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Research Article

A new high yielding proso millet variety (*Panicum miliaceum* L.): PMV 442

C. Nandini*, Sujata Bhat , Prabhakar , Jayaramegowda, M. Krishnappa, S. Srinatha Reddy, Prabhu C. Ganiger, K. B. Palanna , T. S. Sukanya, B. Boraiah, Kiran, T. Lavanya Bai and N. Vinay

Project Coordinating Unit on Small millets, AICRP on Small millets, University of Agricultural Sciences, GKVK, Bengaluru-560065, Karnataka, India
***E-Mail:** nandini.vinutha@gmail.com

Abstract
A high yielding short duration new proso millet variety GPUP 25 was developed at Project Coordinating Unit, AICRP on Small Millets, University of Agricultural Sciences, GKVK, Bengaluru for cultivation in Karnataka and other states in India during 2019 at central level and released as PMV 442. This variety is a derivative of a cross GPMS 109 and GPMS 908 developed by recombining the desirable characteristics of both the parents. This new variety matures in 70-75 days and has erect plant type with dwarf stature (85-90 cm), non- lodging, narrow leaves. Panicle is semi compact and medium sized. The grains are bold, oval shape and gray in colour. The grain of this variety contains calcium (26.0 mg/100 g), iron (6 mg/100 g seed) protein (7.41 %), and crude fiber (9.72 g/100 g). The variety GPUP 25 showed 29.78 and 16.39 per cent increased seed yield over the local check GPUP 21 and National check TNAU 145 respectively in Station trials. Likewise, in All India Coordinated Trials PMV 442 (GPUP 25) has showed superior performance in grain yield over national checks GPUP 21, TNAU 151 and TNAU 164 by 12.99, 23.73 and 12.44 per cent, respectively at national level. This variety has been released and notified in 83rd meeting of Central Sub -Committee on Crop Standards, Notification and release of varieties for agricultural crops held on 4th October 2019. This variety is recommended for cultivation in Andhra Pradesh, Bihar, Karnataka, Tamil Nadu, and Telangana states.

Key words
Coordinated trials, Grain yield, Panicle, Proso millet, Variety

INTRODUCTION

Proso millet (*Panicum miliaceum* L.) is one of the important small millets, commonly known as broomcorn millet, common millet, hog millet, Russian millet, and by other names in different regions. Proso millet is a warm-season annual grass, grows at a wide range of altitudes, with a short growth cycle and can complete its life cycle within 60-100 days (Rao, 1989; Baltensperger, 2002). Proso millet is highly drought- resistant, which makes it of interest to regions with low water availability and longer periods without rain (Ceccarelli and Grando, 1996).

Proso millet is grown in northern China, Mongolia, Republic of Korea, South Eastern Russia, Afghanistan, Pakistan, India, and Southern Europe. Among the millet species produced worldwide, proso millet is the most important species traded in the world market. Proso millet is used for feeding birds and livestocks in developed countries and for food in some parts of Asia (Rajput *et al*., 2014). In India proso millet is largely grown in Madhya Pradesh, Eastern Uttar Pradesh, Bihar, Tamil Nadu, Maharashtra, Andhra Pradesh and Karnataka. In India it is cultivated over an area of 0.41 lakh ha with total production of about 0.22 lakh tones and with productivity of 531 kg/ha during the year 2015-16.

Nutritionally, proso millet grains are rich in protein which ranges from 11.3 to 17 per cent of grain dry matter and its grains are richer in essential amino acids (leucine,

isoleucine and methionine) than those of wheat (Saleh *et al*., 2013). It is also rich in dietary fiber (14.2 g/100 g seed) and micro nutrients *viz*., iron, zinc and potassium (Demirbas 2005, Gomeshe, 2017).Green plants are excellent fodder for cattle and horses and are also used as hay. Proso millet has been receiving growing interest from food industries in Europe and North America because of its mild flavor, light colour, gluten-free quality, and potential health benefits (Wang *et al*., 2016).

Genetic improvement and cultivar development of proso millet, has been achieved largely through direct selection of promising germplasm. In India, 24 cultivars have been released, of which seven were developed by hybridization followed by selection and the remaining by selection from landraces.

