rathee[4], Kuldeep Tripathi[1], Neeta Singh[1], Girish P Dixit[5], JC Rana[6], Sushil Pandey[1], Ashok Kumar[1] and Kuldeep Singh[1]**

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## Introduction

IC248147 is resistant to Ascochyta blight caused by *Ascochyta rabiei* (Pass.) Labr. The pathogen *A. rabiei* is highly variable. Total 1970 chickpea accessions were screened at two hotspot locations viz. PAU, Ludhiana and HAREC, CSK HPKV, Dhaulakuan. The chickpea germplasm was screened and promising accessions were validated against the disease for over the six years under artificial epiphytotic conditions in two locations i.e. PAU, Ludhiana and CSK HPKV, Dhaulakuan. An artificial standard inoculation procedure was followed for uniform spread of the pathogen (Gayacharan *et al.,* 2020). The disease reaction: 0 (immune) to 9 (highly susceptible) is as given below:

Screening of IC248147 for Ascochyta blight resistantance

| *Genebank I.D.* | *PAU, Ludhiana* | | | *HAREC, CSK HPKV, Dhaulakuan* |
|---|---|---|---|---|
| | *2017-18* | *2018-19* | *2019-20* | *2014-15* |
| IC248147 | 2.5 | 3 | 3 | 5 |
| L550 (susceptible check) | 9 | 9 | 9 | 9 |
| JG62 (susceptible check) | 9 | 9 | 9 | 9 |

### *Morpho-agronomic Characteristics*

| Seed type | Desi | Days to 50% flowering | 110 days |
|---|---|---|---|
| Flower Color | Pink | Seed shape | Angular |
| Seed Color | Brown beige | 100 seed weight | 12.5 g |

## References

Gayacharan, U Rani, S Singh, AK Basandrai, VK Rathee, K Tripathi, N Singh, GP Dixit, JC Rana, A Kumar and K Singh (2020). Identification of novel resistant sources for ascochyta blight (*Ascochyta rabiei*) in chickpea. *Plos one***, 15(10):** e0240589.

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ICAR-NBPGR (2020) Annual Report 2019, ICAR- National Bureau of Plant Genetic Resources, New Delhi, India, 236 p. (Page no. 69)

# 28. VRPSel-17 (No-17) (IC640701; INGR21139), a pea (*Pisum sativum* subsp. *hortense*) germplasm of vegetable pea genotypes bearing single flower per peduncle on all the floral nodes

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## Introduction

The number of flower/peduncle (FPP) is an economic trait in peas having agricultural and evolutionary significance that is influenced by a variety of factors including the environment. Thus, a varied expression of FPP can be seen within a single genotype as well within single plant of a genotype with a definite pattern, such as a single flower at the lower few nodes followed by two or three flowers on some of middle nodes, that again terminates into single/double flower at the upper nodes. As a result, it is difficult to get single/double/multi- flower on all the flowering nodes of a plant or a genotype, that usually create confusion in genetic studies especially devoted for flowering traits in peas.

VRPSel-17 (No-17) is a mid-season genotype of vegetable pea, unique in the fact that it bears only one flower (white) on all its flowering nodes, and not affected by external growing conditions including the environment. The genotype is tall in growth habit with longer internodal length and peduncles.

**Table 2:** DUS characterization of 'VRPSel-17' as per the guidelines provided by Protection of Plant Varieties and Farmers' Rights Authority (PPV & FRA) Government of India

| *Sl. No.* | *Type of Assessment* | *DUS Characteristics* | *VRP Sel-17'* |
|---|---|---|---|
| 1. | VS | Stem: Anthocyanin colouration | Absent |
| 2. | VG | Foliage: colour | Green (Yellow green group 147A) * |
| 3. | VG | Foliage: waxy bloom | Absent |
| 4. | VG | Leaf: leaflets | Present |
| 5. | VS | Leaf: axil colour | Green |
| 6. | VG | Stipule: rabbit eared stipules | Present |
| 7. | VG | Stipule: type | Normal |
| 8. | VG | Flower: opening (days) | Medium (50.1) |
| 9. | VG | Flower: standard petal colour | White |
| 10. | VS | Pod: number/axil | Single |
| 11. | VG | Pod: curvature | Absent |
| 12. | VS | Pod: shape of distal part | Blunt |
| 13. | VG | Pod: intensity of green colour | Light green (Yellow Green Group 146B) * |
| 14. | MS | Plant: height | Long (162.7cm) |
| 15. | VG | Seed: shape | Dimpled |
| 16. | VG | Seed: surface | Smooth |
| 17. | VG | Seed: cotyledon colour | Creamy (GYG161C) |
| 18. | MG | Seed: Weight of 1000-seed (dry) | 170g |
| 19. | VG | Seed: testa mottling | Absent |
| 20. | VG | Seed: parchment | Absent |

**MG:** Measurement by a single observation of a group of plants or parts of plants
**MS**: Measurement of a number of individual plants or parts of plants
**VG**: Visual assessment by a single observation of a group of plants or parts of plants
**VS:** Visual assessment by observation of individual plants or parts of plants
* Intensity of color measured by Royal Horticultural Society Color Charts (1804)

Over the years, the genotype exhibited consistent flowering behaviour of single FPP on all the reproductive nodes . The genotype is kept as unique selection from the germplasm, maintained at ICAR-IIVR, Varanasi since last few years and presently in use for various genetic studies.

### *Morpho-agronomic characteristics*

The genotype is characterized by its indeterminate growth habit (average plant height 162.7cm) with longer internodal (8.5cm) and peduncle length (6.2cm) that reflects as a dominate trait in its off-springs. Pods are 6-7 cm long, green in colour having 20-25 pods per plant with four to five seeds per pod. Seeds are smooth, yellowish cream (GYG161C) in colour having 100-Green seed weight of 37-40g while 1000 dry seed weight of 17g.

### *Associated characters and cultivated practices*

The genotype VRPSel-17 is also resistant to powdery mildew and rust under natural field conditions. This genotype also exhibited highest total phenolics content (TPC) and total flavonoids content (TFC) of 37.80 mg GAE/100 g fw) and 15.61 (mg CE/100 g fw), respectively among various white flowered genotypes studied (Devi *et al.,* 2019). Despite its low pod yield (60-70g/plant), this genotype can be used in a variety of genetic studies, including inheritance of flower numbers, flowering time, peduncle traits, seed and pod characters, disease studies, and so on. The genotype is suitable for November sowing under north Indian conditions. The optimum temperature for seed germination is about 22 ± 2°C. Furthermore, standard cultivation practises can be adopted to raise a healthy garden-pea crop.

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## 29. IPFD 18-14 (IC636671; INGR21140), a pea (*Pisum sativum* L.) germplasm with extra early flowering, early maturity and yellow cotyledon

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## Introduction

Field pea is acknowledged as a minor winter season pulse crop of India and is being cultivated in 0.82 mh area with 0.99 mt production. The major field pea growing states in the country are Uttar Pradesh, Madhya Pradesh, Bihar, Assam and Odisha (Anonymous, 2019). This crop is an admirable source of protein, starch, minerals and vitamins, as a result, it is widely used as an important component in many food industries worldwide (Parihar *et al.* 2016).The average productivity of field pea at global level is near 2.0 tonnes per hectare whereas in India it is quite low and being oscillated between 0.8-1.0 tonnes/ha (FAOSTAT, 2019). The major constraints in achieving potential yield in field pea are prevalence of biotic and abiotic stresses especially at terminal stage. Of them powdery mildew, rust and high temperature are the major concern for pea breeders (Parihar *et al.* 2020a). In the recent past, it has been noticed that early shoot up (mid of Jan-Feb) in temperature (>25°C) usually coincides with the flowering or pod filling stage of pea ultimately causing noteworthy reduction in productivity (Parihar *et al.* 2020b). In addition, prolonged kharif season compelled farmers to go for late planting which ultimately led to high temperature (> 30°C) exposure of pea crop during critical growth stages resulting into remarkable yield penalty. At the same time, the diseases pressure particularly of powdery mildew and rust remains high in late planted pea crop (Mishra *et al.* 2020). The central parts and rice fallow situation is a typical short window available which is always terminated by drought and heat stresses. In such situations, extra early maturing varieties (<90days) are the best options and may enhance monetary returns to farmers. In addition, the earliness is the ultimate trait to maximize the yields per unit time and per unit area in any cropping system by vacating the field for timely planting of succeeding crops (Dixit *et al.* 2014). Therefore, keeping in mind above facts, an urgent need was felt to develop extra early genotypes in field pea. Consequently, sincere breeding efforts were made at ICAR-IIPR, Kanpur using inter- specific hybridization to recover desirable segregants in filial generations. To develop extra early materials, a targeted inter-specific crosses were made between selected early type released varieties of Field pea (*Pisum sativum* L. var. *arvense*) and Garden pea (*Pisum sativum* L. var. *hortense*) since earliness trait is prominent in garden pea. The segregating generations were handled using pedigree methods and promising plants were selected in different generations. Based on the earliness, superior fixed lines were identified and of them most promising lines were evaluated consecutively for two years *viz*. 2017-18 and 2018-2019 in winter season for earliness with available early type checks *viz.*, Arkel, VRP 6, AGETA 6, DDR 30, DDR 23 and VRP 22. In addition, staggered planting (04/11/18; 29/12/18; 12/01/19) of the same set was also done during winter 2018-19. Based on over the years and staggered planting performance, one line IPFD 18-14 (DDR 23 x VRP 22) was found extra early. This genotype had flowered and matured in less than 36 days and 75 days, respectively. Hence, this extra early fieldpea genotype can be used as donor to develop short duration varieties in fieldpea breeding program and also for various genetical studies.

### *Morpho-agronomic characteristics*

The genotype (IPFD 18-14) is semi-dwarf type (50-60 cm) and leafy type. It has white colour flowers, white & round seed and yellow cotyledon. It flowered and matured in 30-35 days and 80-85 days respectively with 18.0-19.0 gm 100-seed weight. The average yield of the genotype is more than 1.0t/ha.

### *Associated characters and cultivated practices*

This genotype also has powdery mildew resistance and rust tolerance. It can be grown on different type of soil; however, a well drained soil is essential to achieve good yield potential of this genotype. The field should be well prepared by two to three ploughings. The seeds treatment should be done with fungicide like Thirum/Captan/Carbendazim @ 3.0 g/kg seed + rhizobium culture @1 packet/10 kg + Trichoderma @ 4.0 g/kg at 4-5 days before sowing. The optimum sowing time is October 15-Novemebr 15 with 100 kg/ha seed rate. At the time of field preparation 40 kg N, 40-60 kg $P_2O_5$:20-30 kg $K_2O$: 20 kg S: 15 kg $ZnSO_4$ should be applied as basal application. First irrigation should be given at 45 days and second, if needed, at pod filling stage.

This genotype has good worth as a donor in future fieldpea breeding programme towards development of extra early fieldpea varieties and in other basic studies.

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# 30. IPC 2020-198 (IC640699; INGR21141), a chickpea (*Cicer arietinum* L.) germplasm with high (three) number of seeds per pod

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### *Pedigree*

IPC 20-198 = IPC 2006-88 (*Cicer arietunim*)/ILWC 179 (*Cicer echinospermum*) IPC 2006-88 (recipient parent) = IPC 95-1 /H 82-2

### *Trait for registration*

3 seeds/ pod in ~30% of pods per plant

### *Plant breeding intervention*

The parental lines (IPC 2006-88 and ILWC 179) have 1-2 seeds per pod. The cross was attempted to generate deliberate variability through wide hybridization. The $F_2$ was bulked and generation advancement till $F_5$ was carried out through single plant selections and growing progeny rows from them (Pedigree breeding). However, in the $F_5$ generation

**Table 1:** Performance of the potential RILs with pods having >2 seeds/pod and desirable seedcharacteristics up to the consumer preference

| *RIL no.* | *Pods with 1 seed/ pod* | *Pods with 2 seeds/ pod* | *Pods with 3 seeds/ pod* | *Pods with 4 seeds/ pod* | *Total pods in 3 plants* | *% of pods with >3 seeds/pod* |
|---|---|---|---|---|---|---|
| 62 | 28 | 56 | 14 | 5 | 103 | 19.41 |
| 63 | 18 | 24 | 17 | 3 | 62 | 32.25* |
| 64 | 15 | 41 | 17 | 3 | 76 | 26.31 |
| 30 | 26 | 33 | 16 | 0 | 75 | 21.33 |
| 15 | 21 | 35 | 16 | 0 | 72 | 22.22 |
| 43 | 18 | 30 | 13 | 0 | 61 | 21.31 |

Advanced breeding line IPC 20-198 is the derivative of the line no. 63 in the table.

segregating lines, pods with 3 seeds were observed in high frequency in this population. The Singe Plant Selections (SPS, 137 no.s) were carried out in $F_5$ and $F_6$ progeny rows were raised. Data was generated for the number of seeds per pod in three plants in each row. Multidimensional visualization of the raw data was developed in the parallel coordinate plot (Wegman, 1991) and potential RILs were selected based on the target trait and desirable seed traits (angular seed shape, yellow testa colour and testa without tuberculation).

### *Population structure*

Total $F_6$ population strength: 137, Plants with 1, 2 Seeds/ Pod: 3, Plants with 1, 2, 3 Seeds/Pod: 106 Plants with 1, 2, 3 & 4 Seeds/Pod: 28

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Annual Report 2018-19. Indian Institute of Pulses Research, Kanpur, pp 15.

# 31. ICC 12315 (IC640700; INGR21142), a chickpea (*Cicer arietinum* L.) germplasm with tolerance to post emergent herbicide Imazethapyr

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### *Pedigree*

Selection from H76-49, collected from Haryana.

### *Trait for registration*

Tolerance to post emergent herbicide Imazethapyr (1.5X @ 150g/ ha.) with > 85% of survival and seed setting.

### *Plant breeding intervention*

Desi chickpea genotype ICC 12315 (germplasm accession/ breeding line) was received from ICRISAT under DAC funded project (Mechanical

harvesting and herbicide tolerance). The material was screened for resistance to post emergent herbicide Imazethapyr under supra optimal dose (2X @ 200g/ ha.) along with other genotypes. Heterogeneous response was observed in the treated population at maturity and Single Plant Selections (SPS) setting seeds were retrieved for screening in next season. For three consecutive seasons, spraying the herbicide and selection were carried out. ICC 12315 was observed to be possessing tolerance to post emergent herbicide Imazethapyr (1.5X @ 150g/ ha.) with > 85% of survival and seed setting over years.

