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Plant Germplasm Registration Notice*

The Plant Germplasm Registration Committee of ICAR in its XXXIVth meeting held on May 24th, 2016 at the ICAR-National Bureau of Plant Genetic Resources, New Delhi approved the registration of following 23 germplasm lines out of 35 proposals considered. The information on registered germplasm is published with the purpose to disseminate the information to respective breeders for utilization of these genetic stocks in their crop improvement programmes. Upon request, the developer(s)/author(s) is/are obliged to distribute the material for crop improvement programme of National Agricultural Research System.

1. RP 5448-RIL-501 (IC0617119; INGR16001), a Rice (*Oryza sativa)* Germplasm with Novel Dual Donor for Resistance to both Brown Plant Hopper (BPH) and White Backed Plant Hopper (WBPH). Possesses Resistance at Vegetative and Reproductive Stages

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Brown planthopper (*Nilaparvata lugens* Stal) and whitebacked planthopper (*Sogatella furcifera*) are the most devastating planthoppers causing 100% yield losses under hopper-burn in rice. Resistant varieties are becoming susceptible as the new virulent insect populations are evolving. So it is essential to develop or search for novel donor sources to cope up with infestation. In this context, a genetic stock designated as RP 5448 - RIL-501 was developed at ICAR-Indian Institute of Rice Research, Hyderabad. It was found to be a unique dual donor possessing resistance to two planthoppers namely BPH and WBPH at seedling and reproductive stages. It is a recombinant inbred line (RIL) generated from the cross TN1 (susceptible)/ Ptb 33 (resistant) following single seed descent method of pedigree selection.

Morpho-agronomic Characteristics: Upon screening the RILs (F_9) derived from the cross TN1/Ptb 33 at a natural hot spot namely APRRI, Maruteru in AP during 2012 and thirty RILs showed resistant reaction during reproductive stage. The insect pressure was so high that one of the resistant RILs designated as RP 5448-RIL-501 could withstand the infestation of around 500-567 WBPH insects and 35-40 BPH insects per hill during *kharif*, 2012; 347-415 BPH insects and 10-15 WBPH insects/ hill during *rabi*, 2012 with a damage score (DS) of 3 as per SES of Rice (IRRI, 2002, IIRR Annual report, 2012-13).

In 2013, the same set of 30 resistant lines were rescreened for another 2 seasons. Heavy infestation of 350-515 BPH and 80-130 WBPH insects/hill while 500-600 BPH and 5-10 WBPH insects/hill occurred for a period of >10 days during *Kharif* and *rabi* respectively (Table 1). The same RIL showed resistance for plant hoppers (DS3.9) which survived and produced seed. (IIRR Annual report, 2013-14). Resistant reaction was on par with the resistant check, Ptb 33 (DS: 3) in both years.

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Table 1. Reaction of RP 5448 - RIL - 501 to BPH and WBPH insects under natural and artificial epiphytotics during 2012 and 2013

	Year & Season	BPH/WBPH		Damage Scores of Resistant check		Damage scores of susceptible check	
			Damage scores of RP 5448-RIL-501	Ptb 33 (BPH)	MO1 (WBPH)	TN1 (BPH)	TN1 (WBPH)
Natural conditions (Field)	2012 Kharif and Rabi	BPH + WBPH	3.0 (R)	3 (R)	3 (R)	9 (S)	9 (S)
	2013 Kharif and Rabi	BPH + WBPH	3.9 (R)	3 (R)	3 (R)	9 (S)	9 (S)
		Mean scores	3.45 (R)	3 (R)	3 (R)	9 (S)	9 (S)
Artificial conditions (Green house)	2013 Kharif and Rabi	BPH	2.85 (R)	3 (R)	-	9 (S)	-
		WBPH	3.0 (R)	-	2.9 (R)	-	9 (S)

R: Resistant S: Susceptible

For confirmation, the field resistant RILs were subjected to greenhouse screening simultaneously during 2013 in two seasons at ICAR-IIRR, Hyderabad. The RILs showed varied levels of resistance in greenhouse. However, RP 5448-RIL-501 showed more or less similar kind of resistance against BPH (DS: 2.8) and WBPH (DS: 3.0) during *kharif* and *rabi* seasons of 2013 (Fig.2) as was recorded in field assays. The resistant checks, Ptb 33 and MO1 for BPH and WBPH recorded damage scores of 3 and 2.9 respectively (IIRR newsletter, 2015). Thus the overall resistance reaction was observed to be stable in field and greenhouse.

Associated Characters and Cultivated Practices: RP 5448-RIL-501 is an intermediate, mid duration culture (140 days), possessing medium slender grains and intermediate plant height (120 cm) and non-lodging. It displayed good cooking quality traits such as high milling recovery (61.6%) coupled with medium head rice recovery (53%) and desirable alkali spreading value (4). It recorded intermediate desirable amylose content (25.1 %) with hard GC (22 mm).

Apart from good cooking quality, it exhibited consistent resistance reaction continuously for 4 seasons in 2 years (2012 to 2013) in field and two seasons in glass house for one year (2013). Hence this elite genetic stock could be utilized as a novel donor for developing rice varieties with combined resistance to planthoppers.

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2. DWRB 128 (IC0617170; INGR16002), a Two Row Feed Barley (*Hordeum vulgare* L.) Germplasm with Immune to Yellow Rust (*Puccina striiformis* f. sp. *hordei*)

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DWRB128 (BK1229-DWRUB54/DWRUB75) is two-row high yielding malt barley genotype, which was evaluated for disease reactions at multi-locations for three years viz. *rabi*, 2012-13 to 2014-15 under Initial Barley Disease Screening Nursery (IBDSN) and National Barley Disease Screening Nursery (NBDSN),

respectively (Anonymous 2013; Anonymous 2014; Anonymous 2015). During *rabi*, 2012-13, DWRB128 was evaluated at 4 locations namely, Bajaura, Durgapura, Dhaulakuan and Ludhiana and showed resistant reactions for stripe rust under artificial inoculations (IBDSN). DWRB128 was evaluated in timely and late sown initial malt barley varietal trials (IVT-MB-TS and IVT-MB-LS) during 2013-14 and again confirmed resistance (0=immune response) for barley stripe rust under artificial inoculations in NBDSN at 7 locations (Table 1). The two-row check varieties namely DWRUB52, DWRB92 and DWRB91 exhibited the stripe rust reactions of 10S, 20S and 40S, respectively. During 2013-14, DWRB128 depicted grain yield of 51.7 q/ha and was significantly superior to both the checks viz. DWRUB52 (49.4 q/ha) and DWRB92 (49 q/ha) under timely sown malt barley trial (IVT-MB-TS). In third year of stripe rust resistance confirmation, the DWRB128 again showed of resistant reactions at Bajaura, Durgapura and Almora locations in NBDSN. Whereas, the check varieties *i.e.* DWRUB52, DWRB92 and DWRB91 depicted the yellow rust reactions of 5S, 30S and 10S, respectively (Kumar *et al*., 2015) (Table 1).

On the basis of two years data viz. 2013-14 and 2014-15 the genotype DWRB128 also depicted superiority for Beta-glucan (10.6 %) and grain protein content (10.0%) over malt barley check DWRUB52, respectively.

