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Research Article

VL *Mandua* 382: The first early maturing, white seeded finger millet cultivar suitable for rainfed organic agro-ecology of the Himalayan region

D. C. Joshi*[1], Salej Sood[2], Arun Gupta[3], R. K. Khulbe[1], B. M. Pandey[1], R. S. Pal, M. S. Bhinda[1] and Lakshmi Kant[1]

[1]ICAR- Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, Uttarakhand, India
[2]ICAR-Central Potato Research Institute, Shimla, Himachal Pradesh, India
[3]ICAR-Indian Institute of Wheat and Barley Research, Karnal, India
***E-Mail**: Dinesh.Joshi@icar.gov.in

Abstract
White seeded finger millet is known to have higher acceptability in the baking and food industry compared to the brown seeded finger millet genotypes. The available white seeded finger millet genotypes are late maturing and blast susceptible thereby reducing their farmer's acceptability in the north western Himalayan region particularly in Uttarakhand. Keeping this in view, the development of early maturing, blast resistance white seeded finger millet breeding programme was initiated at ICAR –VPKAS, Almora in 2003-04, which resulted in the release of VL *Mandua* 382in the year 2021, the first early maturing white seeded finger millet cultivar of finger millet suitable for rainfed and organic agro-ecology of the Himalayan region. It was derived from the cross between late maturing, white finger millet genotype WR 2 (obtained from UAS Bangalore) and early maturing and locally adapted blast tolerant brown seeded genotype VL 201. It recorded an average grain yield of 1,198 kg/ha, which was at par with the brown seeded check VL *Mandua* 324 (1,197 kg/ha) and out yielded the brown seeded check PRM-1 (1,163 kg/ha) by 3.0 per cent in State Varietal Trials (SVT) conducted under organic conditions of the Himalayan region. The grains contain higher calcium (340 mg/100g) and protein (8.8%) in comparison to the brown seeded check variety VL *Mandua* 324 (294 mg/100gand 6.6%, respectively). It exhibited moderate resistance to leaf, finger and neck blast in the multilocation trials conducted over 9 locations. Considering the speciality trait (white grains), excellent grain quality, matching yield potential with brown seeded check varieties and blast tolerance, the variety was released for cultivation in rainfed organic agro-ecology of Uttarakhand hills.

Key words: Blast resistance, grain quality, VL *Mandua* 382, white seed finger millet, calcium content

INTRODUCTION

Finger millet is one of the most underutilized nutritious staple cereals, widely cultivated across the dry lands of Asia and Africa by marginal farmers. Being one of the rich reservoirs of micronutrients, dietary fiber, vitamins and phytochemicals of diverse therapeutic uses finger millet has a huge potential to work as alternative grains for ensuring food and nutritional security in most parts of the world (Sood *et al.,* 2016a; Kumar *et al*., 2021). Moreover, as compared to major cereals, it has better adaptability to the fragile mountain ecosystem and rainfed organic agro-ecology of the Himalayan region (Gururani *et al.,* 2021). In the last decade, there has been an increased interest in using finger millet as a nutritional substitute in various food formulations.

In general, finger millet grains are dark brown in

colour due to high levels of tannins and phenolics (Sood *et al*., 2019). The dark colour of grains has been the major hindrance for its acceptability in the baking and food industry (Sharathbabu *et al*., 2008). Sometimes the high amount of tannins and phenolics impart a bitter taste to the value added products thereby reducing their consumer acceptability. To overcome this, few white grain mutant genotypes were developed, which are considered to be of higher grain quality and mostly preferred for making confectionery and bakery products (Sood *et al*., 2016b). In addition to market acceptability, white seeded finger millet is known to possess high protein, high iron and a negligible amount of tannin in comparison to brown seeded genotypes (Rao *et al.,* 1994). Thus, white seeded varieties of finger millet offer great scope for value addition, harnessing marketing potential and generating substantial income for the marginal farmers. Nevertheless, only a few state released cultivars of white seeded finger millet such as Co 6 and Co 9 varieties for Tamil Nadu, KMR 340 for Karnataka and GN5 and GN 7 for Gujarat are available in the country (Ravishankar *et al.,* 2013). However, these genotypes are very late in maturity thereby reducing their farmer's acceptability especially in the North western Himalayan region. In this region early maturing genotypes (100-110 days) are preferred by the farmers as the crop occupies rainfed areas where the growth period is mostly limited due to less availability of water for the crop. Further, hills are the hot spots for all three types of blasts (leaf, neck and finger) of finger millet. Therefore, an early maturing white seeded cultivar with high to moderate resistance to blast with a locally adapted genetic background is required to prevent severe crop damage by biotic and abiotic factors.