### *Morphological characteristics*

Under normal conditions (without herbicide treatment), ICC 12315 has a semi erect plant architecture with medium height (45-50 cm). It initiates flowering in 85-88 days after sowing and matures in 127-130 days. The flower colour is pink. Seeds have light brown testa colour with a hundred seed weight of 21.32 g. ICC 12315 when sprayed with Imazethapyr (1.5x@ 150g/ha.) at 30-40 says after sowing with the weed population competing with crop, it initiates flowering at 90-93 days after sowing and matures in 127-130 days with the unsprayed crop with <5% yield penalty. The herbicide sprayed crop attends a height of 30-35 cm at maturity. The seeds of the sprayed crop have brown testa colour and a hundred seed weight 18-21 g.

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## 32. IC251372 (IC251372; INGR21143), a Vigna (*Vigna glabrescens* Marechal & al.) germplasm with photo-thermo period insensitivity


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The genus *Vigna* comprising >200 different species is highly variable with pantropic distribution. A number of the *Vigna* species *viz*., mungbean [*V. radiata* (L.) Wilczek], blackgram [*V. mungo* (L.) Hepper], cowpea [*V. unguiculata* (L.) Walp], adzuki bean [*V. angularis* (Willd.) Ohwi & Ohashi], bambara groundnut [*V. subterranea* (L.) Verdn.], moth bean [*V. aconitifolia* (Jacq.)] and rice bean [*V. umbellata* (Thunb.) Ohwi & Ohashi] are widely cultivated and consumed and therefore, hold tremendous agronomic promise and economic importance. Among these, mungbean and blackgram are the most popular pulse crops of the *Vigna* group and India is their largest producer, consumer and importer in the world (Pratap *et al*. 2012). Both these crops can be grown across a wide range of adverse soil and climatic conditions, and seasons (spring, summer, winter and rainy seasons) in different parts of the country as a sole, relay or intercrop (Pratap *et al.* 2013). Therefore, these crops also offer an opportunity for their horizontal as well as vertical expansion in large areas. However, the biggest hindrance in horizontal expansion of blackgram and mungbean in India is their photo- and thermo-sensitive behaviour which necessitates breeding of an array of genotypes for different agro-climatic zones of the country. Photo–thermo period sensitivity makes these crops vulnerable to photoperiod and temperature fluctuations, thereby affecting their yield potential drastically, especially when the same variety of these crops is grown across different seasons. Therefore, there is a need to develop cultivars which are largely insensitive to photo- and thermo-period and can be grown over large areas across seasons and agro-climatic zones. However, breeding for photo- and thermo-insensitivity requires robust donors for this trait without a possibility of linkage drag. Keeping this in view, this study aimed at identification of photo- and thermo-insensitive donors in the *Vigna* species so that these could be utilized in mungbean and blackgram improvement programmes through introgression breeding.

A set of 56 accessions of *Vigna* belonging to 13 species (eight accessions of *V. trilobata*, seven of *V. umbellata*, five each of *V. mungo* and *V. hainiana*, four each of *V. sylvestris* and *V. vexillata*, three each of *V. radiata*, *V. sublobata, V. dalzelliana* and *V. pilosa*, and one each of *V. glabrescens, V. trinernia* and *V. unguiculata*) and eight cultigens (four each of mungbean and blackgram) was grown under natural field conditions in the tropical climatic conditions of Kanpur (26°28′ N, 80°24′E) in two consecutive years (2011-13). All the individual plots of 56 accessions were observed every alternate day and the dates of important phenological events and characterization parameters as per NDUS guidelines (IIPR, 2010) were recorded. Viability of the fresh pollen samples in those accessions which survived through the rainy, summer and winter seasons was determined on the basis of observations on stainability of fresh pollen grains. On the basis of phenological events, physiological parameters as well as pollen viability studies, two accessions, *viz., V. umbellata* (IC251442) and *V. glabrescens* (IC251372) were identified to be largely photo- and thermo-period tolerant. Both these accessions behaved normally and were able to flower and set pods at extreme temperatures as high as 43.9°C and as low as 2.7°C. Pollen viability studies were also conducted which recorded viable pollen (>75% at 2.7°C and >85% at 41.9°C) and normal pollen tube growth at both the extremes of temperature. The identified *V. glabrescens* accession has long, constricted pods and dark green, mottled seeds while *V. umbellata* has smooth, curved pods and shining, oval, large seeds. Both these accessions have several other desirable characters besides photo- and thermo-period tolerance, such as long and bold pods, profuse branching and resistance to all major diseases of *Vigna* species, and therefore these could be potential donors for the above traits in *Vigna* through introgression breeding. Earlier *V. radiata* X *V. umbellata* and *V. mungo* X *V. umbellata* crosses have been successfully generated to transfer resistance to MYMV and other desirable traits into mungbean (Singh *et al*. 2003; Chaisen *et al*. 2013) and urdbean (Pal *et al*., 2005). Both these accessions are currently being utilized in developing photo–thermo tolerant genotypes in cultivated *Vigna* species.

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# 33. IC15925 (IC272450; INGR21144), a chickpea (*Cicer arietinum* L.) germplasm with heat tolerance

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Heat stress remains one of the important abiotic stresses causing significant yield loss in various crops including chickpea across the globe (Jha *et al*. 2014). Thus, identifying heat tolerant genotype is becoming important for developing heat tolerant chickpea genotype. A set of 182 chickpea along with genotype ICC15925 was tested for four season under normal sown and late sown condition (during 2017-18 and 2018-2019 years) along with the check ICCV92944 (heat tolerant check) and ICC10685 (heat sensitive check). Based on various morphophysiological and yield parameters ICC15925 was identified to be heat tolerant (Jha *et al* 2021). This genotype matures in 125 days under normal condition and under late sown condition it matures in 108 days. The yield of this genotype was noted to be superior to the check (ICCV92944/JG14) under late sown condition during 2017-2018 (Annual report 2018). In the year 2018-2019, the yield of this genotype was noted to be superior to the check (ICCV92944/JG14) under late sown condition (Annual report 2019). It matured in 126 days under normal sown condition and 106 days under late sown condition. Additionally, characterisation of physiological traits *viz*., cell membrane stability, peroxidase, super oxidase mutase was done for this genotype. Thus, based on both physiological and yield parameters this genotype showed heat tolerance. Besides, this genotypes has been used as donor for transferring heat tolerant traits to elite chickpea cultivars *viz*., in JG11, Pusa362, JG315 through crossing programme (Annual report 2018-2019). Therefore, in future this genotype can be used further used as donor for transferring heat tolerance trait to other high yielding chickpea yet heat stress sensitive cultivar.

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# 34. IC635410; BG-114-1 (IC635410; INGR21145), a bottle gourd [*Lagenaria siceraria* (Mol.) Standl.)] germplasm with resistance to gummy stem blight and short cylindrical fruit character

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## Introduction

Bottle gourd [*Lagenaria siceraria* (Mol) Standle; 2n = 22] commonly known as 'white flowered gourd' or 'calabash gourd' belongs to the family Cucurbitaceae. Its fruits are known for good nutritive value. It is rich source of vitamins, minerals and also possess diuretic, antioxidant, cardio protective properties (Barot *et al*. 2015). Acceptability for fruit shape varies with the region and segment. The Southern parts of the country prefer cylindrical shape, whereas North and north eastern regions prefer round to oblong shaped fruits. For achieving quick cultivar development in the desired shape, presence and utilization of resistance source in the desired fruit shape is well appreciated by the breeders in the development of varieties/hybrids with resistance. Keeping in view, ICAR-IIHR, Bengaluru has come out with genetic stocks having resistance to major biotic stress *i.e* gummy stem blight which is confronting the farmers. A promising genetic stock BG-114-1 with short, cylindrical shaped fruits was developed through individual plant selection from a open pollinated population collected and maintained in the germplasm. It was found to be resistant for gummy stem blight disease.

### *Morpho-agronomic characteristics*

Plants are monoceious, annual vine with soft pubescence and produces white solitary flowers during evening hours. It takes an average of 41.38 days for first female flower appearance at 10.53 node. Fruits are green, short cylindrical with a length of 18.95 cm and circumference 25.66 cm. It also produces 5.75 number of fruits per plant with an marketable yield of 43.12t/ha.

### *Associated Characters and cultivation practices*

Fruits are green, short cylindrical. It is also rich in Vit Ct and minerals like Iron, zinc, manganese and potash. Plants shows resistant reaction for gummy stem blight disease incidence across season with an average PDI of 9.01 under field screening and 9.25 under artificial screening. Bottle gourd is a warm season vegetable crop, it cannot with stand frost and usually prefers hot and moist climate for cultivation. Seeds are sown from January to February for summer crop, June to July for rainy season crop and October - November for Rabi season. Land should be prepared well before planting by repeated ploughing and harrowing, 20-25 tonnes of farm yard manure/ha should be broadcasted after the first ploughing.

Apply the recommended fertilizer mixture of 75kg N, 100 kg $P_2O_5$ and 35-70 $K_2O$/ha in two to three splits. Seeds are sown on raised beds of 15-30 cm height, 1-1.5m width during rainy season by maintaining a spacing of 1.6 m between the rows and 1m between the plants. Two to three seeds were sown per hill and covered with soil and light irrigation was given. Thinning of seedling should be done 25-30 days after sowing, retaining one healthy seedling per hill. Plants should be properly trained on the supporting structure to facilitate intercultural operations, thereby it reduces the incidence of pest and disease.

Traits of economic importance in (IC635410; INGR21145)

| *Sl. No* | *Characters* | *BG-114-1* |
|---|---|---|
| Plant morphological and yield traits | | |
| 1. | Days to first female flower appearance | 41.38 |
| 2. | Node on which first female flower appeared | 10.53 |
| 3. | Number of female flower | 10.33 |
| 4. | Number of fruits per plant | 5.75 |
| 5. | Yield/ha | 43.12 |
| Fruit quality traits | | |
| 6. | Fruit length(cm) | 18.95 |
| 7. | Fruit width(cm) | 23.98 |
| 8. | Fruit weight(kg) | 1.25 |
| 9. | Fruit shape | Short cylindrical |
| Nutrient and nutraceutical traits | | |
| 10. | Vit C (mg/100 g FW) | 12.30 |
| 11. | Potassium (%) | 5.54 |
| 12. | Iron (ppm) | 74.00 |
| 13. | Manganese (ppm) | 9.60 |
| 14. | Zinc (ppm) | 23.00 |
| Disease reaction | | |
| 15. | Gummy stem blight (PDI- Artificial screening) | 9.25 |
| 16. | Gummy stem blight (PDI- Field screening) | 9.01 |

## References

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# 35. BG-114-3 (IC635411; INGR21146), a bottle gourd [*Lagenaria siceraria* (Mol.) Standl.)] germplasm with resistance to gummy stem blight and medium cylindrical fruit

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## Introduction

Bottle gourd [*Lagenaria siceraria* (Mol) Standle; 2n = 22] commonly known as 'white flowered gourd' or 'calabash gourd' belongs to the family Cucurbitaceae. Its fruits are known for good nutritive value. It is rich source of vitamins, minerals and also possess diuretic, antioxidant, cardio protective properties (Barot *et al*. 2015). Acceptability for fruit shape varies with the region and segment. The Southern parts of the country prefer cylindrical shape, where as North and north eastern regions prefer round to oblong shaped fruits. For achieving quick cultivar development in the desired shape, presence and utilization of resistance source in the desired fruit shape is well appreciated by the breeders in the development of varieties/hybrids with resistance. Keeping in view, ICAR-IIHR, Bengaluru has come out with genetic stocks having resistance to major biotic stress *i.e* gummy stem blight which is confronting the farmers. A promising genetic stock BG-114-3 with medium cylindrical shaped fruits was developed through individual plant selection from a open pollinated population collected and maintained in the germplasm. It was found to be resistant for GSB across the seasons with an average PDI of 6.22 under field screening and 9.45 under artificial screening.

### *Morpho-agronomic characterstics*

Plants are monoecious, annual vine with soft pubescence and produces white solitary flowers during evening hours. It takes an average of 45.92 days for first female flower appearance at 9.24$^{th}$ node. Fruits are green, medium cylindrical with a length of 25.93 cm and circumference 25.66 cm. It also produces 7.16 number of fruits per plant with a marketable yield of 46.80t/ha.

### *Associated Characters and cultivation practices*

It is also rich in Vit C and minerals like Iron, zinc, manganese and potash. It is a typical warm season vegetable, it cannot with stand frost and usually prefers hot and moist climate for cultivation. Seeds are sown from January to February for summer crop, June to July for rainy season crop and October - November for Rabi season. Land should be prepared well before planting by repeated ploughing and harrowing, 20-25 tonnes of farm yard manure/ha should be broadcasted after the first ploughing. Apply the recommended fertilizer mixture of 75 kg N, 100 kg $P_2O_5$ and 35-70 $K_2O$/ha in two to three splits. Seeds are sown on raised beds of 15- 30cm height, 1-1.5m width during rainy season by maintaining a spacing of 1.6 m between the rows and 1 m between the plants. Two to three seeds were sown per hill and covered with soil and light irrigation was given. Thinning of seedling should be done 25-30 days after sowing, retaining one healthy seedling per hill. Plants should be properly trained on the supporting structure to facilitate intercultural operations, thereby it reduces the incidence of pest and disease.