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Table 1. Multi-location stripe rust reactions (artificial inoculations) of DWRB128 and checks for three years

Year	Location	DWRB128 (2R-BK1229)	DWRUB52 (2R-check)	DWRB92 (2R-check)	DWRB91 (2R-check)	Infector
First year (2012-13)	Bajaura	0	0	0	5S	80S
	Dhaulakuan	0	0	5S	0	60S
	Durgapura	tMR	tMS	10MS	10S	100S
	Ludhiana	0	0	5S	5S	60S
Second Year (2013-14)	Bajaura	0	0	0	5MR	100S
	Dhaulakuan	0	0	0	0	100S
	Durgapura	0	10S	20S	40S	100S
	Ludhiana	0	0	tS	0	40S
	Karnal	0	0	0	0	80S
	Hisar	0	0	0	0	80S
	Almora	0	0	5MS	tR	80S
Third year (2014-15)	Bajaura	0	0	30S	0	100S
	Durgapura	tMR	5MS	20MR	10S	100S
	Almora	0	5S	20S	5S	60S
Over all HS		tMR	10S	30S	40S	100S

3. DWRB 1143 (IC0617171; INGR16003), a Six Row Malt Barley (*Hordeum vulgare* L.) Germplasm Immune to Highly Resistant for Yellow Rust (*Puccina striiformis* f. sp. *hordei*)

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DWRB143 (BK1333) is a six-row high yielding genotype, which was developed by pedigree method (DWRB73/DWR83) at ICAR-IIWBR, Karnal. It was screened for disease reactions at multi-locations for consecutive two years viz. *rabi*, 2013-14 and 2014-15, under Initial Barley Disease Screening Nursery (IBDSN) and National Barley Disease Screening Nursery (NBDSN), respectively. During *rabi*, 2013-14, the genotype DWRB143 was evaluated by code BK1333 at five locations namely, Bajaura, Durgapura, Dhaulakuan, Ludhiana and Karnal in IBDSN. The genotype BK1333 exhibited immune response (0 reaction) for yellow rust under artificial disease epiphytotic conditions (Anonymous, 2014). The check varieties of NEPZ namely Lakhan exhibited susceptible yellow rust reactions of 100S followed by K603 (80S), whereas, NWPZ *elite* feed barley varieties BH902 and BH946 also showed susceptible reactions of 30S and 10S, respectively in NBDSN at the same locations (Table 1). Similarly, During *rabi*, 2014-15, DWRB143 was evaluated in initial varietal rainfed coordinated trial in NEPZ (IVT-RF-NEPZ) for grain yield and vis-à-vis for disease resistance under artificial inoculations in NBDSN. DWRB143 again showed immune response to yellow rust (0 reaction) at all the centres namely Durgapura, Bajaura and Almora (Anonymous, 2015; Kumar *et al*., 2015) (Table 1).

Table 1. Multi-location stripe rust reactions (artificial inoculations) of DWRB143 and checks for two years

Year	Location	DWRB143 (6R-BK1333)	Checks of NEPZ (same trial)		Recent checks of NWPZ		Infector
			Lakhan (6R-check)	K603 (6R-check)	BH902 (6R-check)	BH946 (6R-check)	
First year (2013-14)	Bajaura	0	30S	40S	30S	0	100S
	Dhaulakuan	0	20S	60S	0	0	100S
	Durgapura	0	100S	80S	0	10S	100S
	Ludhiana	0	5S	5S	0	0	40S
	Karnal	0	40S	40S	10MS	0	80S
Second Year (2014-15)	Durgapura	0	100S	60S	tMR	10MR	100S
	Bajaura	0	60S	20S	0	10S	100S
	Almora	0	80S	80S	5S	10MS	60S
Two years HS		0	100S	80S	30S	10S	100S

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4. PPMI 904 (IC0617290; INGR16004), a Pearl Millet (*Pennisetum glaucum* L.) Germplasm with High Iron Content of 91 mg/kg High Zinc Content of 78 mg/kg

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Pearl millet is a major warm-season cereal, grown in more than 29 million ha in the arid and semi-arid tropical regions of Africa and Asia (Kannan *et. al*., 2014). India is the largest producer of this crop in Asia. During 2013-14, pearl millet in India being grown in 7.91 m ha with a production 9.19 m ton and productivity 1161 kg/ha (DES-DAC, 2014). In Pearl millet growing regions 35% of total intake of calories, protein, iron and zinc is from this millet only and it is the cheapest source of iron and zinc content compared to other cereals such as rice and wheat (Rao *et al.,* 2006). Biofortification approach involves enchancing the levels of specific, limiting micronutrients in edible tissues of crops by combining crop management, breeding, and genetic approaches (Hirschi, 2009). Micronutrient-enriched or biofortified pearl millet serves as the logical vehicle for providing Fe and Zn in the diets of the people and also shall be a cost-effective and sustainable approach to alleviate micronutrient deficiencies. Bashir *et al*. (2014) observed a wide range of variation for iron and zinc content (Fe:19.7 mg/kg to 86.4 mg/kg and Zn : 13.5 mg/kg to 82.4 mg/kg). Rai *et al*., (2012) reported iron content as high as 135 ppm and zinc being 92 ppm in pearl millet grains, whereas Govindaraj *et al.,* (2011) reported a little narrower range of these micronutrients (iron: 30.1 to 75.7mg/kg and zinc: 24.5-64.8mg/kg) in improved populations obtained from India and Africa.

We are proposing pearl millet line named PPMI 904 for registration as pearl millet lines with high iron and zinc. PPMI 904 is unique because it is rich in Iron and Zinc, 91 mg/kg and 78 mg/kg of grain respectively. As per the harvest plus millet strategy (2010), the target levels of iron are 77 mg/kg grain of pearl millet. The proposed pearl millet line was developed at Division of Genetics, IARI, New Delhi from the recombinant inbred line population from cross between PPMI 683 x PPMI 627 parents initiated in *kharif*, 2009. This line was tested in All India Coordinated Pearl millet improvement programme's high iron or elite joint biofortification trial in multilocations in *kharif*, 2013.

The same material was tested in 8 diverse locations in *Kharif*, 2014 for grain iron and zinc content (Tara Satyavathi *et al*., 2015)

Morpho-agronomic characters: Morpho-agronomic characters of line PPMI 904 are its height is approx. 120 cm with erect plant type with days to 50% flowering around 65 days. The nodes are green in colour. Anthers are yellow in colour. Panicle exertion is complete and length of panicle is 24 cm in length and girth is 2.74 cm. The spike is cylindrical in shape with semi compact nature. The 1000 seed weight of PPMI904 is 8.23 grams. Seed colour is grey and seed is globular to obovate in shape.

Table 1. Mean performance of the proposed pearl millet genotype along with checks in multi-locational test conducted during Kharif, 2013 in High iron joint biofortification trials of All India Coordinated Pearl millet improvement Programme

Entry	Coimbatore		Delhi		Durgapura		Gwalior		Jamnagar		Ludhiana		Mandor		Grand Mean	
	Fe	Zn	Fe	Zn	Fe	Zn	Fe	Zn	Fe	Zn	Fe	Zn	Fe	Zn	Fe	Zn
PPMI 903	46	66	98	99	54	68	92	52	100	64	58	83	85	72	76	72
PPMI 904	93	107	130	121	48	48	143	81			29	33	105	78	91	78
PPMI 905	27	48	50	61	44	48	35	37	72	54	41	75	35	37	44	51
PPMI 906	54	81	94	97	57	71	97	59	88	61	50	69	56	52	71	70
841 B	32	42	45	46	42	50	38	38	62	46	27	42	33	37	40	43
D 23	33	46	48	44	69	51	46	39	59	49	28	37	34	36	45	43
ICTP 8203 imp																

Source: Annual Report of All India Coordinated Pearl millet Improvement Project 2013-14

Table 2. Mean data for grain Fe & Zn(ppm) and grain yield (kg/ha) of 8 pearl millet genotypes grown at 8 locations during *Kharif*, 2014