Thus with the objective to develop an early maturing, blast resistant white seeded finger millet variety specifically suited to rainfed and organic agro-ecology of hills, breeding work was initiated. The first variety VL *Mandua* 382 was developed to provide a new option to farmers growing traditional brown finger millet varieties as well as to create avenues for harnessing the marketing potential of this nutraceutical crop.

MATERIALS AND METHODS

Hybridization was attempted between WR 2 and VL 201 in the year 2004 using the hot water emasculation method. The WR 2 is white seeded, late maturing and blast susceptible genotype obtained from UAS, Bangalore, whereas, VL 201 is brown seeded, early maturing and locally adapted blast tolerant genotype. In the F_1 generation only those plants were selected which were having dark brown coloured grains. During the segregating generations (F_2 to F_5) derived from the cross WR 2 × VL 201, selections were made for the white seeded background of WR 2 with a keen emphasis on early duration and resistance to both neck and finger blast diseases.

Uniform promising lines were bulked and tested in station trials along with brown grain check varieties (VL *Mandua* 324, VR 708 and GPU 45) during 2011 and 2012. In the trials, the homozygous and homogeneous genotype VL 382, emerged as the best, and subsequently, was tested in multilocational state varietal trials of Uttarakhand during *kharif* 2013, 2014 and 2015 at five locations following randomized complete block design with three replicates under organic conditions. The recommended sowing time of June was followed and the row to row distance of 22.5 cm and row length of 3 m with the plot of 5 rows were followed uniformly at all the locations. The crop was raised under organic conditions by the recommended dose of FYM@15t/ha. The strain was also nominated to All India Coordinated Small Millets (AICRP-SM) Trial-2018 and was evaluated in multi-location All India Coordinated Small Millets Early and Medium Duration Trials conducted in inorganic conditions during 2018-2019. Disease screening was done in the National disease screening nurseries of AICRP-SM 2018-2019 along with the GE 4449 and *Uduru mallige* as resistant and susceptible checks for blast disease, respectively.

RESULTS AND DISCUSSION

In the SVT trials, VL *Mandua* 382 recorded an average grain yield of 1,198 kg/ha, which was at par with the brown seeded check VL *Mandua* 324 (1,197 kg/ha) and out yielded the brown seeded check PRM-1 (1,163 kg/ha) by 3.0 per cent in conducted under organic conditions in hills of Uttarakhand over three years (**Table 1**). Considering the speciality trait (white grains), excellent grain quality (high protein and calcium) and matching yield potential with checks and ruling brown seeded variety of the state (VL *Mandua* 324), VL *Mandua* 382 was released by State Varietal Release Committee Uttarakhand and subsequently, it was notified by the Central Sub-Committee on Crop Standards and Release for Agricultural Crops of Varieties vide notification number S.O.500 (E) dated 29th January 2021. The specific niche area of adaptation of this variety is the rainfed organic condition of Uttarakhand hills. Based on the mean grain yield performance of the AICRP-SM IVT trial conducted at 10 locations under inorganic conditions VL *Mandua* 382 (1,853 kg/ha) was at par with the national check GPU 67 (1,844 kg/ha) and subpar to the rest of the national checks (**Table 2**). However, at the state level VL *Mandua* 382 (2,075 kg/ha) out yielded the national checks GPU 67(1,388 kg/ha) and PR 202 (1,753 kg/ha) by an impressive margin of 49.50 and 18.37 per cent, respectively and was at par with GPU 45 (2,072 kg/ha) in AICRP-SM Initial Varietal Trials (**Table 2**).