Generally lower yields in proso millet are due to lack of high yielding varieties and non adoption of improved cultural practices by the dry land farmers. There is a need to improve the genetic yield potentiality and evolve new high yielding varieties with shootfly resistance, suitable for proso millet growing areas. Keeping this objective in view, breeding work was initiated to evolve new high yielding proso millet varieties to promote cultivation of this crop in different agro climatic conditions. The new culture GPUP 25, derivative of a cross GPMS 109 and GPMS 908 developed by recombining the desirable characteristics of both the parents.

MATERIALS AND METHODS

The proso millet culture PMV 442 (GPUP 25) was evolved at Project Coordinating Unit, AICRP on Small Millets, University of Agricultural Sciences, GKVK, Bengaluru for cultivation in Karnataka and other states in India. It has been evolved through hybridization between two germplasm accessions GPMS 109 (early maturing, non pigmented plant type, glabrous pubescence, diffused inflorescence shape, open panicle with grey coloured seed) and GPMS 908 (high yielding, late maturing, strongly pubescence, globose shaped compact panicle, straw white coloured grains) followed by pedigree selection method.

The elite plants were selected from F_2 onwards and they were evaluated for their sustained yield ability and homozygosity and the GPUP 25 was found the best one among the selected lines. This culture was evaluated with local and national checks in station trials at Project Coordinating Unit, AICRP on Small Millets, University of Agricultural Sciences, GKVK, Bengaluru starting from 2014-2016 and All India Co-ordinated trials during 2016-19. Besides this, this culture was also screened for brown spot, leaf blight diseases and shoot fly incidence as per the standard scale.

Table 1. Performance of new variety PMV 442 (GPUP 25) in station trials.

Sl. No.	Trial Name	Variety PMV 442(GPUP 25)	GPUP 21(Local check)	TNAU 145 (National check)
1	Priliminary Yield Trial (2013-14)	35.28	28.45	30.20
2	Station Trial(2014-15)	34.00	30.24	32.10
3	Station Trial(2015-16)	39.84	25.39	31.45
	Mean	**36.37**	**28.03**	**31.25**
	% increase over checks		**29.78**	**16.39**

Table 2. Summary of seed yield (q/ha) of PMV 442 (GPUP 25) in All India Coordinated Varietal Trials

Year of testing	Name of the trial	No. of Trials	Variety	National check	National check	Latest released check	Qualifying variety
			PMV 442 (GPUP 25)	**GPUP 21**	**TNAU 151**	**TNAU 164**	**PMV 441 (TNPM 238)**
2016-17	IVT	5	18.25	18.22	17.2	-	19.62
2017-18	PAVT	5	18.14	17.51	16.09	18.42	18.22
2018-19	PIAVT	7	19.21	14.49	12.75	15.23	12.98
	Weighted Mean	**17**	**18.61**	**16.47**	**15.04**	**16.55**	**16.04**
			Per cent increase over the checks				
2016-17	IVT	5		0.16	6.10	-	-6.98
2017-18	PAVT	5		3.59	12.74	-1.52	-0.43
2018-19	PIAVT	7		32.57	50.60	26.13	47.99
	Weighted Mean	**17**		**12.99**	**23.73**	**12.44**	**12.99**

Table 3. Centre- wise and year -wise grain yield data of new variety PMV 442 (GPUP 25)