Genotype	Grain iron content (ppm)									Grain Zinc content (ppm)								
	L1	L2	L3	L4	L5	L6	L7	L8	Geno Mean	L1	L2	L3	L4	L5	L6	L7	L8	Geno Mean
PPMI 903	67.67	98.00	65.00	92.00	91.00	67.00	85.33	65.33	78.92	63.67	99.00	69.00	52.00	75.67	83.00	72.00	60.00	71.79
PPMI 904	93.00	126.7	78.00	111.0	111.0	73.67	105.00	87.00	98.17	107.00	114.33	48.00	80.00	82.00	33.00	78.00	103.00	80.67
PPMI 905	29.33	50.00	44.00	34.67	43.00	41.00	38.00	34.33	39.29	46.33	61.00	48.00	36.33	39.67	74.67	37.00	43.67	48.33
PPMI 906	74.33	94.00	60.33	97.00	66.00	65.00	66.00	87.67	76.29	80.67	97.00	70.00	59.00	55.00	69.00	52.00	77.67	70.04
841B	32.00	45.00	42.00	38.67	38.67	27.00	33.00	26.33	35.33	42.00	46.00	50.67	38.00	39.67	42.00	37.00	39.33	41.83
D 23	33.00	48.00	69.00	46.00	39.67	28.67	34.33	27.67	40.79	46.00	44.33	50.00	39.00	41.00	37.33	36.00	41.00	41.83
ICTP 8203	47.00	97.00	76.00	95.67	83.33	74.33	77.00	40.67	73.87	54.00	74.00	69.00	52.00	57.33	62.67	54.00	50.67	59.21
Loc. Mean	46.56	68.50	59.31	66.17	58.69	47.03	53.53	43.61	55.42	56.56	68.67	59.11	48.03	49.39	54.14	45.81	52.97	54.33

Source: Tara Satyavathi, *et al.* (2015).

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5. Cotton Queen (SIMA) (IC0618569; INGR16005), a Tall and Perennial Cotton (*Gossypium barbadense*) Germplasm

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Cotton Queen (SIMA) is 37 feet tall cotton Plant, yield above 2000 bolls per plant with good fobre quality as tested by CICR Nagpur.

6. DOGR-1549-Agg (IC0616539; INGR16006), an Onion (*Allium cepa* var. *aggregatum*) Germplasm with Unique Early Multiplier; Suitable for both *rabi* and *kharif* Seasons; Early Maturing with Six Uniform Bulblets per Bulb

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Multiplier onion (*Allium cepa* var. *aggregatum*) is mainly grown in Tamil Nadu, Andhra Pradesh and Karnataka. It is famous for its use in *Sambar* preparation, an important South Indian dish and have high export potential also. It produces small size bulbs, many in number, to form an aggregated cluster. It is normally propagated by bulblets. There are no early maturing multiplier onion varieties which could be suitable for both *kharif* and *rabi*. Hence, there is need to develop early maturing varieties in multiplier onion. The work in this direction led to development of an early maturing multiplier line DOGR-1549-Agg.

Background

Genotype DOGR-1549-Agg (IC-0616539)were developed through clonal selection from a sample collected from Kagati, Chintamani, Karnataka. It is better than parental population in respect of uniformity, earliness and yield parameters. It is an unique early maturing multiplier onion suitable both for *kharif* and *rabi* seasons. It matures in 85 days after planting i.e. about one week earlier than popular variety CO-5. It has six uniform bulblets per bulb which are attractive pink and oval in shape tapering towards neck [1, 4 & 5].

Table1. Performance of DOGR-1549-Agg in comparison to controls

A. Days to Maturity

Entry	*Rabi* 2012-13	*Rabi* 2013-14	Mean	*Kharif* 2013	*Kharif* 2014	Mean	Overall Mean
1549-Agg	94.00	89.67	91.84	68.33	84.00	76.17	84.00
CO-4 (C)	99.00	90.00	94.50	77.00	85.00	81.00	87.75
CO-5 (C)	97.33	95.00	96.17	78.00	87.00	82.50	89.33

B. Total Yield (q/ha)

Entry	*Rabi* 2012-13	*Rabi* 2013-14	Mean	*Kharif* 2013	*Kharif* 2014	Mean	Overall Mean
1549-Agg	213.30	253.30	233.30	240.22	143.00	191.61	212.46
CO-4 (C)	180.56	180.76	180.66	185.62	129.50	157.56	169.11
CO-5 (C)	176.05	237.52	206.79	177.05	114.00	145.53	176.16

C. No. of Bulblets/bulb

Entry	*Rabi* 2012-13	*Rabi* 2013-14	Mean	*Kharif* 2013	*Kharif* 2014	Mean	Overall Mean
1549-Agg	6.20	6.20	6.20	5.19	6.07	5.63	5.92
CO-4 (C)	5.40	6.00	5.70	4.21	6.40	5.31	5.50
CO-5 (C)	5.47	5.40	5.44	5.23	5.00	5.12	5.28

D. TSS (%)

Entry	*Rabi* 2012-13	*Rabi* 2013-14	Mean	*Kharif* 2013	*Kharif* 2014	Mean	Overall Mean
1549-Agg	12.25	16.20	14.23	13.27	14.11	13.69	13.96
CO-4 (C)	11.60	12.88	12.24	13.76	15.16	14.46	13.35
CO-5 (C)	12.25	12.68	12.47	13.32	13.56	13.44	12.95

* Compiled by Amar Jeet Gupta, Vijay Mahajan, S. Anandhan and Jai Gopal

Morpho-agronomic Characteristics

DOGR-1549-Agg was evaluated along with multiplier onion germplasm maintained at DOGR during *rabi* 2012-13 and 2013-14, and *kharif* 2013-14 and 2014-15 at Rajgurunagar (Table 1) [1, 2, 3 & 4]. It has erect foliage, plant height 25-30 cm with 5-7 green leaves per plant. Compound bulb diameter is 3.0-3.5 cm and bulblet diameter 1.2-1.5 cm. Bulblets are pink oval tapering towards neck.Total soluble solids are 13.5-14.5^0 brix and average yield is 20-22 t/ha.

The uniqueness of this genetic stock is that it is about one week earlier than popular variety CO-5 and is suitable for both *rabi* and *kharif*. It has six uniform pink bulblets per bulb (Fig.1) [5].

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7. MGMS-7 (IC0618568; INGR16007), a Non-Spiny-Marker-Linked Genetic Male Sterile Line in Safflower (*Carthamus tinctorius* L.)

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MGMS-7 (IC0618568; INGR16007) is a genetic male sterile (GMS) in which male sterility is linked to non-spiny trait; the linkage is visible when plant is around 40-45 days old. Inherently, the GMS system segregates into male sterility and fertility in 1:1 ratio (Heaton and Knowles, 1982) and they are distinguishable only after flower opening, which is an impediment for utilization of GMS lines in breeding and hybrid seed production programmes for occurrence of female-selfs in hybrid seed lot. However, MGMS-7, a non-spiny-marker-linked genetic male sterile line developed for the first time in safflower at the Indian Institute of Oilseeds Research, Hyderabad, can distinguish male sterile and fertile plants at about 40-45 days prior to flowering and provides ample time (40-45 days) for roughing-off of fertile plants prior to flowering itself thus facilitates production of genetically pure F_1/cross seed. MGMS-7 was derived from a cross between a spiny GMS parent '13-137' and 'A1'. The 1:1 segregation of male sterile and fertile progenies in MGMS-7 confirmed GMS nature of the line. Absence of male sterility in F_1 and 3:1 segregation of male fertile and male sterile in F_2 confirmed the recessive nature of male sterility in MGMS-7. In MGMS-7, the non-spiny trait is strongly linked to genetic male sterility. The recombination value of 0.15-0.4% over years and 0.16% over seasons confirmed stability of tight linkage between non-spiny marker and male sterility in MGMS-7. This line would be useful to safflower breeders for producing pure hybrid seed as well as in population improvement and gene pyramiding programmes where multiple crossing is a prerequisite. By using MGMS-7, the tedious and time taking emasculation by hand can be avoided and absolute cross seed can be ensured.

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8. CoM7601 (IC0618560; INGR16008), a Sugarcane (*Saccharum officinarum* L.) Germplasm with Resistance to Whip Smut

and

9. MS7604 (IC0618562; INGR16009), a Sugarcane (*Saccharum officinarum* L.) Germplasm with Resistant to Whip Smut

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Achieving durable resistance to important diseases is the prime objective of sugarcane breeding. Screening genotypes for smut resistance with artificial inoculation is being carried out from last 42 years at Central Sugarcane Research Station, Padegaon. Two genotypes bred by this center *viz*., CoM 7601and MS 7604 have shown consistently resistant reaction to smut from the last 28 years. These resistant genotypes could be of immense utility in breeding programme for developing smut resistant sugarcane varieties.