The available white seeded varieties of finger millet are of medium to late maturity duration which does not perform well in higher hills since their maturity phase coincides with low temperatures, resulting in a prolonged approach to maturity or failure to mature altogether. Further, the delay in sowing of the successive *rabi* crops caused

Table 1. Performance of VL *Mandua* 382 in comparison to check varieties in station and state varietal trials conducted from the year 2011 to 2015

Name and year of the trials	Number of locations	Name of locations	Grain yield (kg/ha)					% increase over VL *Mandua* 324	% increase over PRM 1	Days to maturity
			VL *Mandua* 382	VL *Mandua*324	PRM 1	C.D. at 5%	CV (%)			
IST-2011	1	Hawalbagh	2134	1993	1890	3.2	19.86	7.07	13.38	105
AST-2012	1	Hawalbagh	2259	2063	1934	2.7	16.54	9.50	16.80	104
Mean			2196	2028	1912			8.28	14.85	104.5
SVTs-2013	4	Hawalbagh	11.70	12.10	10.70	3.6	18.20			
		Ranichauri	3.54	5.65	5.41	0.42	5.17			
		Majhera	24.20	16.79	13.33	6.11	19.86			
		Chinyalisaur	7.96	7.80	7.86	1.40	12.56			
		Mean	1180	1050	933	-	-	12.28	26.47	114
SVTs-2014	5	Hawalbagh	18.62	17.33	13.0	4.48	14.96			
		Ranichauri	20.67	16.72	21.25	1.53	4.55			
		Thal	6.91	10.57	8.89	1.21	7.71			
		Majhera	13.66	14.81	14.81	6.l1	1.30			
		Chinyalisaur	7.33	5.57	6.04	2.04	0.43			
		Mean	1344	1300	1282	-	-	3.38	4.85	112
SVTs-2015	5	Hawalbagh	27.16	29.39	26.52	5.05	10.19			
		Ranichauri	11.30	4.95	11.39	0.07	0.47			
		Thal	3.65	11.65	7.31	1.90	8.82			
		Majhera	4.77	9.05	9.96	2.23	17.18			
		Chinyalisaur	6.38	5.55	6.22	1.22	11.34			
		Mean	1065	1212	1228	-	-	-12.13	-13.27	109
Pooled mean of SVTs			1198	1197	1163			0.08	3.0	111.0

Table 2. Performance of VL *Mandua* 382 in comparison to national check varieties in Uttarakhand under All India coordinated trial

Locations	Grain yield (kg/ha)										
	VL *Mandua* 382	GPU 67	GPU 45	VL 376	PR 202	% increase over GPU 67	% increase over GPU 45	% increase over VL 376	% increase over PR 202	C.D. at 5%	CV (%)
Almora	2594	1600	2228	2179	1954	62.13	16.43	19.05	32.75	6.0	14.38
Gaja	1759	1267	1457	1432	1366	38.83	20.73	22.84	28.77	1.28	6.03
Majhera	1874	1296	2230	2948	1037	44.60	-15.96	-36.43	80.71	2.35	8.96
Uttarakhand mean	2075	1388	2072	2286	1753	49.50	0.14	-9.23	18.37	9.49	31.95
National (Mean)	1853	1844	1954	2155	1863	0.49	-5.17	-14.01	-0.54	4.86	28.44
Days to maturity (National mean)	102	128	120	112	118	-	-	-	-	11.0	8.35

by the long duration cultivars in the Himalayan region adversely affects the germination and initial growth of crops due to continuously falling temperature as well as depriving the crop of the benefits of residual soil moisture. The newly released white seeded variety VL *Mandua* 382 showed a mean maturity duration of 111 days in SVTs conducted over 5 locations from 2013 to 2015 (**Table 1**). Interestingly, VL *Mandua* 382 showed a mean maturity duration of 102 days in AICRP-SM IVT trials conducted over 10 locations in the year 2018 and was the earliest in maturity in comparison to all the tested 20 entries and four national checks (**Table 2**). Thus, being a shorter duration variety, VL *Mandua* 382 suitably fits into the prevalent cropping system of the Himalayan region and can be sown after the onset of monsoon in the month of June and harvested by the first week of October, thereby ensuring timely sowing of successive *Rabi* crops.

In the coordinated trials, conducted across nine diverse hot spot locations of the blast, the per cent damage due to leaf blast in VL *Mandua* 382 was very low (disease score 3.63) compared to the susceptible check *Uduru Mallige* (disease score 5.67) and it fell in the moderately resistant (MR) reaction category with the checks GPU 67 (3.58) and PR 202 (3.63) (**Table 3**). The per cent damage due to finger blast in VL *Mandua* 382was also very low (13.22%) compared to the susceptible check *Uduru Mallige* (31.48%) and was grouped in the same disease scale category of 11-20% (moderately resistant reaction) as all the brown seeded check varieties (**Table 3**). Likewise, the per cent damage due to neck blast in VL *Mandua* 382 (19.06%) was low compared to the susceptible check *Uduru Mallige* (34.86%) and fell in the same disease scale category of 11-20% (moderately resistant reaction) with all the four brown seeded national checks (**Table 3**).