Traits of economic importance in (IC635411; INGR21146)

| *Sr. No* | *Character* | *BG-114-3* |
|---|---|---|
| Morphological Traits | | |
| 1. | Days to first female flower appearance | 45.92 |
| 2. | Node on which first female flower appeared | 9.24 |
| 3. | Number of female flower | 12.22 |
| 4. | Number of fruits per plant | 7.16 |
| 5. | Yield /ha | 46.80 |
| Fruit quality traits | | |
| 6. | Fruit length (cm) | 25.93 |
| 7. | Fruit circumference (cm) | 25.66 |
| 8. | Fruit weight (kg) | 1.09 |
| 9. | Fruit Shape | Medium Cylindrical |
| Nutrient and neutraceurtical traits | | |
| 10. | Vit C (mg/100 g FW) | 8.20 |
| 11. | DPPH (mg/100g (FW) AEAC | 10.55 |
| 12. | FRAP (mg/100g (FW) AEAC | 13.77 |
| 13. | Potassium (%) | 5.52 |
| 14. | Iron (ppm) | 82.66 |
| 15. | Manganese (ppm) | 12.30 |
| 16. | Zinc (ppm) | 25.00 |
| Disease reaction | | |
| 17. | Gummy stem blight disease (PDI-Artificial screening) | 9.45 |
| 18. | Gummy stem blight disease (PDI-Field screening) | 6.22 |

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# 36. IC635413; BG-6-3 (IC635413; INGR21147), a bottle gourd [*Lagenaria siceraria* (Mol.) Standl.)] germplasm with resistance to powdery mildew and elongated straight fruit

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## Introduction

Bottle gourd [*Lagenaria siceraria* (Mol) Standle; 2n = 22] commonly known as 'white flowered gourd' or 'calabash gourd' belongs to the family Cucurbitaceae. Its fruits are known for good nutritive value. It is rich source of vitamins, minerals and also possess diuretic, antioxidant, cardio protective properties (Barot *et al.* 2015). Acceptability for fruit shape varies with the region and segment. The Southern parts of the country prefer cylindrical shape, where as North and north eastern regions prefer round to oblong shaped fruits. For achieving quick cultivar development in the desired shape, presence and utilization of resistance source in the desired fruit shape is well appreciated by the breeders in the development of varieties/hybrids with resistance. Keeping in view, ICAR-IIHR, Bengaluru has come out with genetic stocks having resistance to major biotic stress *i.e* powdery mildew which is confronting the farmers.

Traits of economic importance in (IC635413; INGR21147)

| *Sl. No* | *Character* | *BG-6-3* |
|---|---|---|
| Plant morphological and yield traits | | |
| 1. | Days to first female flower appearance | 43.15 |
| 2. | Node on which first female flower appeared | 8.21 |
| 3. | Number of female flower | 15.55 |
| 4. | Number of fruits per plant | 5.05 |
| 5. | Yield /ha | 31.81 |
| Fruit quality traits | | |
| 6. | Fruit length(cm) | 34.75 |
| 7. | Fruit circumference (cm) | 27.00 |
| 8. | Fruit weight(kg) | 1.05 |
| 9. | Fruit shape | Elongated straight |
| Disease reaction | | |
| 10. | Powdery mildew | 11.11(PDI) 266.67 (AUDPC) |

A promising genetic stock BG-6-3 with medium elongated straight shape was developed through individual plant selection from a open pollinated population collected and maintained in the germplasm. It was found to be resistant for powdery mildew.

### *Morpho-agronomic characterstics*

Plants are monoceious, annual vine with soft pubescence and produces white solitary flowers during evening hours. It takes an average of 43.15 days for first female flower appearance at 8.21 node. Fruits are green, medium elongated straight with a length of 34.75 cm and circumferance of 27.00 cm. It also produces 5.05 number of fruits per plant with an marketable yield of 31.81t/ha.

### *Associated Characters and cultivation practices*

Fruits are medium, elongated straight with green in colour. Plants shows resistant reaction for powdery mildew disease under artificial screening. It is a typical warm season vegetable, it cannot with stand frost and usually prefers hot and moist climate for cultivation. Seeds are sown from January to February for summer crop, June to July for rainy season crop and October - November for Rabi season. Land should be prepared well before planting by repeated ploughing and harrowing, 20-25 tonnes of farm yard manure/ha should be broadcasted after the first ploughing.

Apply the recommended fertilizer mixture of 75 kg N, 100 kg $P_2O_5$ and 35-70 $K_2O$/ha in two to three splits. Seeds are sown on raised beds of 15- 30cm height, 1-1.5m width during rainy season by maintaining a spacing of 1.6 m between the rows and 1m between the plants. Two to three seeds were sown per hill and covered with soil and light irrigation was given. Thinning of seedling should be done 25-30 days after sowing, retaining one healthy seedling per hill. Plants should be properly trained on the supporting structure to facilitate intercultural operations; thereby it reduces the incidence of pest and disease.

## References

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Hebbar SS, Nair AK, and senthil Kumar M, IIHR, Bengaluru (INDIA), pp 26-28.
Amit B, Suneeta P, Smitha B and Prajapati JP (2015) Composition, Functional Properties and Application of Bottle Gourd in Food Products. *Journal of Dairy Science and Technology*, **4(1):** 15-27.

## 37. IC635412; BG-95 (IC635412; INGR21148), a bottle gourd (*Lagenaria siceraria* (Molina) Standl.) germplasm with resistance to gummy stem blight and round shaped fruit

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### Introduction

Bottle gourd [*Lagenaria siceraria* (Mol) Standle; 2n = 22] commonly known as 'white flowered gourd' or 'calabash gourd' belongs to the family Cucurbitaceae. Its fruits are known for good nutritive value. It is rich source of vitamins, minerals and also possess diuretic, antioxidant, cardio protective properties (Barot *et al.* 2015). Acceptability for fruit shape varies with the region and segment. The Southern parts of the country prefer cylindrical shape, whereas north and north eastern regions prefer round to oblong shaped fruits. For achieving quick cultivar development in the desired shape, presence and utilization of resistance source in the desired fruit shape is well appreciated by the breeders in the development of varieties/hybrids with resistance. Keeping in view, ICAR-IIHR, Bengaluru has come out with genetic stocks having resistance to major biotic stress *i.e* gummy stem blight which is confronting the farmers. A promising genetic stock BG-95 with round shape was developed through individual plant selection from a open pollinated population collected and maintained in the germplasm. It was found to be resistant for gummy stem blight disease.

Traits of economic importance in (IC635412; INGR21148)

| *Sl. No* | *Character* | *BG-95* |
|---|---|---|
| Morphological Traits | | |
| 1. | Days to first female flower appearance | 53.55 |
| 2. | Node on which first female flower appeared | 14.01 |
| 3. | Number of female flower | 12.67 |
| 4. | Number of fruits per plant | 4.79 |
| 5. | Yield /ha | 36.78 |
| Fruit quality traits | | |
| 6. | Fruit length(cm) | 14.25 |
| 7. | Fruit circumference (cm) | 41.48 |
| 8. | Fruit weight(kg) | 1.28 |
| 9. | Fruit shape | Round |
| 10. | Fruit firmness(kg/cm2) | 10.69 |
| 11. | Pericarp thickness(mm) | 15.18 |
| 11. | Gummy stem blight disease (PDI- Artificial screening) | 8.89 |
| 12. | Gummy stem blight disease (PDI- Field screening) | 9.27 |

#### *Morpho-agronomic characteristics*

Plants are monoecious, annual vine with soft pubescence and produces white solitary flowers during evening hours. It takes an average of 53.55 days for first female flower appearance at 14.01 node. Fruits are green, round with a length of 14.25 cm and circumference 41.48cm. It also produces 4.79 number of fruits per plant with an marketable yield of 36.78t/ha.

## 38. VRT12-1-3-2 (IC640702; INGR21149), a tomato (*Solanum lycopersicum* L.) germplasm with broad spectrum resistance to tomato leaf curl virus possessing Ty-3 gene along with uniform ripening fruits and greater combining ability

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Tomato (*Solanum lycopersicum*) is one of the major vegetable crops consumed and cooked in different forms/ways worldwide. Tomato is vulnerable to a wide range of different pathogens leading to significant yield loss every year world over. Among them, *Tomato leaf curl virus* (ToLCV), a *Begomovirus* from the *Geminiviridae* family, transmitted by whiteflies (*Bemisia tabaci*) is a major challenge in tomato production and can cause 100% yield loss if young tomato plants are infected. Breeding and cultivating ToLCV resistant cultivars is a proven strategy to minimize the loss caused by the disease.

Since inception, ICAR-Indian Institute of Vegetable research, Varanasi is working on development of ToLCV resistant tomato cultivars. VRT12-1-3-2 is one such product from resistant breeding efforts and has good resistance against ToLCV. VRT12-1-3-2 was developed through marker assisted selection from $F_2$ populations of a cross between FLA478-6-1-11 × CLN2498C and FLA478-6-1-11 × CLN1621E. The lines CLN2498C and CLN1621E carry *Ty-2* gene. The line FLA478- 6-1-11 carry *Ty-3* gene (Prasanna *et al.*, 2015). *Ty-3* gene is a partially dominant gene and was introgressed into cultivated tomato from *S. chilense* (LA2779) (Verlaan *et al.* 2013).

The tomato genotype VRT12-1-3-2 has *Ty-3* gene. The tomato line VRT12-1- 3-2 showed a high level of resistance to ToLCV. The response of the line to infection by a monopartite (ToLCBV) and a bipartite (ToLCNDV) virus was tested using both field tests and agroinoculation based disease screens. The severity of the disease symptoms (DSI) was assessed at 30 and 60 days following agroinoculation. Tomato line VRT12-1-3-2 had an average DSI of 0.5 to 0.6 and 0.9 in response to ToLCBV and ToLCNDV infection, respectively at 60 DPI. Susceptible genotype Punjab chuuhara showed only moderate susceptibility at 30 days post inoculation (DPI) of Tomato Leaf Curl Bangalore Virus (DSI of 3) but showed higher disease severity at 60DPI (DSI of 3.6). The average DSI of Kashi Vishesh was ≥ 3.1 at different stages in both agroinoculation and field tests. The tomato line VRT2-2-3-1 showed high level of resistance in the field even at 90 days after transplanting (Prasanna *et al.*, 2015).

The *Ty-3* containing tomato line VRT12-1-3-2 recorded an average fruit yield of 4.07 kg. The fruits of the line VRT12-1-3-2 are circular in shape with pericarp thickness of 0.49 cm and with an average locule number of 2.47 per fruit. VRT12-1-3-2 has greater combining ability. With ToLCV resistance, uniform fruit ripening, desirable horticultural characters, and combining ability, VRT12-1-3-2 can be used in different tomato ToLCV resistance breeding programmes like the line can be used as a parent in hybrid development programmes and as source of *Ty-3* gene in gene pyramiding programmes with other economically useful genes.

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## 39. VRT2-2-3-1 (HCP/YSR-2/) (IC637249; INGR21150), a tomato (*Solanum lycopersicum* L.) germplasm with broad spectrum resistance to tomato leaf curl virus and possessing Ty-3 gene along with green fruit shoulder and greater combining ability

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Tomato (*Solanum lycopersicum* L.) is one of the most important vegetable crops in the world along with potato and onion. Tomato (yellow) leaf curl disease (TYLCD/ToLCD) is a major biotic constraint in tomato production and can cause 100% yield loss if young tomato plants are infected. ToLCD caused by begomoviruses and transmitted by whitefly (*Bemisia tabaci*). Among different available strategies, cultivating ToLCD resistant cultivars is the most effective, economical and environmentally safe strategy to manage the disease.

With an aim to develop ToLCV resistant cultivars, resistant breeding programme was initiated at ICAR-Indian Institute of Vegetable research, Varanasi. One of the products of the programme was tomato elite line VRT2-2-3-1. It has good resistance against ToLCV. VRT2-2-3-1 was developed through marker assisted selection from $F_2$ populations of a cross between FLA478-6-1-11 × CLN2498C and FLA478-6-1-11 × CLN1621E. The lines CLN2498C and CLN1621E carry *Ty-2* gene. The line FLA478-6-1-11 carry *Ty-3* gene (Prasanna *et al.*, 2015). VRT2-2-3-1 carries *Ty-3* gene which is a partially dominant gene.

The response of this line to infection by a monopartite (ToLCBV) and a bipartite (ToLCNDV) virus was tested using both field tests and agro inoculation based disease screens. The tomato line VRT2-2-3-1 showed a high level of resistance to both ToLCBV and ToLCNDV. The severity of the disease symptoms (DSI) was assessed at 30 and 60 days following agro inoculation. VRT2-2-3-1 showed similar disease response in two independent inoculation experiments. Susceptible genotype Punjab chuuhara showed only moderate susceptibility at 30 days post inoculation (DPI) of *Tomato Leaf Curl Bangalore Virus* (DSI of ≤ 3) but showed higher disease severity at 60 DPI (DSI > 3.6). The average DSI of Kashi Vishesh was ≥ 3.1 at different stages in both agro inoculation and field tests. The tomato line VRT2-2-3-1 showed high level of resistance in the field even at 90 days after transplanting (Prasanna *et al.*, 2015).

The tomato line VRT2-2-3-1 recorded an average fruit yield of 4.94 kg. The fruits of the line VRT2-2-3-1 showed high pericarp thickness (0.67 cm) with an average locule number of 2.7 per fruit. Fruit of VRT2-2-3-1 are round and has green shoulder. VRT2-2-3-1 has good combining ability. With ToLCV resistance, desirable horticultural characters, green shoulder and combining ability, VRT2-2-3-1 can be used in different tomato ToLCV resistance breeding programmes like the line can be used as a parent in hybrid development programmes especially for green shoulder market segment and as source of *Ty-3* gene in gene pyramiding programmes with other economically useful genes.

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## 40. VRT6-1-4 (HCP/YSR-5/) (IC637252; INGR21151), a tomato (*Solanum lycopersicum* L.) germplasm with broad spectrum resistance to tomato leaf curl virus possessing Ty-2 and Ty-3 genes pyramided along with uniform ripening of fruits.

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The whitefly-transmitted tomato yellow leaf curl virus (ToLCV) is one of the major hurdle in successful cultivation of tomato. Breeding tomatoes with resistance against whiteflies and/or viruses is the most effective method to minimize the damage caused by ToLCV and to avoid excessive use of insecticides. Wild tomato relatives are the main sources for ToLCV resistance. To date, six resistance genes (Ty-1, Ty-2, Ty-3, Ty-4, ty-5, and Ty-6) identified from several wild tomato species have been well studied (Ji *et al.*, 2007; Hutton and Scott, 2014). Among them, Ty-1, Ty-2, and Ty-3 are the main sources of resistance for tomato breeding programs. Ty-1 and Ty-3 are alleles of the same gene.

Tomato line VRT6-1-4 with *Ty2* and *Ty3* genes pyramided was developed at ICAR-Indian Institute of Vegetable research, Varanasi. This tomato genotype has high ToLCV resistance and was developed through marker assisted selection from F2 populations of cross between FLA478-6-1-11 × CLN2498C and FLA478-6--11 × CLN1621E. The lines CLN2498C and CLN1621E carry *Ty-2* gene. The line FLA478-6-1-11 carries *Ty-3* gene (Prasanna *et al.*, 2015).