Whip-smut caused by *Ustilago scitaminae* Sydow. is a serious disease of sugarcane in Tamil Nadu, Karnataka and Maharashtra (Alexander, 1975). Management of plant diseases through host resistance is the best option for crop protection. Development of resistant varieties is followed by coevolution of the pathogen resulting in breakdown of resistance and hence achieving durable resistance is important. Screening sugarcane clones for resistance to whip-smut with artificial inoculation of smut teliospore suspension is being done from 1970 at Central Sugarcane Research Station, Padegaon.

The resistant genotypes were tested every year in *Suru* season (Jan-Feb. planting) against whip-smut from 1970 to confirm the consistence of resistance. Two eye budded setts of each genotype were artificially inoculated by soaking them for 30 minutes in fresh viable (90 to 95% viability) smut teliospore suspension (@ 10 g teliospore powder per 50 lit of water) having spore load of 10^6 to 10^8 teliospores ml^{-1} (Shinde *et al.,* 1985 and Chirme *et al.,* 1998). Treated sets were planted in moist soil in the field @ 15 sets per row of 6 m length. The incidence of smut was recorded at fortnightly interval. Based on the cumulative smut incidence, the genotypes were categorized as resistant (R= 0.0%), moderately resistant (MR= 0.01 to 10.0%), moderately susceptible (MS= 10.01 to 20.0%), susceptible (S= 20.01 to 30.0%) and highly susceptible (HS= >30.0%) as per Shah *et al*. (1997).

Two resistant genotypes bred by this center *viz*., CoM 7601 and MS 7604 have shown consistently resistant reaction to smut from the last 28 years which indicates that these genotypes have durable resistance to smut under artificial inoculation condition.

The usual method of identifying resistant clones through inoculation test is still the reliable method (Flores *et al*., 2009). The method of artificial inoculation by immersion of sugarcane cuttings in the suspension of smut spores was found to be effective to evaluate the resistance against smut in experimental material of sugarcane (Briceno *et al*., 2005).

Thus, it is confirmed that the sources of durable resistance against whip smut are available in sugarcane which can be utilized in breeding programme for evolution of new high yielding sugarcane varieties with in-built resistance to whip smut (Begum *et al*., 2007).

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10. JEX/A 911(IC0618556; INGR16010), a Potato (*Solanum tuberosum* L.) Germplasm with Suitable for Making Multicolor Chips; Tuber Flesh Attractive Multicolored

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Of late, there is an awareness and interest in the presence of antioxidants in the diet. Purple potato colour is caused by the presence of flavonoids. Among these flavonoids, anthocyanins are found to have antioxidant properties in potatoes, fruits and vegetables. Antioxidants in the diet are good and have been associated with a reduced risk of quite a number of diseases, ailments with aging, and so on. Recently, antioxidant rich purple coloured potatoes are being marketed for table consumption in Japan, Canada and US and chips made from these potatoes are also being sold by several companies in the US [EijckPaul van 2008]. In India there is need to develop potato which contain high antioxidants. In order to provide antioxidant rich processed products to the Indian consumers, primitive cultivated andigena germplasm collection (about 770 accessions) which is known for its diversity was screened to identify sources for coloured tuber flesh (Marwaha RS, Kumar Raj, Pandey SK 2008). JEX/A 911 with multicolour flesh tubers, was found to be useful as its tubers were suitable for processing into multicolor chips with attractive chips having deep yellow colour mottled with purple patches and good taste.Tubers of JEX/A 911 had very high dry matter content (24.8%), contained reducing sugars (41.0 mg) in acceptable limit for producing quality chips. JEX/A 911 is a clonal selection from segregating progeny of the accession CIPC700939 of cultivated tetraploid species *Solanum tuberosum* ssp. andigena. This germplasm accession can be very useful in developing pigmented flesh varieties for producing coloured chips with attractive color pattern

Morpho-agronomic Characteristics: Tubers of JEX/A 911 are oval shape, purple skin, medium sized with medium deep eyes. Tuber flesh colour is yellow mottled with purple secondary colour. The flower corolla colour is blue-violet. Plant is medium tall. Leaflets are ovate lanceolate with wavy margin. Sprout colour is purple. The yield of this accession is significantly lower than commercial cultivars Kufri Chipsona-1 and Kufri Chipsona-3.

Associated Characters and Cultivated Practices: This accession is late maturing and susceptible to late blight and early blight diseases.

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11. PDA-01 (IC0618554; INGR16011), a Sweet Bamboo/Asper Bamboo (*Dendrocalamus asper* (Schult.) Baker ex Heyne) Germplasm Tolerant to Water-Logged Conditions

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Dendrocalamus asper (Schult.) Baker ex Heyne, commonly known as sweet bamboo is a multi-purpose tropical sympodial bamboo of high economic value. The young shoots of asper are sweet and are used as food. The food industries based on this edible species are expanding quite fast.Variegated Leaves line PDA-01, a natural mutant was found in the planted area in agroforestry research centre at Pantnagar in 2006.

Three plants showed variegation in their leaves, out of which one plant was selected and maintained in nursery conditions. Then plants were macroproliferated by separating the tillers with rhizomes into more plants and these plants were planted in field. The retention of variegation may be attributed to vegetative propagation which maintains the genetic identity and stability of the character. Trait is stable even after 7 years. There was no significant difference in mutant and normal plant for height, culm diameter and number of culms. In bamboos, leaf variegation has also been reported in *Bambusa multiplex* and *B. heterostachya* but report on variegated asper plant has not been found in the literature elsewhere. Reported variegated *D. asper* has huge potential to be used as ornamental plant and as marker in genetical and breeding studies.

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12. PBN 12-01 (IC0618555; INGR16012), a Malla Bamboo (*Bambusa nutans* Wall. Ex Munro) Tolerant to Water-Logged Conditions

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Bamboos are one of the fast growing plants on the earth. They are known to grow under dry conditions. Particularly,stagnated water is found very fatal to their survival and growth of the bamboos. Among promising bamboo species which are preferred by the growers, problem of growing under wet-land is much severe. Among preferred species, a line of *Bambusa nutans* Wall. ex Munro has been found to tolerant to water stagnation at Pantnagar conditions. Nutans bamboo commonly known as malla bamboo, is a multi-purpose tropical sympodial bamboo which may attain a height of 20 meters. This bamboo is used in house construction, basketry and crafts. It grows best at altitudes of between 500-1500 m. Thrives on moist hill slopes and flat uplands, and well-drained sandy loam to clayey loam soils.

A line from the germplasm of *Bambusa nutans* was selected from natural areas near Raipur–Dehradun, plants were found to be viable even after long period of 4 months of water logged conditions (line was identified in 2008 and selected in 2012). Later this line was evaluated under experimental water stagnated conditions where it showed survival even after 6 months of water stagnation. Line was named as PBN 12-1. Generally, bamboos are said to be recommend only in dry conditions with well

Table 1. Growth of *Bambusa nutans* PBN 12-1 under water-logged conditions (Planted in July 2008 and data taken from one year age in July every year)

Age (year)	Culm ht (m)	Diameter (cm)	No of new culms	Total No of culms	Fresh Culm weight (kg)
1 yr-2009	4.4	2.9	6.9	6.9	1.5
2 yr-2010	7.5	3.8	7.2	12.2	3.2
3 yr-2011	9.2	4.5	7.5	18.5	7.3
4 yr-2012	9.8	5.7	8.2	22.1	9.1
5 yr-2013	10.1	6.4	11.4	30.8	10.2
6 yr-2014	11.9	6.8	12.8	38.1	14.3

drained soils but this particular line was found tolerant to water logged conditions during rainy season almost for 4-6 months for over six years of testing (2008 to 2015). Line PBN 12-1 will have high practical applicability to be grown in low lying areas with problem of soil erosion. Therefore, farmers and tree growers may like to plant this particular line on their lands for economic and ecological benefits.