State	Centres	Year	Variety PMV 442 (GPUP 25)	Checks			Qualifying varieties
				National ceck GPUP21	National Check TNAU151	Latest released Check TNAU164	PMV 441 (TNPM 238)
Bihar	Dholi	2016-17	*	*	*	*	*
		2017-18	18.83	15.43	19.75	22.53	14.20
		2018-19	11.42	12.04	10.19	17.59	10.80
		Mean	**15.125**	**13.735**	**14.97**	**20.06**	**12.5**
		State mean	**15.125**	**13.735**	**14.97**	**20.06**	**12.5**
		% over check	**-**	**10.120**	**1.035**	**-24.60**	**21.0**
Tamil Nadu	Athiyandal	2016-17	20.14	18.97	20.92	-	19.88
		2017-18	28.97	26.39	23.48	20.37	26.12
		2018-19	21.43	25.07	25.53	22.82	23.02
		Mean	**23.51**	**23.47**	**23.31**	**21.595**	**23.00**
		State mean	**23.51**	**23.47**	**23.31**	**21.595**	**23.00**
		% over check	**-**	**0.17**	**0.858**	**8.86**	**2.21**
Karnataka	Bangalore	2016-17	17.78	16.35	11.16	-	16.44
		2017-18	-	-	-	-	-
		2018-19	28.05	20.49	9.63	18.91	21.88
		Mean	**22.91**	**18.42**	**10.395**	**10.91**	**19.16**
	Hagari	2016-17	14.37	14.48	13.26	-	14.78
		2017-18	7.22	10.04	9.74	11.85	12.41
		2018-19	23.33	20.74	23.44	24.48	14.78
		Mean	**14.97**	**15.42**	**15.48**	**18.165**	**13.99**
	Hanumana-matti	2016-17	15.91	16.20	12.62	-	14.12
		2017-18	*	*	*	*	*
		2018-19	*	*	*	*	*
		Mean	**15.91**	**16.20**	**12.62**	**-**	**14.12**
	Hiriyur	2016-17	-	-	-	-	-
		2017-18	-	-	-	-	-
		2018-19	14.88	13.93	5.65	7.14	4.40
		Mean	**14.88**	**13.93**	**5.65**	**7.14**	**4.40**
	Mean	2016-17	16.02	15.67	12.34	-	15.11
		2017-18	7.22	10.04	9.74	11.85	12.41
		2018-19	22.08	18.38	12.29	16.84	13.68
		Weighted State Mean	**17.16**	**15.99**	**11.03**	**14.73**	**12.91**
		% over check		**7.31**	**55.57**	**16.49**	**32.92**
Andhra Pradesh	Guntur	2016-17	23.05	25.10	28.02	-	32.89
		2017-18	*	*	*	*	*
		2018-19	*	*	*	*	*
		Mean	23.05	25.10	28.02	-	32.89
	Nandyal	2016-17	-	-	-	-	-
		2017-18	¤	¤	¤	¤	¤
		2018-19	16.17	5.49	10.25	10.56	11.79
	Mean	2016-17	23.05	25.10	28.02	-	32.89
		2017-18	-	-	-	-	-
		2018-19	16.17	5.49	10.25	10.56	11.79
		State mean	**19.61**	**15.295**	**19.135**	**10.56**	**22.34**
		% over check	**-**	**28.21**	**2.48**	**85.70**	**-12.22**
Telangana	Palem	2016-17	-	-	-	-	-
		2017-18	18.00	20.44	12.59	21.33	22.37
		2018-19	-	-	-	-	-
		Mean	**18.00**	**20.44**	**12.59**	**21.33**	**22.37**
	IIMR, Hyderabad	2016-17	*	*	*	*	*
		2017-18	*	*	*	*	*
		2018-19	*	3.70	4.54	5.09	4.21
		Mean	**-**	**3.70**	**4.54**	**5.09**	**4.21**
	Mean	2016-17	-	-	-	-	-
		2017-18	18.00	20.44	12.59	21.33	22.37
		2018-19	*	3.70	4.54	5.09	4.21
		State mean	**18.00**	**12.07**	**8.565**	**13.21**	**13.29**
		% over check	**-**	**49.13**	**110.15**	**36.26**	**35.44**
Puducherry	Karaikal	2016-17	-	-	-	-	-
		2017-18	17.69	14.24	14.87	16.00	16.00
		2018-19	*	*	*	*	*
		Mean	17.69	14.24	14.87	16.00	16.00
		State mean	**17.69**	**14.24**	**14.87**	**16.00**	**16.00**
		% over check	**-**	**24.22**	**18.96**	**10.560**	**10.560**

*Trial vitiated
¤ Trial rejected due to high CV %

RESULTS AND DISCUSSION

The seed yield data of proso millet culture GPUP 25 along with local check GPUP 21 and national check TNAU 145 in preliminary yield trial (2013-14) and station trials during 2014-16 was presented in **Table 1**. The cultivar GPUP 25 recorded a mean seed yield of 36.37 q/ha compared to the local check GPUP 21 (28.03 q/ha) and a national check TNAU 145 (31.25 q/ha). The variety GPUP 25 showed 29.78 and 16.39 per cent increased seed yield over the local check GPUP 21 and National check TNAU 145 ,respectively. In All India Co-Ordinated Trials, the cultivar GPUP 25 was tested in Initial varietal trial during 2016-17 and Advanced Varietal Trials during 2017-18 and 2018-19.

Across the locations over three years the variety PMV 442 (GPUP 25) has recorded grain yield of 18.61q/ ha. National checks GPUP 21, TNAU 151 and TNAU 164 recorded grain yield of 16.47 q/ha, 15.04 q/ha and 16.55 q/ha respectively. Similarly PMV 442 (GPUP 25) has showed superior performance over national checks GPUP 21, TNAU 151 and TNAU 164 by 12.99, 23.73 and 12.44 per cent, respectively at national level. Summary grain yield data of Coordinated Varietal Trials (2016-18) were presented in **Table 2**.