The tomato line VRT6-1-4 showed a high level of resistance in both field tests and agroinoculation based disease screens. Tomato-infecting begomovirus species used in agroinoculation comprised bipartite Tomato leaf curl New Delhi virus (ToLCNDV) and Tomato leaf curl Palampur virus (ToLCPalV), and a monopartite Tomato leaf curl Bangalore virus (ToLCBV). The severity of the disease symptoms (DSI) was assessed at 30 and 60 days following agroinoculation and at 45 and 90 days after transplanting in field conditions. Tomato line VRT6-1-4 had an average DSI of and 0.2 in response to ToLCNDV and ToLCPalV infection, respectively at 60 DPI. There were no ToLCV symptoms even after 60 days following agroinoculation with monopartite ToLCBV. Cultivars Kashi Vishesh and Punjab Chhuhara were used as susceptible checks and they showed disease symptoms in all the experiments. High disease severity index (DSI) of ≥ 3.7 was recorded on both of these cultivars at 60 DPI. The line carrying Ty-2 showed moderate resistance to ToLCBV (DSI <2) with moderate leaf curling symptoms, but it was susceptible to both bipartite ToLCNDV (DSI 2.9) and ToLCPalV (DSI 2.2) at 60 DPI. The tomato line VRT6-1-4 showed high level of resistance under natural epiphytotic conditions in field even at 90 days after transplanting (Prasanna *et al.*, 2015).

The pyramided line VRT6-1-4 recorded an average fruit yield of 3.22 kg/plant. The fruits of pyramided line D6-1-4 showed high pericarp thickness of 0.5-cm with an average locule number of 3.8 per fruit and total soluble solids (TSS) of 4.8 Brix. Fruit diameter and fruit length recorded on the fruits of VRT6-1-4 indicated that the high-yielding pyramided line VRT6-1-4 had round to high round fruits that ripen uniformly. VRT6-1-4 can be used in the tomato ToLCV resistance breeding programmes. It can be used as inbred in hybrid development programmes especially for uniform ripening market segment and as a source of *Ty-2 +Ty-3* in gene pyramiding programmes to combine other Ty genes.

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# 41. Selection-24 (IC640703; INGR21152), a natural dwarf variant of tomato (*Solanum lycopersicum* L.)

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## Introduction

Selection-24 (Seln-24) a natural dwarf variant identified and stabilized from a segregating population of tomato variety Pusa Gaurav. The line is dwarf in nature with mean plant height of about 40-45 cm. Line has shown consistent field tolerance to whitefly and leaf curl virus disease (Chandrashekar *et al.,* 2019 and Saha *et al.*, 2021). The attributes of Seln-24 *viz.*, determinate dwarf bushy plants with moderate green foliagecover, attractivebullet shaped immature fruits and attractive deep red color elliptical (egg-shaped) ripe fruits, makes it highly suitable for terrace and vertical gardening. Due to its compact and dwarf nature, Seln-24 requires minimum staking and training.

### *Morpho-agronomic characteristics*

Seln-24 showed significant reduction in plant height (42 cm) which was up to 4 times less compared to parental line Pusa Gaurav ranging between 130.9 to 140.72 cm (Table 1). Plants are determinate, dwarf bushy with moderate green foliage cover. Leaf shape is slightly serrated, green. Number of flowers per truss are more than six, number of fruits per

**Table 1:** Comparison of L-24 for plant height, yield, pest and disease incidence along with the checks (2016-2018)

| *S. No.* | *Line* | *Plant height (CM)* | *Whitefly (No./leaf)* | *Thrips (No./sample)* | *Leaf curl (% incidence)* | *Yield (KG/Plant)* | *TSS* |
|---|---|---|---|---|---|---|---|
| | | | | *2016* | | | |
| 1 | Seln-24 | 53.01 ± 2.51 | 0.08 ± 0.0 | 0.58 ± 0.04 | 7.4 ± 1.2 | 1.58 ± 0.11 | 3.72 ± 0.19 |
| 2 | Pusa Rohini | 150.37 ± 5.72 | 0.25 ± 0.1 | 0.42 ± 0.04 | 23.3 ± 5.8 | 1.90 ± 0.90 | 4.06 ± 0.06 |
| 3 | L-29 | 209.30 ± 4.93 | 0.17 ± 0.01 | 0.64 ± 0.22 | 9.1 ± 4.0 | 2.34 ± 0.67 | 4.26 ± 0.19 |
| 4 | L-33 | 139.70 ± 2.13 | 0.5 ± 0.19 | 0.59 ± 0.0 | 0.0 | 1.76 ± 0.22 | 3.8 ± 0.17 |
| 5 | Arka Rakshak | 169.31 ± 5.30 | 0.2 ± 0.2 | 0.42 ± 0.04 | 7.25 ± 2.5 | 4.21 ± 1.33 | 4.96 ± 0.04 |
| 6 | Pusa Gaurav | 130.05 ± 13.0 | 0.25 ± 0.0 | 0.82 ± 0.04 | 10.5 ± 3.8 | 2.75 ± 0.14 | 3.8 ± 0.10 |
| | | | | 2017 | | | |
| 1 | Seln-24 | 38.0 ± 2.97 | 1.00 ± 0.01 | 2.80 ± 0.33 | 2.10 ± 1.96 | 1.36 ± 0.27 | 3.60 ± 0.3 |
| 2 | Pusa Rohini | 173.74 ± 12.01 | 1.67 ± 0.2 | 3.33 ± 0.33 | 41.43 ± 7.78 | 2.06 ± 0.23 | 4.0 ± 0.0 |
| 3 | L-29 | 251.97 ± 21.67 | 0.20 ± 0.05 | 3.67 ± 0.67 | 3.7 ± 2.56 | 1.14 ± 0.09 | 4.17 ± 0.23 |
| 4 | L-33 | 170.69 ± 3.05 | 1.67 ± 0.25 | 3.00 ± 0.67 | 0.0 | 2.19 ± 0.20 | 3.73 ± 0.29 |
| 5 | Arka Rakshak | 217.42 ± 4.93 | 3.33 ± 0.1 | 4.67 ± 0.42 | 12.63 ± 2.78 | 2.78 ± 0.76 | 5.0 ± 0.0 |
| 6 | Pusa Gaurav | 140.72 ± 5.74 | 1.67 ± 0.1 | 3.0 ± 0.33 | 22.5 ± 6.4 | 1.82 ± 0.13 | 3.8 ± 0.20 |
| | | | | 2018 | | | |
| 1 | Seln-24 | 32.99 ± 2.31 | 1.67 ± 0.67 | 2.13 ± 0.66 | 6.86 ± 1.7 | 1.54 ± 0.20 | 3.93 ± 0.07 |
| 2 | Pusa Rohini | 171.20 ± 10.19 | 1.33 ± 0.33 | 3 ± 0.93 | 11.46 ± 1.0 | 1.84 ± 0.14 | 4.10 ± 0.10 |
| 3 | L-29 | 262.64 ± 23.93 | 0.3 ± 0.1 | 3.8 ± 1.04 | 3.79 ± 0.8 | 1.68 ± 0.18 | 4.47 ± 0.24 |
| 4 | L-33 | 181.86 ± 11.86 | 3.3 ± 0.6 | 4.53 ± 1.15 | 0.0 | 2.31 ± 0.33 | 4.0 ± 0.12 |
| 5 | Arka Rakshak | 218.95 ± 5.44 | 1.67 ± 0.33 | 3 ± 1.24 | 6.84 ± 1.96 | 3.52 ± 0.18 | 4.93 ± 0.19 |
| 6 | Pusa Gaurav | 133.10 ± 7.54 | 1.33 ± 067 | 2.60 ± 0.66 | 8.2 ± 2.5 | 2.63 ± 0.28 | 3.4 ± 0.14 |

cluster is more than five, average number of fruits per plant vary from 50-55. Fruits are smooth, elliptical (egg-shaped) and borne in clusters, uniformly red and thick skinned with two locules. Average yield per plant is around 1.5-2.0 kg/ plant. TSS (3.6 Brix) and better keeping quality at room temperature.

Mean fruit weight varies from 50-60 g. Fruit length more than 5 cm while fruit diameter is 4 cm. The vitamin C content is quite higher i.e. 43 mg/100gFW (Table 2). SeIn-24 evaluated for performance under terrace gardening in different sized pots. When grown in large pots each plant yielded on an average 2.0 kg fruits/plant.

SeIn-24 has consistently showed field tolerance to whiteflies and leaf curl disease during the years 2016, 2017, 2018-19 (Table 1) and 2019-20 (which was comparable to standard leaf curl resistant check "Arka Rakshak", a parent line "Pusa Gaurav" and diseases resistant check lines (L-29 and L-33). The disease tolerance observed during the year 2016, 2017 and 2018 in SeIn-24 (7.4, 2.10 and 3.79% disease incidence) which was similar to Arka Rakshak (7.25, 12.63 and 6.84%) and much higher than popular variety Pusa Rohini (23.3, 41.43 and 11.46%) (Table1). The population of whiteflies recorded on SeIn-24 was 0.58, 2.80 and 2.13 whiteflies/leaf respectively, in the year 2016, 2017 and 2018. The population of whiteflies recorded on standard check Pusa Rohini was 0.42, 3.33 and 3.0 and on Arka Rakshak it was 0.4 4.67 and 3.0 whiteflies/leaf respectively. Similar tolerance to vector and leaf curl virus was also observed during 2019-20 also.

### *Associated characters and cultivation practices*

Average plant height observed for SeIn-24 is the most suitable for pot culture as well as high density planting. Huge cost is involved in staking sticks/stumps, steel wires, gunny twine/rope and labour for twining tomato plants. The cost involve in this activity varies from 7 to 11%. Use of dwarf determinate variety SeIn-24 in the near future will lead to savings in cost of cultivation for the staking in tomato.

Since the line is dwarf type staking operation is not required which saves a lot of labour and expenditure.

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**Table 2:** Mean performance of yield, and quality traits of various tomato genotypes

| *S. No.* | *Accessions* | *Plant height (cm)* | *No of branches/ plant* | *No of flowers /truss* | *No of fruits/ cluster* | *No of fruits/ plant* | *Yield /plant (kg)* | *Yield (t/ha)* | *IFW (g)* | *FL (cm)* | *FD v(cm)* | *PT (cm)* | *FC (cm)* | *TSS° Brix* | *Vitamin C (mg/100g FW)* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Arka Rakshak | 201.84 | 5.93 | 6.40 | 5.93 | 81.8 | 3.31 | 81.90 | 81.53 | 5.31 | 4.88 | 0.60 | 3.91 | 3.40 | 19.38 |
| 2 | Pusa Rohini | 165.10 | 6.73 | 6.46 | 6.27 | 85.1 | 1.86 | 45.94 | 71.25 | 4.45 | 5.15 | 0.65 | 4.16 | 3.45 | 28.63 |
| 3 | Pusa Gaurav | 134.62 | 7.33 | 4.26 | 5.67 | 64.6 | 2.29 | 56.76 | 48.11 | 4.9 | 4.51 | 0.55 | 3.50 | 3.60 | 40.47 |
| 4 | SeIn-29 | 241.30 | 8.13 | 7.40 | 5.53 | 53.27 | 1.81 | 44.78 | 34.78 | 4.16 | 3.98 | 0.51 | 3.00 | 2.73 | 21.62 |
| 5 | SeIn-33 | 164.08 | 7.93 | 6.13 | 6.20 | 47.7 | 2.05 | 50.69 | 35.41 | 4.48 | 3.93 | 0.55 | 2.86 | 3.13 | 14.78 |
| 6 | SeIn-24 | 41.53 | 7.13 | 6.40 | 5.40 | 55.5 | 1.18 | 29.33 | 53.58 | 5.48 | 4.13 | 0.56 | 3.06 | 2.93 | 43.88 |
| | Mean | 158.07 | 7.19 | 6.17 | 5.83 | 64.66 | 2.08 | 51.56 | 54.11 | 4.79 | 4.43 | 0.57 | 3.41 | 3.20 | 28.12 |
| | CD | 23.58 | NS | NS | NS | 12.56 | 0.75 | 18.70 | 6.18 | 0.43 | 0.4 | NS | 0.29 | NS | 4.98 |
| | CV | 8.20 | 15.85 | 16.75 | 18.53 | 21.58 | 40.25 | 40.26 | 6.28 | 5.02 | 5.06 | 13.69 | 4.71 | 12.03 | 9.74 |

(FL-Fruit length, FD- Fruit Diameter, PT- Pericarp Thickness, FC- Fruit Cavity, IFW- Individual Fruit Weight, TSS- Total Soluble Solids)

## 42. CARI Brinjal 2 (IC640704; INGR21153), a brinjal (*Solanum melongena* L.) germplasm with resistance to bacterial wilt disease caused by *Ralstonia solanacearum*

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Brinjal or eggplant (*Solanum melongena* L.) is severely affected by bacterial wilt caused by Ralstonia solanecearum in India. Resistant varieties are most effective and suitable option to reduce crop losses from bacterial wilt but knowledge of resistance mechanism and development of resistant varieties is difficult and time taking job. Further, most of the brinjal germplasm in India showed susceptible reaction under rainfed low land conditions of Andaman and Nicobar Islands. Thus, the present study was carried out at ICAR-CIARI, Port Blair during 2010-2018 to understand the genetic behaviour of bacterial wilt resistance in brinjal and developed a bacterial wilt resistant variety by pedigree selection method where crosses made between "Pusa Purple Long" (5) x "CARI Brinjal 1" (R) in Island conditions. Single F, plant progenies were advanced up to F4 and recorded the reaction of segregating population in the sick plots_ In this process, one bacterial wilt resistant brinjal line CARI Brinjal 2 has been identified as medium tall, semi-spreading plant type with profuse branching habit and smooth stems. Leaves are smooth medium leaves which are green in colour. Fruits are oblong in shape, purple in colour, medium compact, pendent position and medium seeded. Seeds of this line are medium in shape and size and light yellow in colour. It gives fruit yield up to 16 t/ha under rainfed conditions of Andaman and Nicobar Islands during Rabi season.