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13. LBRIL 189 (IC0611476; INGR16013), a Wheat (*Triticum aestivum*) Germplasm with Resistance to Spot Blotch

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Spot blotch or foliar blight caused by *Bipolaris sorokiniana* of wheat is the major disease and its occurrence is higher in north eastern plains zone (NEPZ) due to favourable conditions (hot and humid weather). The disease is spreading to other regions of the country and thus requires attention of researchers. Improvement of host resistance against spot blotch disease and widening the genetic base of the model genotypes through introduction of new alleles for resistance are the major activities being carried out at Indian Institute of Wheat and Barley Research, Karnal. This way, integration of conventional breeding with molecular tools will help in mitigating the problem of spot blotch disease in wheat through incorporation of useful QTLs in susceptible yet popular genotypes that are adapted to a particular region (Singh *et al*., 2016). In a set of breeding material developed to meet the these challenge, 215 recombinant inbred lines (RILs) derived from the cross between agronomic parent (disease susceptible genotype) "Kanchan" (HUW-202//K-7537/ HD-2160-N) and highly resistant genotype Chirya 1 (CS/*Ag.cu*//Glennson-81/3/ Alondra/ Pavon-76/ 4/ Ningmai-4/ Olesen//Alondra/Yangmai-4) and advanced to F_{9-10} generation. Complete set of this population of RILs (F_{9-10}) were phenotyped for assessing spot blotch disease during two consecutive crop seasons (2012-13 and 2013-14) under natural high disease pressure (two hot spot) locations namely, Coochbehar, Kalyani (West Bengal) in eastern India and also at IIWBR, Karnal under field and epiphytotic conditions (poly house) having 03 replications. Phenotypic data and disease score recorded on double digit scale at dough stage (taking disease reaction of top two leaves, flag and flag-1) at three different stages was for the study. Out of the potential material, one promising line LBRIL-189 that showed comparatively higher level of resistance against spot blotch as compared to even resistant parent (Chirya-1) consistently across the locations and over the two years (Table 1) was shortlisted as has been approved for registration as genetic stock.

Morpho-agronomic Characters: In addition to the better resistance, some of the morphological features like; days to heading (76-97), days to maturity (102-128) and plant height (94-113) that varied in different environments were also comparable. Besides, the average 1000-grain weight (TKW) of the genotype LBRIL 189 (40.0 g) was also comparable to its best check i.e. Chirya-1 (donor parent) which had TKW of 42.0 g and much higher than the agronomic parent.

Associated Characters and Cultivation Practices: LBRIL 189 was also observed to be leaf rust resistant

Table 1. Performance of LBRIL-189 for resistance and agronomic traits evaluated under four environments over two years (2012-13 & 2013-14)

Genotype	Condition	LB Score	Days to heading	Days to maturity	Plant height	1000-grain weight
LBRIL-189	Field	02	85	111	103	39
	Polyhouse	02	84	103	103	40
Chirya 1 (Resistant Parent)	Field	13	85	115	92	42
	Polyhouse	13	74	107	91	43
Kanchan (Agronomic parent)	Field	67	82	116	101	32
	Polyhouse	89	81	106	95	32

and thus can be grown in spot blotch affected regions by adopting normal wheat cultivation practices. Diagnostic markers reported earlier *Xgwm*371, *Xgwm* 425 (Kumar *et al.*, 2010) were also used to validate the promising line for spot blotch resistant (Singh *et al*., 2014).

The identified genetic stock possess high degree of resistance along with desired agronomic background thus will serve as potential donor for improving spot blotch resistance in wheat.

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14. GPHCPB 45 (IC0614156; INGR16014), a Finger Millet (*Eleusine coracana*) Germplasm with High Calcium Content 452.8mg/100g

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Finger millet is an important staple in most parts of India and Africa and is a good source of nutrients especially calcium with an average value of 344 mg 100 g^{-1} (Gopalan *et al*., 2004). Finger millet grains are known to contain high calcium in comparison to all important food grains. GPHCPB 45, an elite finger millet line has been identified as unique germplasm with respect to grain calcium. It has highest grain calcium (452.80 mg/100 g seed) in comparison to check varieties VL 149 (360 mg/100 g seed) and VR 708 (370 mg/100 g seed). This line is a local collection from Uttarakhand hills. The germplasm was collected by erstwhile hill campus Ranichauri (Now a campus of UUHF, Barshar, Uttarakhand) of GB Pant University of Agriculture and Technology, Pantnagar, India.

In addition to high calcium content, GPHCPB 45 also possesses larger ears in comparison to the checks. GPHCPB 45 has erect growth habit and droopy leaves. The details of morphological traits are given in Table 1. The germplasm line recorded higher incidence of finger and neck blast in comparison to elite lines and improved varieties. However, it can be used as a donor for the development of new varieties with high calcium content and in basic studies for identification of molecular markers /QTL's for grain calcium content. Diversification of germplasm with the involvement of this high calcium line in hybridization would be useful for enhancing the nutritional value of the crop in particular and nutritional security of the masses in general.

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Table 1. Distinguishing characteristics of GPHCPB 45 compared to check as recorded at Almora location

Character name	GPHCPB 45	VL Ragi 149	VR 708
Pigmentation on node	Absent	Present	Absent
Growth habit	Erect	Erect	Erect
Leaf blade pubescence	Present	Present	Present
Leaf attitude	Droopy	Droopy	Droopy
Ear shape	Open with finger straight at the time of flowering and curved at the time of maturity	Open with top curved finger	Compact fist type
Number of fingers/ear	8-10	8-10	7-9
Ear length (cm)	10-12	8-10	5-7
1000 Seed weight (g)	2.58	2.71	2.83
Days to flowering	70-75 days	65-70	60-65
Days to Maturity	103-107 days	100-105	95-100
Plant height (cm)	125-135	120-125	115-120
Grain color	Dark Red Color	Copper color	Light copper color

15. Ogu 3A (IC0614417; INGR16015), a Cytoplasmic Male Sterile Line of Cauliflower (*Brassica oleracea* Var. *botrytis* L.) with Good Seed Yield; Cream Coloured Flower

and

16. Kt-3B (IC0614418; INGR16016), a Male Fertile Maintainer Line of Ogu 3A Cauliflower (*Brassica oleracea* Var. *botrytis* L.)

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Cauliflower is an important vegetable crop and more than 90% area is covered by F_1 hybrids. Snowball cauliflowers are grown throughout the north Indian plain during rabi season and almost throughout the year in hilly regions of India. In cauliflower, F_1 hybrids are advantageous especially in uniform maturity, high early and total yield, better curd quality with respect to compactness and colour, resistance to insect pests, diseases and unfavorable weather conditions (Kucera *et al.,* 2006). Two pollination control mechanisms *viz.* self-incompatibility (SI) and male sterility (particularly CMS) are used widely for production of F_1 hybrid seed However, the contribution of indigenous hybrids is negligible and bulk of the seeds is imported from outside (Sharma *et al.,* 2004). Development indigenous hybrid seed industry in vegetable crop like cauliflower is the need of the hour. It will not only save revenues spent in import of their seeds but will also create several employment in rural India. Development of indigenous pollination control mechanism like CMS holds the key for indigenous hybrid seed production. The snowball cauliflower CMS line, Ogu3A is one indigenously developed CMS line. It has refined Ogura male sterile cytoplasm which if free from any floral deformities (Dey *et al.*, 2011).It has partially covered snow white-curd. The line was developed by transferring refined *Ogura* male sterile cytoplasm into nuclear background of snowball cauliflower variety, Pusa Snowball K-1 after 13 generation of backcrossing (BC_{13}).