This variety has given 12.99 per cent increased grain yield over the qualifying variety PMV 441 (TNPM 238) in All India Coordinated Trials. This new variety yields on an average of 3.75 t/ha of straw yield under rain fed condition. Because of its increased yield superiority variety PMV 442 (GPUP 25) has been identified by Varietal Identification Committee in the 30th Annual Group Meeting of ICAR-AICRP on small millets on 7th & 8th march 2019. Further this variety has been released and notified in 83rd meeting of Central Sub -committee on Crop Standards, Notification and release of varieties for agricultural crops held on 4th October 2019.

Centre- wise and year -wise grain yield data of GPUP 25 is presented in **Table 3**. Variety PMV 442 (GPUP 25) registered a grain yield of 28.21, 2.48 and 85.70 per cent in Andhra Pradesh; 7.31, 55.57 and 16.49 per cent in Karnataka; 0.17, 0.85 and 8.86 per cent in Tamil Nadu, 49.13, 110.15 and 36.26 per cent in Telangana, over national checks GPUP 21, TNAU 151 and TNAU 164, respectively. This variety produced 10.12 and 1.03 per cent increased grain yield over checks GPUP 21 and TNAU 151, respectively at Bihar state. As compared with qualifying variety PMV441, PMV 442 (GPUP 25) showed grain yield superiority of 21.0, 32.92, 2.21 and 35.44 per cent in states *viz.,* Bihar, Karnataka, Tamil Nadu and Telangana, respectively. Because of superior performance of this variety in these states variety has been recommended for Andhra Pradesh, Bihar, Karnataka, Tamil Nadu, and Telangana for cultivation.

Across the locations the variety PMV 442 (GPUP 25) exhibited grain yield of 1375 kg/ha which was found 31.2, 39.03 and 39.61 per cent higher than national check TNAU 164, TNAU 202 and qualifying variety PMV 441 (TNPM 238), respectively. Summary of grain and straw yield data of Agronomic Trial (2018) is presented in **Table 4.**

Table 4. Summary grain and straw yield data of Agronomic Trial (2018)

Variety: PMV 442 (GPUP 25)			Adaptability Zone: National Production condition: Rain-fed							
Name of Expt.	**Item**	**Fertilizer dose**	**Variety**		**National Checks**				**Qualifying Varieties**	
			PMV 442 (GPUP 25)		**TNAU164**		**TNAU 202**		**PMV 441 (TNPM238)**	
			Grain	**Straw**	**Grain**	**Straw**	**Grain**	**Straw**	**Grain**	**Straw**
Fertilizer experiment	Grain yield (kg/ha) under recommended dose	**F_2 100%RDF**	1362	2174	974	2184	874	2103	909	1988
		F_1 75%RDF	1211	2134	937	2106	811	1909	791	1890
		F_3 125%RDF	1553	2119	1232	2268	1282	2185	1256	2185
		Mean	**1375**	**2142**	**1048**	**2186**	**989**	**2066**	**985**	**2021**

Under agronomic trial new variety recorded increased straw yield of 6.52 and 13.46 per cent over check TNAU 164 and qualifying variety PMV 441 (TNPM 238), respectively.

Variety GPUP 25 showed fewer incidences than check GPUP 21 for disease reaction to leaf blight (5.00) and also it showed fewer incidences than check TNAU 151 and qualifying variety PMV 441 (TNPM 238) for brown spot disease (2.5). PMV 442 (GPUP 25) exhibited less infestation of shoot fly than the national checks TNAU 151(27.62) and TNAU 164 (28.87) and qualifying variety PMV 441 (TNPM 238) (27.66). Reaction to diseases and insect pests were represented in **Table 5 and 6** respectively.