In most cultivated peppers (*Capsicum* spp.) the fruit adheres

## 43. NPC-3 (IC631915; INGR21154), a chilli (*Capsicum annuum* L.) germplasm with non-persistent calyx, erect bearing habit and high yield

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tightly to the calyx when ripe and the pedicel remains attached to the fruit when harvested. An economical problem with most cultivated pepper fruit used for processing is the tight adherence of the fruit to the receptacle which results in attached woody pedicels and green calyxes on the fruits and it impart off-colour, lower the quality and high cost during processing. Dry chilli industries are also suffering with labor shortage for the removal of stalk or pedicel before processing. Consequently, processors bid 5 to 10% less to the farmers chilli produce which is pedicel attached chilli by considering the quality. This identified chilli germplasm/ line, NPC-3 (IC631915) is erect bearing and will overcome the problem of removal of stems/stalks from the fruits and increases quality of the product. At the time of harvesting, this line expresses the easy separable character of stems/ stalks from the fruits, the fruits will be separated easily from the plants without stalk. Identified germplasm is stalk less line which facilitate to easy separation of fruits from stalk. So that, cost of post harvest handling and processing can be reduced.

NPC-3 (1.44 t/ha) was shown stability for the trait and yielded highest across the years in the same location and over the check (1.29 t/ha). The genotype NPC-3 was shown moderately resistannce for the chilli leaf curl, good capsaicin content of 19217 SHU and having good red color count of 138.5 ASTA.

## 44. NPC-5 (IC631916; INGR21155), a chilli (*Capsicum annuum* L.) germplasm with non-persistent calyx, pendent bearing habit, high yield and resistance to chilli leaf curl complex

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In most cultivated peppers (*Capsicum* spp.) the fruit adheres tightly to the calyx when ripe and the pedicel remains attached to the fruit when harvested. An economical problem with most cultivated chilli fruit used for processing is the tight adherence of the fruit to the receptacle which results in attached woody pedicels and green calyxes on the fruits and it impart off-colour, lower the quality and high cost during processing. Dry chilli industries are also suffering with labor shortage for the removal of stalk or pedicel before processing. This identified chilli germplasm/ line, NPC-5 (IC631916) is pendent bearing and overcome the problem of removal of stems/stalks from the fruits and increases quality of the product. This line is having the easy separable character of stems/stalks from the fruits. While harvesting, the fruits will be separated easily from the plants without stalk. Identified germplasm is stalk less line which facilitate to easy separation of fruits from stalk.

So that, cost of post harvest handling and processing can be reduced. NPC-5 (1.48 t/ha) was shown stability for the trait and yielded highest across the four years in the same location and over the Sapan F1 hybrid Dandicut (1.29 t/ha). The NPC-5 was recorded resistance for the chilli leaf curl and high yield.

Traits of economic importance in (IC631916; INGR21155)

| *Characters* | *Expression* |
|---|---|
| Growth habit | Upright |
| Bearing habit | Solitary |
| Fruit length (cm) | Medium (6.5 to 7.5) |
| Fruit width (cm) | Medium (1.10 to 1.4) |
| Flower position/orientation | Pendent/drooping |
| Colour at ripen maturity | Red |
| Capsaicin content (SHU) | 14494 (0.0.09 %) |
| Ripened fruit Color (ASTA) | 77.5 |
| Oleoresin recovery (%) | 15.0 to 16.50 |
| Pedicel with fruit | Non persistent |
| Pedicel with stem | Persistent |
| Yield per plant (g) | 46 to 55 |
| Yield potentiality (t/ha) | 1.30 to 2.30 |
| Reaction to chilli leaf curl disease | Moderately resistance |
| Suitability | Dry chilli industry |

## 45. TCGS-1862 (IC640705; INGR21156), a groundnut (*Arachis hypogaea* L.) germplasm with stay green character and resistance to stem rot, late leaf spot and rust

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### Introduction

The low productivity in groundnut is attributed to several production constraints. Increased groundnut production can be achieved by using high yielding varieties and adopting improved crop management practices. Seed and seedling diseases cause severe seedling mortality resulting in "patchy" crop stand and ultimately reduced yields. Among seed and seedling diseases, collar rot and stem rot diseases are considered economically important diseases of groundnut in India and world as well. 80% of groundnut area is under rainfed situation in Andhra Pradesh. It is cultivated in light sandy soils where the incidence of soil borne diseases (Collar rot and stem rot) is more. It is difficult to control the soil borne diseases through foliar spray. The yield losses of over 25% have been reported by Mayee and Datar (1988) in Maharashtra. Collar rot disease causes considerable seedling mortality in early stages of crop growth. Crop yield is directly affected by reduction in the stand of the crop. These soil borne diseases reduce pod yield and haulms yield. Late

**Table 1:** Mean performance of the groundnut germplasm accession TCGS- 1862 (INGR 21156)

| *S.No* | *Character* | *2016* | *2016-17* | *2017* | *Mean* |
|---|---|---|---|---|---|
| 1. | Plant height (cm) | 26.6 | 17.6 | 32.2 | 25.5 |
| 2. | Days to 50% flowering | 32 | 30 | 29 | 30.3 |
| 3. | Days to maturity | 120 | 117 | 99 | 112.0 |
| 4 | Final plant stand ('000'/ha) | 291 | 197 | 202 | 230.0 |
| 5 | No. of primary branches/ plant | 8.8 | 4.4 | 5.2 | 6.1 |
| 6 | No. of secondary branches/ plant | 3.2 | 2.8 | 4.0 | 3.3 |
| 7 | 100 pod weight (g) | 54 | 82 | 77 | 71.0 |
| 8 | 100 kernel weight (g) | 22 | 37 | 30 | 29.7 |
| 9 | Sound mature kernel per cent | 82 | 84 | 86 | 84.0 |
| 10 | Shelling per cent | 59 | 64 | 64 | 62.0 |
| 11 | Haulm yield (kg/ha) | 4550 | 2719 | 2746 | 3338 |
| 12 | Pod yield (kg/ha) | 1888 | 3181 | 2559 | 2543 |
| 13 | Kernel yield (kg/ha) | 1114 | 2036 | 1639 | 1596 |

**Table 2:** Reaction of groundnut germplasm accession TCGS-1862 against soil born and foliar diseases of groundnut

| *S. No.* | *Genotypes* | *Dry root rot (%)* | *Stem Rot (%)* | *ELS (1-9 scale)* | *LLS (1-9 scale)* | *Rust (1-9 scale)* |
|---|---|---|---|---|---|---|
| 1 | TCGS-1862 | 0.0 | 0.0 | 2 | 1 | 1 |
| | Checks | | | | | |
| 1 | National-JL24 | 21.3 | 16.8 | 9 | 7 | 7 |
| 2 | Local-Narayani | 17.6 | 14.2 | 8 | 7 | 6 |

**Table 3:** Reaction of groundnut germplasm accession TCGS-1862 against viral PSND/PBND diseases of groundnut

| *S. No.* | | *Plant stand* | *PSND Plants (No.)* | *PSND (%)* | *PBND Plants (No.)* | *PBND (%)* |
|---|---|---|---|---|---|---|
| 1 | TCGS-1862 | 121 | 6 | 9.9 | 4 | 6.3 |
| 1 | National-JL24 | 68 | 28 | 36.7 | 15 | 22.0 |
| 2 | Local-Narayani | 59 | 19 | 32.2 | 14 | 23.7 |

leaf spot disease reduce the yield and also have an adverse affect on seed quality and grade characteristics, deteriorate the quality of plant biomass and thus render the fodder unsuitable as animal feed.

Hence, it is necessary to breed for high yielding genotypes with resistance/tolerance to collar rot and stem rot , late leaf spot diseases and tolerant to drought and sucking insects to increase and stabilize groundnut production.

Groundnut genotype TCGS 1862 was developed from KDG-128 x NRCG-CS-425 following the modified pedigree method of breeding and was found promising for the required attributes *viz.*, resistance to stem rot, collar rot, late leaf spot diseases , tolerant to drought, and sucking insects and defoliators. TCGS 1862 has recorded high pod and kernel yields.

### *Morpho-Agronomic Characteristics*

The plants are medium stature (25-30 cm), leaflets are Small with dark green in colour. The stem is angular, Growth habit is erect to decumbent-3, sequential flowering and the branching pattern is sequential. The leaves remain green up to harvest (stay green character). It is resistance to stem rot, collar rot, late leaf spot diseases, tolerant to drought and sucking insects. Moderate pod constriction and moderate reticulation. Seeds have rose testa colour. It has recoded shelling out-turn of 62%

## Reference

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## 46. ICS-200 (IC0638880; INGR21157), a castor (*Ricinus communis* L.) germplasm with resistance to leafhopper (*Empoasca flavescens*) and thrips (*Scirtothrips dorsalis*)

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## Introduction

Castor (*Ricinus communis* L.), 2n=20, is an important commercial, industrial and non-edible oilseed crop suitable for both rainfed and irrigated cultivation in tropical and sub-tropical climatic conditions. India contributes for 85% of the castor production with highest productivity in the world. During 2019-20, castor was cultivated in an area of 9.70 lakh hectares with a production of 19.50 lakh tonnes and productivity of 2010 kg/ha. Gujarat and Rajasthan account for 92% of the total castor area under irrigated conditions while 8% of the total castor area is under rainfed conditions (Solvent Extractors of India, India). The present genetic stock, ICS-200 was developed through conventional breeding technique *viz*., intra varietal hybridization (VP-1 x 48-1) followed by pedigree method of selection and generation advancement at ICAR-IIOR, Hyderabad.

### *Morpho-agronomic characteristics*

Leafhopper, *Empoasca flavescens* (Cicadellidae: Homoptera) is the most important sucking insect pests in all the castor growing areas in India and causing severe hopper burn damage during both *kharif* and *rabi* seasons. Thrips, *Scirtothrips dorsalis* (Thripidae: Thysanoptera) feed on terminal leaves, floral parts and immature capsules results in leaf curling and drying of flowers and immature capsules. The proposed genotype, ICS-200 was screened at three hot spot locations *viz*., ICAR-IIOR-Hyderabad (Telangana), Palem (Telangana) and SK Nagar (Gujarat) consecutively for two years (2018-19 and 2019-20) using infester row method (in sandwich technique to increase leafhopper and thrips infestation) which was the standard screening method used in AICRP on Castor. Two years of screening under high leafhopper population confirmed the resistance of ICS-200 against leafhopper (hopper burn grade of 0 to 1 on 0–4 scale) at all the three locations in both the years of screening (Table 1) compared to susceptible check DPC-9 (hopper burn grade 3 to 4). Based on two years data, the monoecious line *viz*., ICS-200 was also found promising against thrips with low infestation of thrips on spikes (3.1 to 20.5 thrips/spike) at all the three locations as compared to susceptible check, DCS-9 (17.5 to 42.9 thrips/spike) (Table 2)

It is green, triple bloom and has non-spiny and non-dehiscent capsules. Other distinct features include short plant height (40-45 cm up to primary spike), loose spike, low number of nodes to the primary spike (mean 9.1), basal branching, early flowering of primary spike (40 days after sowing) and early maturity of primary spike (85-90 DAS). It has primary spike of length 38 to 41 cm, 100 seed weight of 24-26 grams with an oil content of 47-48%.

**Table 1:** Reaction of ICS-200 against leafhopper in multi-locations in different years

| *Genotype* | *Year of screening* | *Hyderabad* | *Palem* | *SK Nagar* |
|---|---|---|---|---|
| | | *HPB (0-4 scale)* | *HPB (0-4 scale)* | *HPB (0-4 scale)* |
| ICS-200 | 2018-19 | 1 | 1 | 1 |
| DPC-9 (SC) | | 4 | 3 | 4 |
| DCH-519 (RC) | | 1 | 1 | 2 |
| ICS-200 | 2019-20 | 1 | 0 | 1 |
| DPC-9 (SC) | | 4 | 3 | 4 |
| DCH-519 (RC) | | 1 | 0 | 1 |

HPB – Hopper burn [ 0 – No injury (Highly Resistant); 1 – upto 10% (Resistant); 2 - 11 to 25% (Moderately Resistant); 3 -26 to 50% (Susceptible); 4 – above 50% (Highly Susceptible)], SC- Susceptible check; RC – Resistant check

**Table 2:** Reaction of ICS-200 against thrips in multi-locations in different years

| | *Year of Screening* | *Thrips/spike* | | |
|---|---|---|---|---|
| | | *Hyderabad* | *Palem* | *SK Nagar* |
| ICS-200 | 2018-19 | 10.6 | 3.1 | 7.6 |
| DCS-9 (SC) | | 42.9 | 17.5 | 20.8 |
| M-574 (RC) | | 6.2 | 5.9 | 16.6 |
| | CD (P=0.05) | 11.1 | 2.1 | 1.5 |
| ICS-200 | 2019-20 | 13.0 | 9.3 | 20.5 |
| DCS-9 (SC) | | 39.8 | 29.3 | 32.2 |
| M-574 (RC) | | 20.7 | 11.6 | 28.8 |
| | CD (P=0.05) | 10.3 | 5.0 | 2.2 |

SC- Susceptible check; RC – Resistant check

### *Associated characters and utility*

It also has low node number making it early flowering and maturity and hence ICS-200 will be useful as a male parent to develop high yielding early castor hybrids and varieties with resistance to leafhopper and thrips.

## 47. DRMRHT-13-22-10 (IC640708; INGR21158), an Indian mustard (*Brassica juncea* L.) germplasm with heat tolerance at juvenile stage under field conditions

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*Brassica juncea* is the predominant oilseed brassica in the Indian subcontinent. The growing of Indian mustard in Rajasthan is mostly carried out under conserve soil moisture conditions where sowing commences after south west monsoon rains. Early rains may lead the farmers to sow the crop early in the season to take advantage of conserved moisture in the soil. However, at the time of early sowing (second fortnight of September to first fortnight of October), the mean surface soil temperature may reach as high as 45°C. High soil temperature often results in seedling mortality upon initial germination which may eventually require re-sowing. Heat stress at the seedling stage can increase mortality and has become an increasing threat for Indian mustard cultivation. Hence, this study was planned to evolve, evaluate and identify some of the promising heat stress tolerant lines from a pool of advanced breeding lines, to be used as probable donors for transferring heat tolerance.

DRMRHT-13-22-10a genotype of Indian mustard derived from crosses between JN032 X BPR549-9 and further selection were made through pedigree-selection method. Strain DRMRHT-13-22-10 was evaluated alongwith 7 advanced breeding lines and 2 checks *i.e.* NPJ- 112 and BPR 543-2 to assess the heat tolerance between advanced genotypes under heat stress conditions during rabi2017-18at the ICAR-DRMR, Bharatpur. The genotype DRMRHT-13-22- 10 recorded maximum relative water content (81.22%) as compared to best check NPJ112 (76.08%) for heat tolerance. DRMRHT-13-22-10genotype was evaluated alongwith 7 advanced breeding lines and 2 checks to assess the heat tolerance between advanced genotypes under heat stress conditions during 2018-19.The genotype DRMRHT-13-22-10 recorded maximum membrane stability index (23.02%) as compared to best check NPJ112 (16.06%). The genotype DRMRHT-13-22-10 recorded maximum water retention capacity of leaves (67.87%) as compared to best check NPJ112 (59.08%) for enhanced heat stress tolerance.