Morpho-agronomic characteristics: This is one of the first snowball cauliflower CMS line with refined Ogura male sterile cytoplasm. This line belongs to late group of cauliflower (December onwards maturity) with a maturity period of 120-130 days at temperate regions and 70-80 days in North Indian plains. This line has normal floral traits with good nectar development. Thus, good honeybee activity was observed in this line. This line has seed yield of 26.8 g /plant when allowed

Table1. Important horticultural and seed yield of the CMS line Ogu33A as compared to the fertile maintainer line

Traits	Ogu3A	Ogu3B
Days to 50% maturity	132.8	131.3
Marketable curd weight (Kg)	0.8	0.8
Nos. of pods/plant	1007.5	1418.8
Seed yield/plant (g)	26.8	29.7

to set seed under natural isolation along with fertile maintainer in the ratio of 1:1. Thus, seed yield was at par with the fertile maintainer line and this line can be used in commercial hybrid breeding programme. The net individual curd size of the line was 0.80 Kg with a total yield of 35.5 tonnes/ha.

Associated characters and cultivated practices: The line Ogu3A belongs to the snowball group of cauliflower and cultivated mainly during the winter season. This male sterile line has cream coloured flowers with normal ovary and good nectar development. Because of normal seed yield this line can be used in commercial hybrid seed production programme. For hybrid seed production it is recommended to follow a planting ratio of 1:1 with fertile male parental lines.

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17. Ogu 33A (IC0614419; INGR16017), a Cytoplasmic Male Sterile Line of Cauliflower (*Brassica oleracea* Var. *botrytis L.*) with Good Seed Yield and Cream Coloured Flower

and

18. Kt-33B (IC0614420; INGR16018), Maintainer Line of Ogu 33A Cauliflower (*Brassica oleracea* Var. *botrytis* L.)

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Cauliflower is an important vegetable crop and more than 90% area is covered by F_1 hybrids. However, the contribution of indigenous hybrids is negligible and bulk of the seeds is imported from outside. Non-availability of indigenous pollination control mechanisms mainly Self-incompatibility and cytoplasmic male sterility (CMS) is the main bottleneck in development of indigenous F_1 hybrids (Sharma *et al.*, 2004). There is an urgent need to develop indigenous CMS lines in crop like cauliflower for development of hybrid seed industry in India. It will not only save a huge amount of revenues spent every year in import of cauliflower hybrid seeds but will also create several employment opportunities in rural India. It was earlier reported that the superior Ogura based CMS lines in cauliflower are highly suitable for cauliflower hybrid development (Dey *et al.*, 2011a and Dey *et al.*, 2011b). The mid-late (November maturity) cauliflower CMS line, Ogu33A is one indigenously developed CMS line. It has refined Ogura male sterile cytoplasm which if free from any floral deformities (Dey *et al.*, 2014). This line has shriveled anther with no viable pollen development.It has partially covered snow white-curd. The line was developed by transferring refined *Ogura* male sterile cytoplasm from Snowball-16 into nuclear background of November maturity cauliflower line, 33B after 12 generation of backcrossing (BC_{12}).

Morpho-agronomic characteristics: This is one of the first cauliflower CMS line with refined Ogura male sterile cytoplasm in November maturity group. This line belongs to mid-late group with a maturity period

of 90-100 days at temperate regions and 60-70 days in North Indian plains. This line has normal floral traits with good nectar development. Thus, good honeybee activity was observed in this line. This line has seed yield of 28.6 g /plant when allowed to set seed under natural isolation along with fertile maintainer in the ratio of 1:1. Thus, seed yield was at par with the fertile maintainer line and this line can be used in commercial hybrid breeding programme. The marketable individual curd size of the line was 1.03 Kg with a total yield of 45.2 tonnes/ha (Dey *et al.,* 2014).

Table1. Important horticultural and seed yield of the CMS line Ogu33A as compared to the fertile maintainer line

Traits	Ogu33A	Ogu33B
Days to 50% maturity	100.8	94.7
Marketable curd weight (Kg)	1.03	0.82
Nos. of pods/plant	1123.5	1224.2
Seed yield/plant (g)	28.6	33.2

Associated characters and cultivated practices: The CMS line Ogu33A has milky white flower colour with straight stigma and normal ovary. This line has dark green slightly puckered leaves and compact curd. As this line has been developed after 12 generation of back-crossing there is significant difference with fertile maintainer line. For development of hybrids it is recommended to plant the CMS line with the fertile male parental line in the ratio of 1:1.

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19. NRCG CS 281 (IC0616376; INGR16019), a Spanish Bunch Genotype of Groundnut (*Arachis hypogaea* L.) with Extra-large Kernel Size (HPS type)

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Groundnut (*Arachis hypogaea* L.) is a major oilseed and food crop of the world. It is cultivated approximately in an area of 25.44 m ha producing 45.22 m tons of nut in shell (FAOSTAT, 2014). Although groundnut is primarily a source of fat, it is also a rich source for protein (~25%), micronutrients and secondary metabolites. Current figures show that ~50% of groundnut produce is crushed for extraction of oil and about ~40% is used for various food purpose. Improved groundnut varieties that meet processing and or export quality are needs of the food industry. Varieties that combine 'large kernel size' with other processing quality traits like higher protein, blanchability, shelling ease, flavor attributes are chosen for table purpose and or by the industry. The groundnut, which is used for direct consumption is generally referred as large seeded groundnut or hand-picked selection (HPS) groundnut and confectionary groundnut depending upon the quality attributes (Dwivedi and Nigam, 2005). Indian groundnut is very popular in the international market for the table purpose, due to its characteristics natural nutty flavour, taste and crunchy texture. In spite of the immense export potential, only limited genotypes have been bred with an aim to obtain early maturing HPS or confectionary groundnut in India. Considering these facts, attempts were made to develop a short duration large seeded groundnut genotype.

The groundnut genotype NRCGCS 281, an interspecific derivative with extra-large kernel size has been developed through pedigree selection from a cross between '(Deep Red Mutant x Purple Variegated Mutant) x *Arachis duranansis*' at ICAR-Directorate of Groundnut Research, Junagadh, Gujarat. It has erect growth habit, produces 50% flowering in 25 days after sowing (DAS) and matures in 100 to 110 DAS during

Table 1. Mean pod yield of NRCGCS 281 (kg/ ha) and check variety over two years (2008 & 2009) at four AICRP on groundnut centres*

Genotype / Year	Junagadh, Gujarat	Rahuri, Maharahtra	Shirgaon, Maharastra	Vridhachalam, Tamil Nadu	Pooled
NRCGCS 281	3341	4644	2633	1737	3089
TPG 41 (Check)	3813	5507	2631	1726	3419
CD at 5%	453.4	1156.4	476.8	407.9	674.2

Table 2. Mean hundred kernel weight (g) of NRCGCS 281 and check variety over two years (2008 & 2009) at four AICRP on groundnut centres *

Genotype / Year	Junagadh, Gujarat	Rahuri, Maharahtra	Shirgaon, Maharastra	Vridhachalam, Tamil Nadu	Pooled
NRCGCS 281	72	87	71	86	79
TPG 41 (Check)	36	84	55	66	60
CD at 5%	51.8	16.8	16.7	24.8	30.1

*Data mentioned in Tables 1 and 2 are reproduced from the Annual report, 2009-10 of Annual *Rabi*-Simmer Groundnut Researchers Group meeting held at BCKV, Mohanpur, West Bengal during November 18-19, 2010.

rainy season. NRCGCS 281 produces an average pod yield of 3000 kg/ hawith72% shelling out turn (Table 1). Pods are moderately beaked with deep constriction and without reticulation; mostly two seeded with rose colour testa. Kernels are extra-large in size with hundred kernel mass ranging of 80-90 g (Table 2) and contain 50.5% oil. This is the first report of a Spanish Bunch early maturing groundnut genotype (NRCGCS 281) with extra-large kernel size in India (Fig. 1). Besides, it is also resistant to Rust disease and suitable for cultivation both in *rabi*/Summer as well as *kharif* seasons. It could be well promoted for table purpose and export with premium price which could fetch higher return to the farmers. In addition to interspecific breeding lines with HPS quality could be a potential donors (Bera *et al*. 2008) for breeding groundnut with extra-large kernel size and has also been used effectively in marker assisted breeding (Bindu *et al*., 2013).