In terms of grain quality (**Table 4**), VL *Mandua* 382 has higher calcium (340 mg/100g) and protein content (8.8%) in comparison to the brown seeded check VL *Mandua* 324 (294 mg/100g and 6.6% respectively). In addition, sucrose content was also higher in VL *Mandua* 382 (0.960 mg/100mgdwt) in comparison to brown seeded variety VL *Mandua* 324 (0.635 mg/100mg dwt). Usually, grains with high oligosaccharides (raffinose and stachyose) considered as antinutritional factors causes flatulence problem in human being, grains with low are preferred by common people. Interestingly, the newly developed white seeded variety VL *Mandua* 382 has a low concentration of total oligosaccharides (0.17 mg/100g dwt), raffinose (0.10mg/100g dwt) and stachyose (0.07mg/100 g dwt) compared to the brown seeded cultivar VL 324 (**Table 4**). VL *Mandua* 382 is characterized by white colour grains (**Fig. 1**) with an average test weight of 2.34g. The plants and leaves are green in colour and nodes are non-pigmented. The growth habit is erect and the leaf blades are pubescent. The earheads are semi-compact with long fingers (9.06 cm). The detailed descriptor of the variety is presented in **Table 5**.

Table 3. Reaction of VL *Mandua* 382 to major diseases as observed in AICRP-SM IVT coordinated trials conducted in 9 locations during *kharif* 2018

Genotype	Year	Number of locations	Leaf blast (grade)	Neck blast (% damage)	Finger blast (% damage)
VL *Mandua* 382	2018	9	3.63 (17)	19.06 (19)	13.22 (12)
GE 4449 (RC)	2018	9	2.02 (1)	4.92 (1)	5.27 (1)
Uduru Mallige (SC)	2018	9	5.67 (23)	34.86 (25)	31.48 (26)
GPU 45	2018	9	3.00 (5)	14.25 (12)	13.44 (13)
VL 376	2018	9	2.79 (3)	11.48 (5)	12.30 (11)
GPU 67	2018	9	3.58 (15)	18.36 (18)	15.12 (18)
PR 202	2018	9	3.63 (16)	19.82 (21)	18.30 (25)

*Values in parentheses indicates the all India rank of the genotype

Table 4. Grain quality parameters of VL *Mandua* 324 in comparison to the brown seeded check variety VL *Mandua* 324

Quality parameters	VL *Mandua* 382	VL *Mandua* 324
Calcium (mg/100g)	340	294
Zinc (mg/100g)	2.2	3.0
Iron (mg/100g)	3.3	2.8
Protein (%)	8..8	6.6
Sucrose (mg/100g)	0.945	0.645
Raffinose (mg/100g)	0.10	0.21
Stachyose (mg/100g)	0.07	0.10

Table 5. Distinguishing characteristics of VL *Mandua* 382

Characters	VL *Mandua* 382	VL *Mandua* 324	PRM 1
Days to flowering	70	78	76
Days to maturity	107	118	115
Pigmentation on nodes	Absent	Absent	Absent
Pigmentation on panicles	Absent	Absent	Absent
Plant height (cm)	95.76	85.57	82.34
Earhead shape	Semi-compact	Compact	Semi-compact
Earhead length (cm)	9.06	6.60	8.09
Grain colour	White	Brown	Brown
Test weight (g)	2.34	2.13	2.24