The proposed strain (DRMRHT-13-22-10) is heat tolerant at juvenile stage under field conditions based on testing under AICRP-RM trials *(Annual report 2019-20 pp phy 01, 04 and 2020-21 pp phy 05, 06)*. The genetic stock was tested under field conditions at four locations for two years. Based on pooled data over two years and locations revealed seedling mortality was 20.6% and dry wt./10 seedlings was 6.3g. Hence it was rated as heat tolerant at juvenile stage under field conditions. The proposed strain was tested for physiological traits at Bharatpur during 2017-18 and 2018-19 and it found to possess high MSI, RWC in comparison to checks.

## 48. Jor Lab KH-2 (IC640709; INGR21159), a black Zedoary/black turmeric (*Curcuma caesia* Roxb.) germplasm with the fresh weight rhizome essential oil content > 0.8%

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Black turmeric (*Curcuma caesia* Roxb.) is an important medicinal plant belonging to zingiberaceae family. Although this plant is native to North East India, this is also found in Bangladesh as a wild species (Borah *et al*; 2019). The rhizomes of black turmeric have a high economical importance owing to its putative medicinal properties (Mahanta *et al*; 2019). Rhizome of this plant is claimed to be useful in treating several disease like piles, leprosy, bronchitis, asthma, cancer, epilepsy, fever wounds, impotency, fertility tooth ache and vomiting etc (Paw *et al*; 2020a). Presently *Curcuma caesia* is considered to be a threatened since natural habitat is destroying widely through several human activities such as over-exploitation of black turmeric for traditional medicine purposes, industrialization, urbanization, etc (Paw *et al*; 2020b; Paw *et al.*, 2021).

Therefore, the need of the hour is to develop high essential oil yielding germplasm *Curcuma caesia* suited to India and to maintain the sustainable cultivation and germplasm of these high value medicinal plant species. In this investigation a total of 135 germplasm were collected from different region of India during 2016 and planted in RBD design at experimental farm of CSIR- NEIST, Jorhat, Assam. After two year of the evaluation trial one high rhizome essential oil rich germplasm was identified and named as "Jor Lab KH-2". This identified germplasm were again planted in multilocation trial at five different locations namely Jorhat, Lakhimijan, Imphal, Pasighat and Shillong of NE India during 2019. The identified germplasm was superior over the check variety. The identified germplasm have an average of 124 cm plant height, 49 cm leaf length, 26% dry rhizome recovery, 0.80 % essential oil in fresh rhizome weight basis and 26.18 tones rhizome yield tones/ha. The essential oil of this species has very high commercial values and contain antimicrobial, anti-inflammatory activities and very less genotoxicity (Paw *et al* 2021).

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## 49. Jor Lab CZ-6 (IC640710; INGR21160), a Narkachur (*Curcuma zeodaria*) germplasm with fresh weight rhizome essential oil content > 0.6%

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*Curcuma zedoaria* has long been used as a folk medicine in India. Its smell is similar to that of turmeric and mango. The perennial herb has a warm-spicy, woody and camphoraceous cineolic odor and bears yellow shiny flowers, with red and green bracts. The plant is native to North East India and Indonesia. However, it is widely used as a spice in the Western counties. It is also found in sub-tropical regions of eastern Nepal. It is mainly found in eastern Himalayan. Major chemicals compounds are (+)- germacrone-4, 1,8-cineole, 5-epoxide, germacrone, furanodienone, curzerenone, zederone, dehydrocurdione, curcumenol, isocurcumenol, curcumenone, curmanolide A and curmanolide B found in the rhizome essential oil. Traditionally, the dried rhizome of *Curcuma zedoaria* is selected to make drinks or to be extracted as medicine (Mau *et al.,* 2003). The uses of *Curcuma zedoaria* in traditional medicine have been well documented (Prajapati *et al*; 2003). Rhizomes are used as a carminative, digestive stimulant, and in treatment of colds and infections. They exhibit both antibacterial and antifungal activity (Anonymous, 1985; Mau *et al.,* 2003). The essential oils from *Curcuma zedoaria*, obtained by steam distillation of dried tubers form an active ingredients in antibacterial preparations. Starches extracted from this species are used in diets for infants and convalescents due to their cooling and demulcent properties (Prajapati *et al.*, 2003). It has been reported that the boiling water extracts of *Curcuma zedoaria* had a moderate antimutagenic activity against benzo[a] pyrene (Jeng *et al.,* 2003).

Therefore the need of the hour is to develop essential oil yielding germplasm of *Curcuma zedoria* suited to India and to maintain the sustainable cultivation and germplasm of these high value medicinal plant species. In this investigation a total of 86 germplasm were collected from different region of India during

2016 and planted in RBD design at CSIR-NEIST experimental farm, Jorhat, Assam. After two year of the evaluation trial one high essential oil rich germplasm was identified and named as "Jor Lab CZ-6". This identified germplasm was again planted in multilocation trial at five different locations namely Jorhat, Lakhamijan, Imphal, Pasighat and Shillong of NE India during 2019. The identified germplasm was superior over the check variety. The identified germplasm having average of 144 cm plant height, 28 cm leaf length, 23% dry rhizome recovery, 0.65% essential oil in fresh rhizome weight basis and had an average rhizome yield of 31.01 t/ha. The characteristic of the selected germplasm was found to be stable for commercial cultivation.

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## 50. Jor Lab SK-154 (IC0633577; INGR21161), a nightshades (*Solanum khasianum* (C.B. Clarke) germplasm with white colour berries

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One of the ethnic medicinal plants, *Solanum khasianum* (C.B. Clarke) also known as *Solanum aculeatissimum* Jacq., (2n=24) belongs to the family *Solanaceae* and grows wild in Meghalaya hills, Assam, Manipur, Sikkim, West Bengal, Orissa, Arunachal Pradesh and Nilgiri hills of India ascending to an altitude of 1600 m. In India, 33 species of *Solanum* are available (Maiti *et al.,* 1965). The present cultivation area of the species is more than 4000 ha in Maharashtra, Karnataka, Assam, Tripura, Meghalaya and Manipur state of India (Gogoi *et al.,* 2021). The presence of solasodine in the mature berries has a tremendous commercial possibility and completely yellowish berries show the presence of alkaloids in maximum quantity (Mann, 1978). Solasodine is employed as a hormone precursor within the steroid drug business for the manufacturing corticosteroids, anabolic steroids, antifertility drugs etc., in addition to its various medicinal properties (Kumar *et al.*, 2019). It is a stout, branched, woody shrub attaining a height of 0.75 to 1.5 m. Stems are spiny, leaves are ovate to lobed bearing spines on both surfaces, the flowers are hermaphrodite. In general, the berries are yellowish when ripe, seeds are small brown in color and abundant (Gogoi *et al.,* 2021). A total of 273 accessions of *Solanum khasianum* were collected out of which 186 accessions rich in solasodine content (>0.8 %) were selected and planted in RBD design during the year 2017 which were again planted during 2018. After two year of evaluation, a germplasm bearing white berries was identified which was confirmed by planting it as multi-location trial, along with the standard check variety during the year 2019 at four different locations (Jorhat, Bokakhat, Pasighat and Madang) of Northeast India. The identified germplasm of *Solanum khasianum* which bears berries which are white in colour on maturity was found to possess an average solasodine content of 0.99% and average fresh berries yield of 4.2 t/ha. The identified trait was found to be stable for commercial cultivation and could be used in breeding program.

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## 51. Jor Lab SK-3 (IC0633426; INGR21162), a nightshade (*Solanum khasianum* (C.B. Clarke)) germplasm with high fruit solasodine content

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One of the ethnic medicinal plants, *Solanum khasianum* (C.B. Clarke) also known as *Solanum aculeatissimum* Jacq., (2n=24) belongs to the family *Solanaceae* and grows wild in Meghalaya hills, Assam, Manipur, Sikkim, West Bengal, Orissa, Arunachal Pradesh and Nilgiri hills of India ascending to an altitude of 1600 m. 33 species of *Solanum* are available In India (Maiti *et al.*, 1965). The present cultivation area of the species is more than 4000 ha in Maharashtra, Karnataka, Assam, Tripura, Meghalaya and Manipur state of India (Gogoi *et al*; 2021). The presence of phytochemical compounds in the plant indicates their medicinal potential which can be determined by phytochemical analysis (Devi *et al.*, 2014). Such knowledge of plants chemical constituents is desirable due to the presence of great economically and medicinally important substances which can be used as drugs (Chetri *et al*; 2008). The presence of solasodine in the mature berries has a tremendous commercial possibility and completely yellowish berries show the presence of alkaloids in maximum quantity (Mann, 1978). Solasodine is employed as a hormone precursor within the steroid drug business for the manufacturing corticosteroids, anabolic steroids, antifertility drugs etc. Isolated solasodine from solanum plants exploits its medicinal properties such as anticonvulsant, CNS depressant, antioxidant, cytotoxic, antinociceptive, anti-inflammatory, hepatoprotective, immunomodulatory, antiatherosclerotic, antimicrobial, and antiobesity activity, etc (Kumar *et al.*, 2019). Owing to its multiple application of solasodine, the identification of high solasodine content germplasm would be highly beneficial for pharmaceutical and commercial purposes. A total of 273 accessions of *Solanum khasianum* were collected out of which 186 accessions rich in solasodine content (>0.8 %) were selected and planted in RBD design during the year 2017 which were again planted during 2018. After two year of evaluation, a high solasodine-rich line Jor Lab SK-3 was identified which was confirmed by planting in multi-location trial, along with the standard check variety during the year 2019 at four different locations (Jorhat, Bokakhat, Pasighat and Madang) of Northeast India. Jor Lab SK-3 had an average solasodine content of 1.30%. Jor Lab SK-3 was found to be superior in solasodine content trait and was found to be stable for commercial cultivation and could be used in the breeding program.

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## 52. JOR LAB SK-124 (IC0633547; INGR21163), a nightshade (*Solanum khasianum* C.B. Clarke) germplasm with thornless leaves and stem.

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*Solanum khasianum* C.B. Clarke, also known as *Solanum aculeatissimum* Jacq., belongs to the family *Solanaceae* and grows wild in Meghalaya hills, Assam, Manipur, Sikkim, West Bengal, Orissa, Arunachal Pradesh and Nilgiri hills of India ascending to an altitude of 1600 m. In India, 33 species of *Solanum* are available (Maiti *et al.,* 1965). The present cultivation area of the species is more than 4000 ha in Maharashtra, Karnataka, Assam, Tripura, Meghalaya and Manipur state of India (Gogoi *et al.,* 2021). The presence of solasodine in the mature berries has a tremendous commercial possibility and completely yellowish berries show the presence of alkaloids in maximum quantity (Mann, 1978). Solasodine is employed as a hormone precursor within the steroid drug business for the manufacturing corticosteroids, anabolic steroids, antifertility drugs etc. Isolated solasodine from solanum plants exploits its medicinal properties such as anticonvulsant, CNS depressant, antioxidant, cytotoxic, antinociceptive, anti-inflammatory, hepatoprotective, immunomodulatory, antiatherosclerotic, antimicrobial, and antiobesity activity, *etc* (*Kumar et al.,* 2019). The plant is a stout, branched, woody shrub attaining a height of 0.75 to 1.5 m. Stems are spiny, leaves are ovate to lobed bearing spines on both surfaces, the flowers are hermaphrodite, the berries are yellowish when ripe, seeds are small brown in color and abundant. Being a cheaper source for solasodine the berries are in high demand. However, the presence of spiny thorns on the leaves makes the harvesting a tedious process as mechanical harvesting is not possible in the plant. In this investigation, a total of 273 accessions of *Solanum khasianum* were collected out of which 186 accessions rich in solasodine content (>0.8 %) were selected and planted in RBD design during the year 2017 which were again planted during 2018. After two years of evaluation, JOR LAB SK-124 a thorn-less germplasm of *Solanum khasianum* was identified, which was further confirmed by planting it as multi-location trial, along with the standard check variety during the year 2019 at four different locations (Jorhat, Bokakhat, Pasighat and Madang) of Northeast India. JOR LAB SK-124 in which thorns are absent on the leaves would be highly efficient for harvesting of the berries. The germplasm was found to have average fresh berries yield of 5.5 t/ha with an average solasodine content of 1.10%. Furthermore, the identified trait was found to be stable in multilocation testing and the germplasm could be a source of unique traits.

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## 53. JOR LAB SK-9 (IC0633432; INGR21164), a nightshade (*Solanum khasianum* C.B. Clarke.) germplasm with red colour berries at ripening stage

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*Solanum khasianum* C.B. Clarke, belonging to the family *Solanaceae* grows wild in Meghalaya hills, Assam, Manipur, Sikkim, West Bengal, Orissa, Arunachal Pradesh and Nilgiri hills of India ascending to an altitude of 1600 m. In India, 33 species of *Solanum* are available (Maiti *et al*., 1965). The present cultivation area of the species is more than 4000 ha in Maharashtra, Karnataka, Assam, Tripura, Meghalaya and Manipur state of India (Gogoi *et al*., 2021). The plant is a rich source for solasodine. The presence of solasodine in the mature berries has a tremendous commercial possibility and completely yellowish berries show the presence of alkaloids in maximum quantity (Mann, 1978). Solasodine is employed as a hormone precursor within the steroid drug business for the manufacturing corticosteroids, anabolic steroids, antifertility drugs etc. Isolated solasodine from solanum plants exploits its medicinal properties such as anticonvulsant, CNS depressant, antioxidant, cytotoxic, antinociceptive, anti- inflammatory, hepatoprotective, immunomodulatory, antiatherosclerotic, antimicrobial, and antiobesity activity, etc (Kumar *et al*., 2019). It is a stout, branched, woody shrub attaining a height of 0.75 to 1.5 m. Stems are spiny, leaves are ovate to lobed bearing spines on both surfaces, the flowers are hermaphrodite. In general, the berries are yellowish when ripe; seeds are small brown in color and abundant (Gogoi *et al*., 2021). A total of 273 accessions of *Solanum khasianum* were collected out of which 186 accessions rich in solasodine content (>0.8%) were selected and planted in RBD design during the year 2017 which were again planted during 2018. After two years of evaluation, a germplasm JOR LAB SK-9 was identified bearing red berries which was confirmed by planting it as multi-location trial, along with the standard check variety during the year 2019 at four different locations (Jorhat, Bokakhat, Pasighat and Madang) of Northeast India. JOR LAB SK-9 bears berries which are red in colour and turns deep red on maturity was found to be stable with an average solasodine content of 1.01% and average fresh berries yield of 3.5 t/ha. The plant with the trait of berries red in colour was found stable for commercial cultivation and could be used in the breeding program.