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20. JOR LAB L-8 (IC0619026; INGR16020), a Lemon grass (*Cymbopogon flexuosus*) Germplasm with High Herbage Yield with High Essential Oil Content

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Lemongrass (*Cymbopogon flexuosus* L.), family Poaceae is an aromatic grass species and is commonly known as 'East Indian Lemongrass'. It is a vegetatively (also seed) propagated perennial, multicut crop in the tropics. The prefix 'Lemon' owes to its typical lemon-like odor, released from leaves on maceration, which is mainly due to the presence of citral as a cyclic monoterpene. The lemongrass oil as such is widely used in perfumes, soaps and cosmetics to obtain typical lemon notes. Besides, it's an important source of citral, which is used in perfumes and medicine (Saikia *et al*., 2015). While citral forms a significant raw material for confectionery and beverages, it is the principal source of β-ionone which is extensively used for the synthesis of vitamin A and a number of chemicals including synthetic violet perfumes (Lal *et al*., 2016). In future thus generating new varieties with higher oil yield and citral content in lemongrass is of utmost necessity.In the view of above needs and great prospect of cultivation of this crop successfully in various region of India. It is necessary

Table 1. Average morphological and quality data of Jor lab L-8 lines with checks in four locations

Variety	Plant height (cm)	Tillers/plant	Herbage yield/tones/ha	Oil % w/w	Oil yield/kg/ha/year	Citral %
Jor Lab L-8	126-138	78	30.32	1.00	303.20	78
Jor Lab L-2	118-132	42	26.80	0.45	120.60	82
Krishana	106-121	56	27.60	0.90	248.40	81

to evolve high yielding varieties for respective locations. Due to the limited improved varieties for high oil yield and herbage yield, its cultivation is not popular among farmers. Therefore, there is a need to develop superior varieties of lemongrass for high oil yield and herbage yield. In CSIR-NEIST farm there is more than three hundred of cymbopogon species. As per record this germplasm banks is second position after the Oddakali germplasm bank. We screened the genotypes based on high oil yielding and high herbage yield and find a high herbage and high oil genotypes named as Jor Lab L-8. Then, these superior selected clones were evaluated in fourdifferent locations of NE region such as Jorhat (Assam), Lakhimijan (Assam), Imphal(Manipur) and Gaurigaon (Sikkim)where these were compared to all the checks.

As per data from Table 1 the herbage yield and tillers per plant for Jor lab L-8 was significantly higher than the checks. As well as the oil yield is higher than the check variety Krishna. The oil yield per kg/ ha/ year was significantly higher in the variety Jor lab-8. The agronomic trait plant height is not significantly different between the elite lines and checks. The higher oil yield is a desired character in lemon grass as it is more economically beneficial. This elite clone Jor Lab L-8 maintained its superiority over all the checks for herb and oil yield and the elite strain was named as variety 'Jor Lab L-8. Plants of this variety are propagated through only vegetative means using the slips, and the plants are stable for commercial cultivation.

Morpho-agronomic Characteristics

S.No.	Characters	Range
1	Plant height (cm)	126-138
2	Growth habbit	Semi compact
3	No of tillers/plant	68-87
4	Herbage yield /Qt/ha/year	287 to 313
5	Oil content %	1
6	Citral %	78

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21. JOR LAB C-5 (IC0619027; INGR16021), a Java Citronella (*Cymbopogon winterianus* Jowitt) Germplasm with High Herbage Yield with High Essential Oil content

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Java citronella (*Cymbopogon winterianus* Jowitt.) is an aromatic grass belonging to Poaceae family which gives essential oils upon steam distillation (Saikia *et al*., 2015). One of the important essential oils extracted from aromatic grasses is citronella oil obtained from citronella grass. This oil is used extensively as a source of important perfumery chemicals like citronellal and geraniol, which finds it extensive use in soap, perfumery, cosmetic and flavoring industries throughout the world The use of active secondary chemical compounds such as alkaloids and terpenoids in the medicinal plants holds a great promise in the field of medicine in ancient as well as modern era (Lal *et al*., 2016).It is cultivated in parts of tropical and subtropical areas of Asia, Africa and America (Shasany *et al*., 2000). In the view of above needs and great prospect of cultivation of this crop successfully in various region of India, It is necessary to evolve high oil yielding varieties for respective locations. Due to the limited improved varieties for high oil yield and herbage yield, its cultivation is not popular among farmers (Saikia

Table 1. Morphological and oil quality data of four locations (average) of Jor Lab C-5 with check variety

Variety	Plant height cm	Tillers/plant	Herbage yield tonnes/ha	Oil percentage w/w	Major oil content Citronellal	Superior % over oil yield	Total oil yield/ kg/ha/year
Jor Lab C-5	118	148	36.5	1.20	35 %	33%	438
Jor LabC-2 (check)	110	127	32.2	0.9%	32.5%	-	289

et al., 2015). Therefore, there is a need to develop high oil and herbage yielding genotypes of Java citronella. Jor Lab C-5 genotype was developed through mutation breeding using EMS as a mutagenic agent and the parent material was a variety of Java citronella (Jor lab C-2). In order to fulfill this gap we developed this high oil and herbage genotypes. Jor lab C-5 was planted along with check variety in four locations; it gives the high oil yield up to 1.2% and citronellal content up to 35%. This variety is 33% better in oil yield in comparison to the checks over the check.

Morpho–agronomic characteristics: The selected clone was planted in four different locations in Northeast India along with check variety Jor Lab C-2. This new genotypes contains 33 % more oil yield and 12 % more herbage yield and mean total oil yield was 468 kg/ha/year, as compared to the check variety yielding 287.60 kg/ha/year. The plant height was 118 cm in Jor Lab C-5 where as check variety Jor Lab C-2 was 110 cm.The tillers /plant is significantly superior in Jor lab C-5 with 149 compared to check variety with only 126. This elite clone Jor Lab C-5 maintained its superiority over the check for herb and oil yield and named as line Jor Lab C-5'. Plants of this variety are propagated through only vegetative means using the slips, and the plants are stable for commercial cultivation.

Agro Morphological Description of the Jor Lab C-5 Germplasm

S. No.	Characteristics	Description
1	Plant height cm	118
2	Growth habit	Bushy and droopy leaves
3	Stem	Culm, Moderately bold rudimentary, leaves coming out in whorls
4	Colour of leaf	Green
5	Inflorescence	Panicle (rare)
6	Oil content %	1.20
7	Citronellal content %	35
8	Herbage yield qt/ha	36.5
9	Major oil content	Citronellal
10	Tillers/plant	149

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22. SM/00-120 (IC0616580; INGR16022), a Photo-Insensitive High Yielding Potato Hybrid (*Solanum tuberosum* L.) with High Resistance to Late Blight both in Hills and Subtropical Plains

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Potato (*Solanum tuberosum* L.) originated in the Andes about 8000 years ago and evolved as long day, temperate, summer crop. British or Portuguese traders most probably introduced it into India during early 17th century. Initial efforts to introduce and acclimatize European varieties were unsuccessful due to long day adaptability of these cultivars. The organized breeding to develop indigenous varieties began in 1935 for Indian hills. Till date, CPRI has developed and deployed 53 commercial cultivars suitable for growing under different eco-geographical locations but Kufri Jyoti, released in 1968 and Kufri Himalini released in 2006 are the only two successful examples

Table 1. Mean performance of advanced hybrid SM/00-120 at hills (Kufri) and sub-tropical plains (Modipuram)

Genotype/ controls	Kufri					Modipuram			
	Total yield (t/ha)								
	2011-12	2012-13	2013-14	Overall Mean	% Increase over	2012-13	2013-14	Overall Mean	% Increase over
SM/00-120	11.11	19.36	11.0	13.83	-	39.73	37.4	38.6	-
Kufri Girdhari	8.31	18.54	9.67	12.17	13.6	-	18.6	18.6	107.3
Kufri Jyoti (Sprayed)	9.12	13.45	8.53	10.37	33.4	20.58	28.40	24.50	57.50
Kufri Jyoti (Unsprayed)	9.79	10.08	7.73	9.20	50.2	-	-	-	-
Kufri Himalini	9.39	15.44	8.92	11.25	22.9	-	34.8	34.8	10.8
Kufri Bahar	-	-	-	-	-	27.13	38.1	32.6	18.2
Kufri Sadabahar	-	-	-	-	-	23.62	-	23.62	63.3
$CD_{0.05}$	19.65	17.6	12.9	-	-	6.96	4.5	-	-

in the sub-continent which performs considerably well both under short and long day conditions.