Fig.1. Field view and grains of *VL Mandua* 382

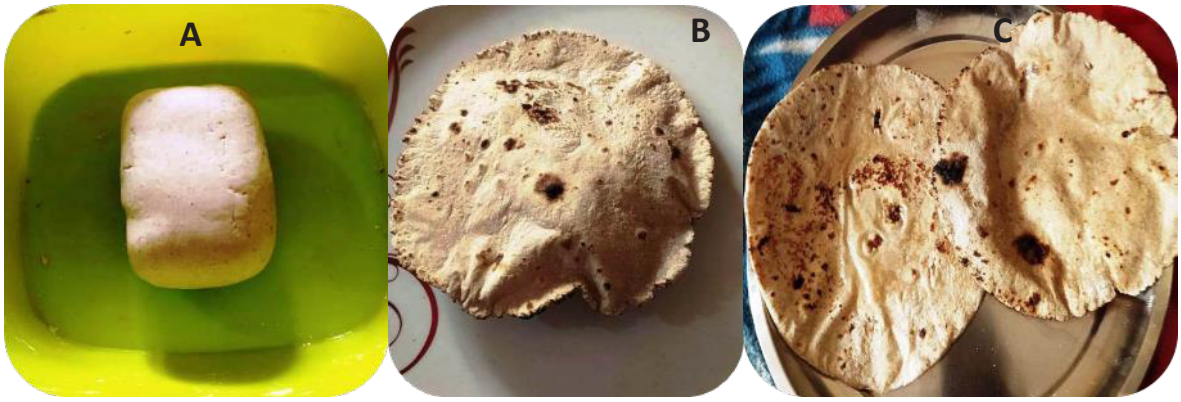

Fig. 2. *Roti* prepared from VL *Mandua* 382

A. Dough of VL Mandua 382 mixed with gethi bark powder.
B. Puffedroti made from VL Mandua 382.
C. Roti prepared from wheat flour (left) and roti prepared from white ragi VL Mandua 382 (right).

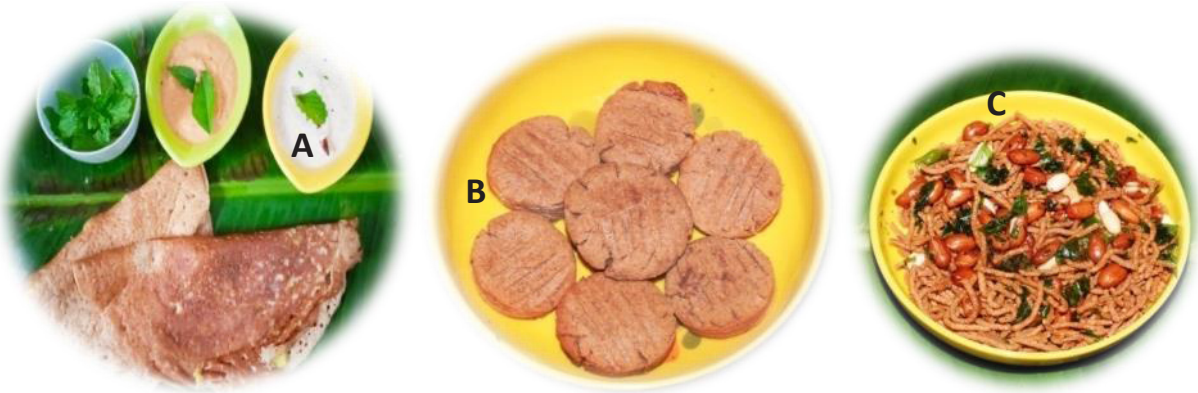

Fig. 3. Value added products of VL *Mandua* 382. A. *Dosa.* B. Biscuits. C. *Namkeen*

In the Himalayan region, finger millet is mainly consumed in the form of *roti.* However, the dark physical appearance and poor puffing quality of *roti* prepared from brown finger millet grains limit its wide acceptability among the masses. This drawback/disadvantage may be addressed by replacing dark colour flour of traditional finger millet with white flour of VL *Mandua* 382 and by adding a small quantity of dry bark powder of a tree locally known as *Gethi* (*Boehmeria rugulosa* Wedd.) (Khulbe *et al.,* 2014). The white grains provide a better physical appearance to the dough, while the addition of *gethi* bark powder imparts its puffability just like *rotis* prepared from wheat flour (**Fig. 2**). Similarly, other value added products such as biscuits, *namkeen,* doughnuts and *dosa* with better taste and physical appearance (**Fig. 3**) can help in the promotion of white seeded finger millet variety among the consumers. In view of the speciality trait (white grains), superior grain quality (high protein and calcium), early maturity duration and matching yield potential with brown seeded check varieties, VL *Mandua* 382 was released as the first white seeded finger millet variety suitable for rainfed and organic ecology of hills. This would fulfil the long felt need of the farmers of the lower and mid hills of Uttarakhand where brown seeded varieties are predominantly grown under rainfed and organic conditions. The large scale demonstration of the variety and its value added products will enhance its adoption rate among the farmers and acceptability among the consumers.

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