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## 54. JOR LAB ZB-103 (IC640711; INGR21165), a ginger [*Zingiber zerumbet* (L.) Roscoe ex Sm.] germplasm with high fresh weight of rhizome and high content of essential oil

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### Abstract

*Zingiber zerumbet* (L.) Roscoe ex Sm. belonging to the Zingiberaceae family is an aromatic herbal species. This species is commonly known as Asian ginger, bitter ginger, shampoo ginger. It is a perennial tuberous herb plant commonly found in damp areas and areas with partial shade (Yob *et al*; 2011). It is cultivated widely in South East Asia countries, tropical and subtropical regions around the world (Rashid *et al*., 2005; Baby *et al*., 2009).

*Zingiber zerumbet* of the Zingiberaceae family is known as wild edible ginger having immense medicinal properties (Al-Zubari *et al* 2010 ; Eid *et al* 2011). The present study was aimed to identification of high essential oil yielding genotypes tested through stability parameters at multilocation trials. During the year 2017 a total of 47 genotypes of *Z. zerumbet* was collected and planted at CSIR-NEIST experimental farm. A selection trial was conducted for two years *viz.*, 2017 and 2018 for all the collected germplasm which led to identification of JOR LAB ZB-103 with high fresh rhizome and essential oil yielding traits. JOR LAB ZB-103 was subjected to stability analysis along with two check varieties at five multilocation trials at five different locations

namely Jorhat, Lakhamijan, Imphal, Pasighat and Shillong of NE India in March, 2019. JOR LAB ZB-103 and an average fresh rhizome yield of 24.86 t/ha and an average of 0.75% essential oil yield on fresh weight basis. The assessment of stable performance was evaluated using Eberhart and Russell model. Variable environments were found to be present in the study as revealed by the significant variance due to environment and environment (linear). The genotype × environment interaction of the selected genotype also showed significant variance for all the traits revealing the well interaction of the genotype with all the environmental conditions. On comparative assessment, the identified genotype was found to be highly stable with high adaptability to varying environments for all the traits under studied. While both the check varieties revealed low adaptability to varying environments for the higher-yielding traits. The GC/MS analysis of the essential oil of Jor Lab ZB-103 revealed zerumbone (32.79%) as the major compound followed by camphene (19.41%) and eucalyptol (6.8%). The other compounds were present as minor and trace compounds. Thus, the high yielding genotype Jor Lab ZB-103 was found to be highly stable genotype which could be made available in the public domain for wide-scale cultivation.

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**Table 1:** Estimation of stability ameters for six traits of selected genotype and check varieties at multilocation trials

| Genotype | *Plant height (cm)* | *No. of tillers/ plant* | *Leaf length (cm)* | *Dry rhizome recovery %* | *Fresh rhizome yield (t/ha)* | *Essential Oil %* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\beta i$ | $\sigma^2 di$ | $\beta i$ | $\sigma^2 di$ | $\beta i$ | $\sigma^2 di$ | $\beta i$ | $\sigma^2 di$ | $\beta i$ | $\sigma^2 di$ | $\beta i$ | $\sigma^2 di$ |
| Jor Lab | 1.013 | 0.227 | 0.105 | 0.248 | 0.794 | 0.634 | 0.265 | 0.675 | 0.695 | 0.078 | - | - |
| ZB-103 | 3 | 7 | 9 | 5 | 7 | 7 | 9 | 4 | 9 | 8 | 0.96 | 0.000 |
| | | | | | | | | | | | 0 | 1 |
| Changla | 1.219 | 0.372 | 1.055 | 0.985 | - | 0.807 | 0.481 | 1.425 | 0.949 | 0.528 | 1.83 | 0.000 |
| ng local | 7 | 1 | | 9 | 0.252 | 4 | 5 | 4 | 2 | 0 | 0 | 0 |
| | | | | | 5 | | | | | | | |
| RRLJZB | 0.767 | 0.024 | 1.447 | 0.506 | 0.457 | 0.205 | 2.037 | 0.721 | 1.354 | 0.633 | 2.13 | 0.000 |
| -151 | 0 | 5 | 1 | 5 | 8 | 9 | 0 | 7 | 9 | 0 | 0 | 1 |

$\beta i$ = regression coefficient, $\sigma^2 di$ = deviation from regression

## 55. IIHRJ3-2 (IC0624508; INGR21166), a china aster [*Callistephus chinensis* (L.) Nees.] germplasm with Red Purple flower colour group, long flower stalk and long vase life


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## Introduction

China aster is commercially important popular annual flowering plant belonging to the family Asteraceae. In India, it is grown traditionally for loose flower, cut flower, landscape, floral decoration, making garlands and *venis* (Rao *et al.*, 2012). The China aster germplasm IIHRJ3-2 is derived from the cross Arka Kamini x Local White following pedigree selection and it was developed at ICAR- Indian Institute of Horticultural Research, Bengaluru, Karnataka (13° 58′ N Latitude, 78°E Longitude and at an altitude of 890 meter above mean sea level), India. The germplasm IIHRJ3-2 has unique semi- double, very light pink flower colour (Red Purple group, 65D, Fan 2) with long flower stalk and vase life.

**Table 1:** Morpho-agronomic description of China aster germplasm IIHRJ3-2

| *Sl. No.* | *Traits Description* | *Average value* |
|---|---|---|
| 1. | Plant height (cm) | 67.89 |
| 2. | Plant spread (cm) | 26.00 |
| 3. | Days to flower | 73.33 |
| 4. | Number of branches per plant | 10.33 |
| 5. | Flower head diameter (cm) | 5.04 |
| 6. | Number of flowers per plant | 56.44 |
| 7. | Stalk length (cm) | 47.67 |
| 8. | Vase life (days) | 10.11 |
| 9. | Flower colour as per RHS Colour Chart | Red Purple group, 65D, Fan 2 |
| 10. | Flower form | Semi-double |
| 11. | Utility | Cut flower and flower arrangement |

### *Morpho-Agronomic Characteristics*

The China aster germplasm IIHRJ3-2 has erect plants with average plant height (67.89 cm), number of branches per plant (10.33) and number of flowers per plant (56.44). Its flowers has unique flower colour (Red Purple group, 65D, Fan 2).

### *Associated Characters and Cultivated Practices*

The flowers of China aster germplasm IIHRJ3-2 is having very light pink flower colour (Red Purple group, 65D, Fan 2), semi-double flower type with 5 to 6 whorls of ray florets. It has average plant spread (26.00 cm), days to flower (73.33 days), flower head diameter (5.04 cm), stalk length (47.67) and vase life (10.11 days). It is found suitable for cut flower and flower arrangement.

It grows best in open and well drained loamy soil with soil pH 6 to 7. A temperature of 20° to 30°C during day and 15° to 17°C during night with relative humidity of 50-60% is most suitable for its growth and flowering. Thirty days seedlings are transplanted at a spacing of 30 cm x 30 cm. Plants are pinched 35 to 40 days after transplanting. The China aster is extensively grown in Karnataka, Tamil Nadu, West Bengal and Maharashtra. The germplasm IIHR3-2 is found suitable for cut flower and flower arrangement.

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## 56. CZC-94 (IC0640712; INGR21167), a Cumin (*Cuminum cyminum* L.) germplasm with early flowering and early plant maturity under normal condition of sowing

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Cumin (*Cuminum cyminum*) is the important commercial crop of western arid regions of India. The available diversity in cumin germplasm is low for agro-morphological traits and all cultivated varieties are of longer duration (125-135 days). Among the cultivars, Gujarat Cumin-4 (GC-4), is most popular in arid regions of India. In arid regions the cost of cultivation for raising a long duration crop is high considering the requirement of irrigation water and plant protection. Hence, early maturing cumin cultivar of 100 to 110 days duration has been a felt need for resources limited arid regions.

At ICAR-CAZRI, Jodhpur an early maturing natural variant was selected in *Rabi* 2017-18 from seed production plot of the GC-4; denominated as CAZRI Cumin-94 (CZC-94). Genotype CZC-94 commence flowering in around 40 days and matured in less than 100 days; whereas its parent population (GC-4) flowers in 65-70 days and

**Table 1:** Phenotypic expression of GC-4 and four morphotypes selected during rabi 2017

| *S. No* | *Marker traits* | *GC-4* | *MT-1* | *MT-2* | *MT-3* | *MT-4* |
|---|---|---|---|---|---|---|
| 1 | FID | 61-65 | 42 | 65 | 63 | 62 |
| 2 | FC | Pink (P) | Pink (P) | White (W) | White (W) | Pink (P) |
| 3 | PT | Bushy with high biomass (BHB) | Open canopy with low biomass (OLB) | Bushy withhigh biomass (BHB) | Erect (E) | Erect with high biomass (EHB) |
| 4 | Plant height | 35-40 cm | 25 cm | 32 cm | 40 cm | 45 cm |

*FID: Flowering initiation in days; FC: Flower colour; PT: plant type*

**Table 2:** Phenotypic expression of the morpho-types during year 2017, 2018 and 2019

| *Marker Traits /Year* | *MT-1* | *MT-2* | *MT-3* | *MT-4* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2017 | 2018 | 2019 | 2017 | 2018 | 2019 | 2017 | 2018 | 2019 | 2017 | 2018 | 2019 |
| FID | 42 | 40-43 | 42-44 | 65 | 64-68 | 62-66 | 63 | 61-65 | 62-65 | 58 | 55-60 | 59-62 |
| FC | P | P | P | W | W | W | W | W | W | P | P | P |
| PT | OLB | OLB | OLB | BHB | BHB | BHB | E | E | E | EHB | EHB | EHB |

*FID: Flowering initiation in days; FC: Flower colour; PT: plant type*

**Table 3:** Phenotypic expression for marker traits observed over number of plants over years

| |
|---|
| 20192017Morpho- typesS.No |
| NPNENPEPSSSNPNENPEPSSSNP |
| 0325325200075755001MT 11 |
| 0340340200080805001MT 22 |
| 0328328200078785001MT 33 |
| 0335335200085855001MT 44 |

NP: Number of plants; SS: No of seeds sown; PS: Plant stand at observation; NPE: No of plants expressing the marker trait; NPNE: No of plants not expressing the marker trait

matures in 130-135 days. Subsequently in 2018-19, CZC-94 was evaluated in 'plant to row progeny' for heritability of earliness and interestingly all plants showed the same expression for flowering and maturity. The bulk harvest of CZC-94 was further evaluated in *Rabi* 2019-20 with popular released varieties *viz.,* GC-4, RZ-19, RZ-209 and RZ-223 under variable date of sowings. Again, same performance for flowering i.e. 40-42 days was observed in all dates of sowings demonstrated high heritability of earliness. This much needed early maturity cumin genotype has high prospects to be developed as cultivar for the resource limited cumin growing regions of the country.

## 57. IC0635379 (IC0635379; INGR21168), a Jamun [*Syzygium cuminii* (L.) Skeels] germplasm with seedless character

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Jamun (*Syzygium cuminii* (L.) Skeels ) is an evergreen tree of tropical and subtropical region. It is originated from Indian subcontinent. Jamun, widely known as Jambuphalam in Sanskrit, is extensively used in several holistic treatments of Ayurveda, Unani, Siddha and Chinese medicines. Jamun is found grown as a wild and semi-wild tree in entire tropical and subtropical parts of India. Jamun cultivation is gaining popularity in the last decade with release of new varieties and increased demand for various reasons. Vast genetic and species diversity exists in the jamun in India. Sizable diversity of jamun is observed in Maharashtra, Rajasthan, Gujarat, Uttar Pradesh, Haryana, West Bengal, and the Western Ghats region. (Daware *et al.,* 1985; Malik *et al.*, 2017). Selection is the crop improvement method widely adopted in jamun and several varieties are being released using this method (Keskar *et al,* 1989). Extensive surveys which were undertaken in different parts of the country lead to several collections of jamun. These collections were planted in the field at ICAR-Indian Institute of Horticulture Research, Bengaluru and *ex- situ* evaluation at ICAR-Indian Institute of Horticulture Research, Bengaluru.

A seedless jamun collection was identified from the collections made earlier from Western Ghats. The collection does not have any seed and not even rudimentary seed is present and the whole fruit is edible. The tree is spreading type. The leaf length is 10.53 cm while the leaf width is 6.30cm. The petiole length is 2.52 cm. It flowers during March -April, almost 15-20 days later than other jamun genotypes an d the fruit matures in the month of July. The fruits are available almost 15-20 days later as compared to Cv. Dhoopdal under Bengaluru conditions. The fruits are produced in clusters of up to 15 fruits. The tree yield more than 10000 fruits (10-15 kg) per tree. The fruits are oblong shape and weighing about 0.8 to 1.3 g. The fruit colour is dark purple and pulp is pinkish white (Table 1). The juice content is 62.2 percent and total soluble solids are 13.5$^{O}$Brix. capacity is 726.2 mg and 1391 mg AE/100 g, as measured in terms of DPPH radical scavenging activity and FRAP reducing power, respectively. The *anthocyanin* content (230mg/100g) is higher than the Dhoopdal variety (124mg/100g). The total phenols are 10.25 mg/g and total flavonoids are 227 mg (Table 1). There is no seed and only one pink spot is visible in the transverse section of the fruit.The selection can be used as fresh as well as processing. This can also be used in breeding programme for decreasing seed size and incorporation of selflessness.