Table 5. Reaction to major diseases

Variety: PMV 442 (GPUP 25)			Adaptability Zone : National Production condition: Rainfed				
Disease name	Screening condition	Year	Variety	National Checks			Qualifying Varieties
			PMV 442 (GPUP 25)	GPUP21	TNAU151	TNAU 164	PMV 441 (TNPM 238)
Leaf blight (G)	Natural	2016-17	-	-	-	-	-
		2017-18	2.67	4.33	4.0	3.33	3.33
		2018-19	7.33	6.0	5.33	5.00	5.67
		Mean	**5.00**	**5.16**	**4.66**	**4.16**	**4.5**
Brown spot (G)	Natural	2016-17	4.00	4.00	3.00	-	5.00
		2017-18	-	-	-	-	-
		2018-19	1.00	1.00	1.00	2.00	1.67
		Mean	**2.50**	**2.50**	**2.00**	**2.00**	**3.33**

Table 6. Reaction to Insect Pests

Variety:PMV 442 (GPUP 25)				Adaptability Zone : National Production condition: Rainfed			
Insect name	Screening condition	Year	Variety	National Checks			Qualifying Varieties
			PMV 442 (GPUP 25)	GPUP21	TNAU151	TNAU 164	PMV 441 (TNPM 238)
Shoot fly(% incidence)	Natural	2016-17	28.00	23.00	28.00	-	25.00
		2017-18	13.63	11.55	14.44	23.33	22.55
		2018-19	37.28	32.55	40.44	34.61	35.44
		Mean	**26.30**	**22.36**	**27.62**	**28.97**	**27.66**

Table 7. Grain quality characteristics of new variety PMV 442 (GPUP 25)

S. No	Nutritional Quality characteristics	Variety PMV 442 (GPUP 25)	Check 2 TNAU 164
1.	Protein (g/100g)	7.41	9.76
2.	Crude fiber (g/100g)	9.72	10.56
3.	Calcium (mg/100g)	26.0	25.0
4.	Iron (mg/100g)	6.00	7.00

Table 8. Descriptors of variety PMV 442 (GPUP 25)

Sl. No.	Characters	Description
1	Growth habit	Erect
2	Basal tillers: Number	Medium
3	Days to 50 % flowering (days)	40
4	Ligule: Pubescence	Present
5	Plant height (cm)	85 cm
6	Plant pigment	Absent
7	Culm branching	Absent
8	Panicle : Compactness	Intermediate
9	Colour of the leaves	Green
10	Seed : Shattering	Absent
11	Lodging	Absent
12	Grain colour	gray
13	Grain shape	Oval

This new variety matures in 70-75 days and has erect plant type with dwarf stature (85-90cm), non- lodging, narrow leaves. Panicle is semi compact and medium sized. The grains are bold, oval shape and gray in colour with test weight of 6.58 g. This variety is suited for *kharif* season under rainfed conditions. Descriptors of the new variety PMV 442 (GPUP 25) is presented in **Table 7**. Field view of new variety GPUP 25 and its seed is depicted in **Fig. 1 and Fig. 2**, respectively.

PMV 442 (GPUP 25) noticed more grain calcium (26.0 mg/100 g) content compared to the check TNAU 164. This variety has iron content of 6 mg/100 g of seed, 7.41 per cent protein, and 26.0 mg/100 g of calcium and 9.72 g/100 g of crude fiber. Grain quality characteristics of variety PMV 442 (GPUP 25) over national check TNAU 164 is presented in **Table 8**.

Fig.1. Field view of new variety PMV 442 (GPUP 25)

Fig.2. Seeds of new variety PMV 442 (GPUP 25)

New variety PMV442 (GPUP 25) along with check varieties *viz*., GPUP 21 and TNAU 151 were used for DNA finger printing using SSR markers. Five SSR markers *viz*., GB-PMM-134, GBPMM-085, PVCA 639-640, PVCA 309-310 and GB-PMM-111 were differentiated between variety PMV442 (GPUP 25) and check varieties. Gel picture depicting polymorphism between new variety and check varieties were depicted in **Fig 3**. Details of Primers which showed polymorphism is presented in **Table 9**.