Among biotic stresses affecting potato, late blight caused by oomycetes *Phytophthora infestans* is the most devastating for potato cultivation. In India, late blight acts as serious impediment in increasing potato production and affects most of the potato growing regions in varying degree depending upon the variety grown and control measures adopted (Singh *et al*., 2007). It appears in epiphytotic conditions in the hills every year and once in 2-3 years in devastating form, in the plains. Losses caused by this disease may go as high as 85% in the hills, if the varieties grown are susceptible and are not chemically protected, while losses up to 60-70% can occur in the plains in some years. Historically, resistance against late blight is not durable because of development of matching virulences in the pathogen thereby ensuing an everlasting battle between the breeders and the pathogen. Consequently, development and deployment of new, resistant varieties became the only viable option alongwith other blight management strategies to check this menace. Late blight resistance is a desired trait both in hills and plains but higher the level of resistance longer is the crop duration thus rendering such varieties difficult to fit in short crop duration in the plains.

Disease resistance and adaptability of a genotype to varied environmental conditions is an added advantage for its success. Endogenous plant hormones mediate photoperiod response and day neutral varieties have no or low hormonal-photoperiod response thus perform well both under long and short day conditions. Although, varieties like Kufri Jyoti and Kufri Himalini were bred for long day conditions but now are well adapted for shorter day conditions of plains and plateau regions. However, these varieties have now become susceptible to late blight resulting in lower yields. Consequently, new short duration varieties with high resistance to late blight and photo-in-sensitivity needs to be developed and deployed in these areas to sustain profitable potato production.

Hybrid, SM/00-120 is a promising clone selected from the segregating generation of the cross EB/A-304 × Ex/A-680-16 made in year 2000. It is a day neutral, late blight resistant advanced hybrid with medium maturity and produces yellow skinned ovoid tubers with shallow eyes and cream-yellow flesh. The hybrid yields high both under hills and sub-tropical plains conditions. At Kufri, hybrid out yielded the control variety, K. Girdhari by 13.6%, K. Himalini by 22.9% and Kufri Jyoti (sprayed) by 33.4% for total tuber yield over last 3 years at 100 days crop duration (Table 1.). Under sub-tropical plains at Modipuram, hybrid out yielded the local control, K. Bahar by margin of 18.2%, K. Himalini by 10.8% and Kufri Jyoti by 57.5% for total tuber yield over last 2 years. At Kufri, though the AUDPC of the hybrid is higher (131) than highly resistant control variety, Kufri Girdhari (33) but it is much lower than susceptible control varieties viz., K. Jyoti (799) and K. Himalini (520). The hybrid possesses high level of resistance against late blight along with medium dormancy and good keeping quality under country store conditions. With these parameters, SM/00-120 can be helpful in expanding the potato area under kharif cultivation and can suitably supplement Kufri Jyoti, the leading cultivar of the country.

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CPRI Annual Report, 2014-15, pp. **74.**

23. SS 1652-09 (IC0616581; INGR16023), a Wild Potato (*Solanum Jamesii*) Clone Possessing High Resistance to Late Blight and Low Cold Induced Sweetening

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The discovery and incorporation of resistance and other genes of economical value to the cultivated germplasm is the key for sustaining crop productivity. In potato, late blight is caused by oomycete *Phytophthora infestans*, and is the most important biotic stress afflicting potato crop worldwide. Host resistance is an important component for the management of late blight on potato.To reduce the cost of the disease and the environmental damage, it is important to identify resistance that can be used inbreeding programs. In the past, 11 major resistance genes(R-genes) were introgressed from hexaploid *S. demissum* into cultivated potato and all these genes confer race-specific resistance.Thus, the resistance based on these geneswas quickly overcome by the pathogen. Hence, newsources of resistance are required to develop late blightresistant potato varieties. Utilization of *S. demissum* as donor parent for late blight resistance breeding led to high genetic similarity among many potato cultivars released and results in vulnerability of crop to the pathogen and necessities search for new resistance source in the wild potato species in order to broaden the genetic base of future cultivars.Keeping this view wild potato species were screened for late blight resistance by detached leaf method for two years in laboratory condition and one year screening in open field under natural epiphytotic condition. For detach leaf method six leaflets of top 4-5th leaf from 2-4 plants/ clone were artificially inoculated with complex races of *P. infestans* using 6×10^6 sporangia per ml. For field screening the clones were graded on 1-5 scale (1-highly resistant, 5-highly susceptible). Based on results obtained accession SS1652-9 of *S. jamesii* was reported highly resistant (lesion area <1.0 cm^2). This identified resistance source can be used to further diversify the source of resistance to late blight in cultivated potatoes.

Similarly, producing light-colored chips is a significant challenge to the potato industry. Over 90 % of the annual potato crop in India is grown in sub tropics during short days of winter season and harvested in the month of February-March when the temperature starts rising. This necessitates the storage of potato at low temperature (2-4 °C) for round the year availability. Low-temperature storage is highly beneficial because it extends storage duration by minimizing pathogen activity, reduces water loss and prevents tuber sprouting. But low temperature storage stimulate cold-induced sweetening (CIS), which is characterized by an accumulation of sucrose and conversion of sucrose to reducing sugars by vacuolar acid invertase. Cold stored potatoes produce dark colored chips (Malliard reaction) that are carcinogenic and disliked by consumers. Resistance to CIS, or cold chipping, is the ability of a genotype to produce light colored potato chips directly following cold storage. An ideal reducing sugar content should be below 100 mg per 100 g of tuber fresh weight (0.1 %).

For resistance to cold-induced sweetening there is a need of introgression genes from wild *Solanum* species as till date no cultivar has been reported resistant to CIS.Despite the presence of heritable variation for cold chipping, no commercial cultivars are currently available that can chip acceptably directly from 4 °C storage. This necessitates the potato growers to use post harvest agrochemicals to reduce storage losses. The identification of cultivars that chip directly from 4 °C will allow growers to reduce storage losses without the use of post harvest agrochemicals. The biggest impediment towards

development of cold resistant potato cultivars through conventional breeding is lack of suitable germplasm to be used as parents. Therefore, to identify genotypes resistant to cold induced sweetening, 72 accessions of 15 wild and cultivated species were screened for glucose content before and after cold storage (cold stored at 2-4 °C for nearly six months, without reconditioning) during 2007-08 and 2008-09. The glucose estimation was done by analyzing the potato tuber juice through YSI Biochemistry Analyzer.

Wild species accession namely SS1652-9 (*S. jamesii*) maintained low glucose level (glucose content <50 mg/100 gram fresh tuber weight) before and after cold storage over the years. This accession can be used to diversify the genes of resistance to cold induced sweetening in cultivated potatoes as most of the wild species can be crossed to cultivated types following ploidy manipulations. This wild potato accession has medium plant height,hollow stem,open canopy, open leaf structure with narrow lanceolate leaflets,white flowers, moderate flowering and high pollen fertility. The tubers are white-cream,smooth, roundwith shallow eyes.

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