**Table 1:** Comparison of Growth and fruit characters of seedless selection with Dhoopdal

| *Traits* | *Seedless selection* | *Dhoopdal* | *Traits* | *Seedless selection* | *Dhoopdal* |
|---|---|---|---|---|---|
| IC number | IC-0635379 | IC-0621955 | Fruit weight (g) | 1.1 | 10.52 |
| Tree growth | Spreading | Spreading | Fruit length (cm) | 1.37 | 3.16 |
| Leaf length (cm) | 10.53 | 11.32 | Fruit width (cm) | 0.63 | 2.01 |
| Leaf breadth (cm) | 6.30 | 6.82 | Fruit shape | Oblong | Oblong |
| Petiole length (cm) | 2.52 | 1.91 | Fruit colour | Dark Purple | Dark purple |
| Flowering time | March -April | Feb- March | Juiciness | High | Medium |
| Bearing patten | Clusters up 15, interior bearing | Clusters up 6-8, interior bearing | Fruit taste | Sweet | Sweet |
| Maturity period | July | June | Pulp colour | Pinkish White | Whitish purple |
| Yield (No. of fruits) | > 10000 | > 3000 | Pulp weight (g) | 1.1 | 7.04 |
| Yield (kg) | 8-10kg | 40-50 kg | Pulp-seed ratio | - | 4.76 |
| TSS (°Brix) | 13.5 | 17.33 | Anthocyanins( mg/100 g FW Pulp) | 230 | 124 |
| Acidity (%) | 0.17 | 0.21 | Total phenols mg/100 g FW Pulp | 1025 | 335 |
| Total Sugar (%) | 6.72 | 6.35 | DPPH mg AE / 100 g FW Pulp | 726.1 | 403 |
| Reducing sugar | 3.53 | 3.25 | FRAP Antioxidant activity mgAE/ 100 g FW Pulp | 1391 | 316 |

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# 58. MSH/14-7 (IC640713; INGR21169), an interspecific somatic hybrid-derived clone Potato (*Solanum tuberosum* L.) germplasm with wider genetic base, high yield combined with moderate resistance to late blight

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Interspecific potato hybrid MSH/14-7 is a back-cross progeny of advanced stage clonal selection at ninth generation ($BC_1$-$C_9$). MSH/14-7 was developed by crossing between Kufri Garima and bulk pollen of somatic hybrids clones P1 to P14. These interspecific somatic hybrids were developed by protoplast fusion between *Solanum tuberosum* dihaploid 'C-13' and diploid wild potato species *S. pinnatisectum*. MSH/14-7 possesses wider genetic base in cultivated (*S. tuberosum*) from wild species (*S. pinnatisectum*) with high tuber yield (avg.44.72 tonnes/hectare), attractive tubers, shallow eyes depth, 20% tuber dry matter content, very good keeping quality and moderate resistance to late blight disease under the natural (hot-spot) field conditions at Kufri, Shimla. This shows successful utilization of somatic hybrids in developing a promising advanced stage hybrid (MSH/14-7) for high yield combined with late blight resistance to be used as a parental line in potato breeding in future. Additionally, molecular profiling using SSR markers (STU: 174, 182, 190, 200 bp; and STIKA: 195, 198, 219, 221, 223, 242, 245, 248 bp) were revealed for genetic fidelity purpose. A few DUS descriptors of MSH/14-7 are: white-green sprout, compact plant foliage, tall plant height, green stem colour, intermediate leaf structure, large leaf length, broad leaf width, no anthocyanin coulouration on flower bud, white flower corolla, small flower size, yellow anther colour, irregular anther cone, irregular pistil, equal stylar length, light yellow tuber skin colour, smooth skin, ovoid shape, shallow eye depth and light yellow tuber flesh colour. This interspecific potato hybrid with diverse genetic background, high yield and moderate resistance to late blight disease under hot-spot conditions has potential to employ in potato breeding programmes to widen the genetic base of the cultivated gene pool.

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## 59. CPH62 (IC640714; INGR21170), a diploid potato (*Solanum Cardiophyllum* Lindl) germplasm highly resistant to late blight disease and somatic hybridization

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An elite genetic stock CPH62 was developed at ICAR-Central Potato Research Institute, Shimla by Clonal Selection method from several clones regenerated from true potato seed (TPS) of wild species (*Solanum cardiophyllum*, Accession no. PI283062). CPH62 is an important genetic material for fusion parent in somatic hybridization and parental line in diploid breeding programme for introgression of very high resistance to late blight trait with wider genetic base into cultivated potato and also basic research studies on diploid potato breeding. Since potato is native to Lima, Peru (South America) and under the routine germplasm procurement programme of the institute. Our finding shows successful utilization of clonal selection method in development of elite genetic stock CPH62 for high resistance to late blight over four seasons under controlled conditions by challenge inoculation. DNA fingerprinting of CPH62 revealed SSR alleles (STU: 175, 178, 182, 187, 197, 202, 206, 209 bp, and STIIKA: 195, 203, 209, 214, 223 bp) for genetic fidelity. A few DUS descriptors of CPH62 are: purple lightsprout, semi-compact plant foliage, tall plant height, green stem colour, intermediate leaf structure, small leaf length, narrow leaf width, ovate lanceolate leaflet shape, blue-violet flower corolla, small flower corolla size, yellow anther colour, normal anther cone, normal pistil, longer stylar length, late maturity, white cream tuber skin colour, smooth skin type, ovoid tuber shape, shallow eye depth and white tuber flesh colour. This diploid wild species CPH62 with diverse genetic background having very high resistance to late blight disease has potential to widen the gene pool of the cultivated potato.

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## 60. PNT43 (IC640715; INGR21171), a diploid potato (*Solanum pinnatisectum* Dunal) germplasm highly resistant to late blight disease and suitable for protoplast fusion and somatic hybrid development.

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An elite genetic stock PNT43 was developed at ICAR-Central Potato Research Institute, Shimla by Clonal Selection method from several clones regenerated from true potato seed (TPS) of wild species (*Solanum pinnatisectum*, Accession no. CGN17443). PNT43 is an important genetic material for fusion parent in somatic hybridization and parental line in diploid breeding programme for introgression of very high resistance to late blight trait with wider genetic base into cultivated potato and also basic research studies on diploid potato breeding. Since potato is native to Lima, Peru (South America) and under the routine germplasm procurement programme of the institute. Our finding shows successful utilization of clonal selection method in development of elite genetic stock PNT43 for high resistance to late blight over four seasons under controlled conditions by challenge inoculation. DNA fingerprinting of PNT43 revealed SSR alleles (STU: 171, 175, 178, 187, 190, 202 bp, and STIIKA: 192, 195, 203, 209, 214, 218, 223 bp) for genetic fidelity. A few DUS descriptors of PNT43 are: purple lightsprout, open plant foliage, small plant height, green stem colour, open leaf structure, small leaf length, narrow leaf width, narrow lanceolate leaflet shape, white flower corolla, small flower corolla size, yellow anther colour, normal anther cone, normal pistil, longer stylar length, late maturity, white tuber skin colour, rough skin type, round tuber shape, shallow eye depth and white tuber flesh colour. This diploid wild species PNT43 with diverse genetic background having very high resistance to late blight disease has potential to widen the gene pool of the cultivated potato.

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## 61. STO61 (IC640716; INGR21172), a diploid potato (*Solanum stoloniferum* Schltdl. & Bouché) germplasm highly resistant to late blight disease

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The elite genetic stock STO61 was developed at ICAR-Central Potato Research Institute, Shimla by Clonal Selection method from several clones regenerated from true potato seed (TPS) of wild species (*Solanum stoloniferum*. Accession no. PI225661). STO61 is an important genetic material for fusion parent in somatic hybridization and parental line in diploid breeding programme for introgression of very high resistance to late blight trait with wider genetic base into cultivated potato and also basic research studies on diploid potato breeding. Since potato is native to Lima, Peru (South America) and under the routine germplasm procurement programme of the institute. Our finding shows successful utilization of clonal selection method in development of elite genetic stock STO61 for high resistance to late blight over four seasons under controlled conditions by challenge inoculation. DNA fingerprinting of STO61 revealed SSR alleles (STU: 171, 178, 184, 190, 193, 197, 202 bp, and STIIKA: 188, 195, 209, 214, 230, 234 bp) for genetic fidelity. A few DUS descriptors of STO61 are: purple lightsprout, semi-compact plant foliage, small plant height, dark purple stem colour, intermediate leaf structure, small leaf length, narrow leaf width, ovate lanceolate leaflet shape, white flower corolla, small flower corolla size, yellow anther colour, normal anther cone, normal pistil, longer stylar length, late maturity, brown tuber skin colour, rough skin type, round tuber shape, shallow eye depth and cream tuber flesh colour. This diploid wild species STO61 with diverse genetic background having very high resistance to late blight disease has potential to widen the gene pool of the cultivated potato.

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## 62. MSH/17-16 (IC640717; INGR21173), interspecific somatic hybrid-derived potato (*Solanum tuberosum* L.) germplasm with wider genetic base, yellow tuber flesh colour and high carotenoids content


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Interspecific potato hybrid MSH/17-16 is a back-cross progeny of advanced stage clonal selection at fourth generation ($BC_1$-$C_4$). MSH/17-16 was developed by crossing between Kufri Garima and interspecific potato somatic hybrid clone 'Crd10'. The clone 'Crd10' is an interspecific somatic hybrid, which was developed by protoplast fusion between *Solanum tuberosum* dihaploid 'C-13' and diploid wild potato species *S. cardiophyllum*. This MSH/17- 16 hybrid possesses wider genetic base into cultivated (*S. tuberosum*) from the diploid wild potato species (*S. cardiophyllum*) and possesses yellow tuber flesh colour with high carotenoids content, and also produces medium range of tuber yield (32.78 t/ha) under sub- tropical plain conditions at Modipuram, Meerut (UP). This shows successful utilization of somatic hybrid 'Crd10' in developing a promising advanced stage hybrid (MSH/17-16) with yellow tuber flesh colour and high carotenoids content for use as a parental line in potato breeding in future. Additionally, molecular profiling using SSR markers (STU: 174, 182, 190, 200 bp; and STIKA: 195, 198, 221, 223, 231, 242, 245, 248 bp) were revealed for genetic fidelity purpose. A few DUS descriptors of MSH/14-129 are: red-purple sprout, compact plant foliage, small plant height, green predominant stem colour, intermediate leaf structure, small leaf length, narrow leaf width, no *anthocyanin* coulouration on flower bud, white flower corolla, small flower size, yellow anther colour, irregular anther cone, normal pistil, longer stylar length, yellow tuber colour, smooth skin, ovoid tuber shape, shallow eye depth and yellow tuber flesh colour. This interspecific potato hybrid with diverse genetic background having yellow tuber flesh colour and high carotenoids content has potential to employ in potato breeding programmes to widen the genetic base of the cultivated potato.

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## 63. NUE/15-8 (IC640718; INGR21174), a potato (*Solanum tuberosum* L.) germplasm with high yield under low nitrogen (50 kg N/ha) supply in field conditions and suitable for low input agriculture

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Global agriculture faces problems of environmental pollution due to excess application of nitrogen (N) fertilizers in potato. Hence, aim of this study was to develop potato hybrids with enhanced nitrogen use efficiency (NUE) and yield traits under limited N availability. We generated here a bi-parental population of 116 progenies by crossing two contrasting varieties *viz*., Kufri Jyoti (N inefficient) and Kufri Gaurav (N efficient). After six years (2015-21) of breeding, clonal selection and field trials, we developed advance hybrids based on 20 traits of agronomic, physio-biochemical and NUE parameters. The potato hybrid NUE/15-8 was developed by crossing between Kufri Jyoti (N inefficient) and Kufri Gaurav (N efficient) potato varieties and currently it is at sixth clonal generation ($F_1C_6$). This advance hybrid NUE/15-8 is a nitrogen use efficient and produces about 20% higher yield (47.20 t/ha) than the best control Kufri Gaurav (39.11 t/ha) under limited nitrogen (50 kg N/ha) fertilizer application in the field at ICAR-CPRI, Regional Station, Modipuram (UP). The hybrid NUE/15-8 has significantly ($p < 0.05$) higher Nitrogen Use Efficiency (NUE) parameters than the best control such as NUE (4.11 vs. K. Gaurav: 2.23), Agronomic NUE (AgNUE) (11.79 vs. K. Gaurav: 9.17), Nitrogen Uptake Efficiency (NUpE) (0.12 vs. K. Gaurav: 0.07), and Nitrogen Utilization Efficiency (NUtE) (35.11 vs. K. Gaurav: 34.20). DNA fingerprinting was performed using SSR markers for true-to-type identification (STU: 173, 178, 181, 189, 198, 199 bp; and STIKA: 175, 194, 214, 223, 230, 234, 243, 247 bp). A fewDUS descriptors of NUE/15-8 are: red-purple sprout, compact plant foliage, medium plant height, green predominant stem colour, open leaf structure, medium leaf length, medium leaf width, no anthocyanin coulouration on flower bud, white flower corolla, small flower size, orange anther colour, normal anther cone, normal pistil, longer stylar length, white cream tuber colour, smooth skin, ovoid tuber shape, shallow eye depth and cream tuber flesh colour. This hybrid has potential for cultivation for low input agriculture mainly under limited N.

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## 64. RGM49 (IC628063; INGR21175), a sunflower (*Helianthus annuus* L.) germplasm with resistance to powdery mildew

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

*summer* seasons and under severe conditions disease is found infecting the cotyledonary leaves up to ray florets. Application of fungicides to manage the disease involves high cost, besides the environmental concern and the insensitivity built up in the pathogen limit their usage (Gullino and Kuijpers, 1994). The higher severity has been observed in tropical parts of the world, where it advances senescence of plant at the flowering or post flowering stages (Gulya *et al.,* 1997).

Breeding efforts were initiated to develop powdery mildew resistant sunflower lines at Main Agricultural Research Station, Raichur during 2011-12. It was aimed to incorporate powdery mildew resistance in some of the elite lines of sunflower through intraspecific and interspecific crosses followed by selections to identify powdery mildew resistant lines (Vikas Kulkarni *et al.*, 2015). Raichur Germplasm (RGM-49) was developed from an intraspecific cross between *GM-49* multi-headed restorer lines having good combining ability for seed yield and a multi-headed powdery mildew resistant line *RCR1947/3-2*. The RGM-49 has been found to be good combiner for yield and yield contributing characters with highest levels mid-parent heterosis (80 to 216%) for seed yield (Rudragouda *et al.*, 2017). It has black colour seeds with oil content ranging from 35 to 37 per cent. Several earlier reports are available for powdery mildew resistant line in wild relatives and pre-breed inter-specific crosses of sunflower (Reddy *et al.*, 2013). However, RGM-49 is the first multi-headed intra-specific cross derivative with cultivated background which can be directly used as restorer line for hybrid development.

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