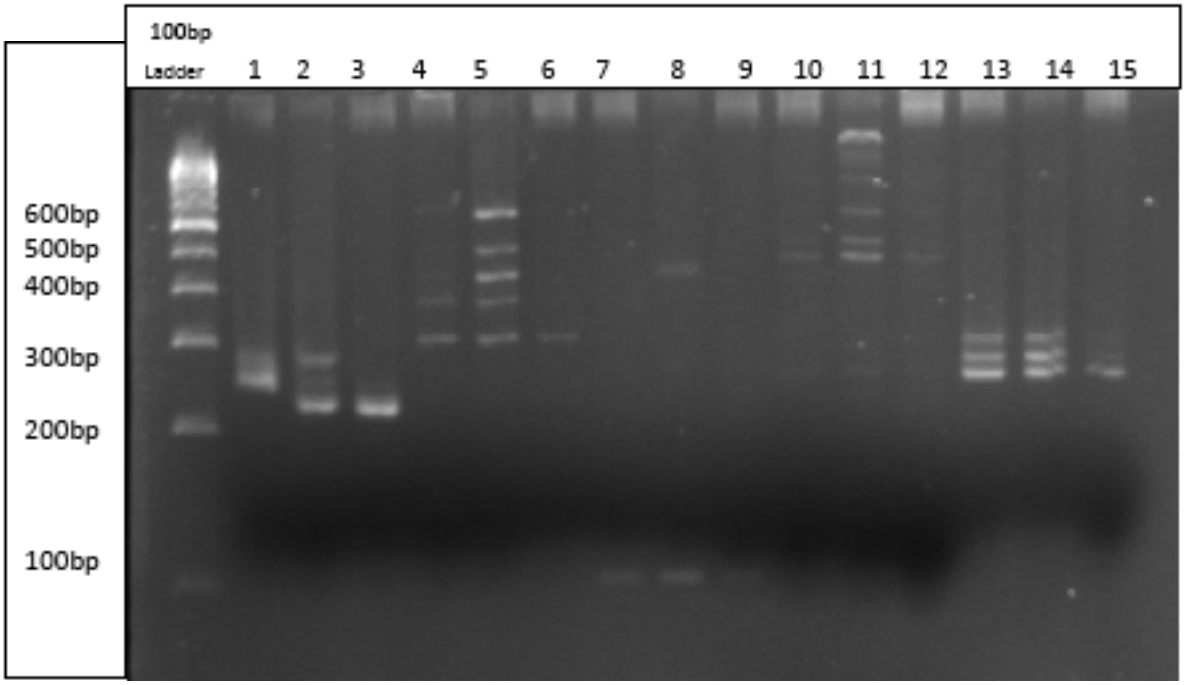

Fig. 3. Gel picture depicting polymorphism between new variety PMV 442 (GPUP 25) and check varieties GPUP 21 and TNAU 151 with 5 SSR Markers

Lane	Primer Name	Lane 1, 4, 7, 10, 13: variety PMV 442
Lane: 1, 2, 3	GB-PMM-134	Lane 2, 5, 8, 11, 14: Check variety GPUP 21
Lane : 4, 5, 6	GBPMM-085,	Lane 3, 6, 9, 12, 15: Check variety TNAU 151
Lane : 7, 8, 9	PVCA 639-640,	
Lane: 10, 11, 12	PVCA 309-310	
Lane: 13, 14, 15	GB-PMM-111	

Table 9. Details of polymorphic Primers used in DNA finger printing of variety GPUP 25

Sl .No.	Primer Name	Sequence
1	GB-PMM-134	F: CAGGCTCTGGCAAAGATG R: CAAGGTCAGGGGAACCAT
2	GBPMM-085,	F: CAGCCCATCACACTCGAT R: CTTCTTCGTCGTCCCTCC
3	PVCA 639-640,	F: ATCAGTTACGACCGTGACCA R: TTGGTAAGTTCGCCACACTC
4	PVCA 309-310	F: GAGAGGAGAGCCTTCTTGGA R: CATATGTGTGTTTGGCGTGA
5	GB-PMM-111	F: GTTCGAGGCTGATGCAAG R: CGCATCACACGTCACATC

At national level across the locations over the three years, this variety PMV 442 (GPUP 25) produced a significantly higher grain yield than the national checks TNAU 164, TNAU 151 and GPUP 21 in all proso millet growing areas of India. This new variety is dwarf stature, non lodging and short duration. Grains are bold and gray in colour. Besides this it showed moderately resistant to brown spot and moderately tolerant to shoot fly damage. This variety exhibits a higher crude fiber and calcium content. Hence, this variety PMV 442 (GPUP 25) has been identified by Varietal Identification Committee in the 30th Annual Group Meeting of ICAR-AICRP on small millets on 7th & 8th march 2019. Further this variety has been released and notified in 83rd meeting of Central Sub -Committee on Crop Standards, Notification and release of varieties for agricultural crops held on 4th October 2019. NBPGR, New Delhi has issued IC No: 6292278 for this variety. GPUP 25 has been recommended for cultivation in Andhra Pradesh, Bihar, Karnataka, Tamil Nadu, and Telangana states.

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