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Research Article

A dual purpose, high yielding little millet (*Panicum sumatrense*) variety 'GV-4' (Ambika) for cultivation in Gujarat

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Abstract
The little millet variety 'GV-4' (Ambika) is a pure line selection from the local germplasm collected from the Dang District. A little millet variety 'GV-4' was tested as a genotype name 'WV-126'. 'WV 126' was tested under the various state trials found to be superior for grain yield (2933 kg/ha) by 21.20, 13.78, 44.39 and 31.44 per cent over the existing checks *i.e.* GV-2 (LC), GNV-3 (LC), CO-2 (NC) and OLM-203 (NC), respectively over thirteen trials and seven years (2014-15 to 2020-21) of study. The genotype matures in 120-125 days includes under medium duration variety. The genotype WV-126 has 9-10 branches per panicle and 35.5 cm average panicle length. It has special attributes of synchronized maturity and non-lodging growth habit. WV-126 is rich in calcium (17.1 mg/100g), protein (12.91 g/100g), fat (3.3 %), crude fiber (7.5 %), carbohydrates (70.40 g/100g) and minerals (2.7 g/100g). It is resistant to blast (leaf, neck and panicle) and moderately resistant to grain smut and sheath blight when compared to local check GV-2 and GV-3 and national check CO-2, OLM-203 and JK-8. A little millet variety 'GV-4' (Gujarat Vari-4) was released as a new variety for cultivation during *kharif* under rainfed conditions of Gujarat state.

Key words: Little millet, high yielding variety, yield attributing characters, nutritional quality etc.

INTRODUCTION

Little millet (*Panicum sumatrense* Roth. Ex Roemer and Schultes) is grown in India under varied agro-ecological situations. The small millets are grown over an area of around 1.88 million hectares in India of which little millet accounts for nearly 25 per cent of the area and the 1/3rd of the production of total small millets. In Gujarat, little millet is cultivated in an area of 9430 ha with average productivity of 1320 kg/ha. (Anonymous, 2019). Not with standing low contribution of these crops to the national food baskets, little millet offer enormous advantages such as early maturity, wide adaptation and high nutritive value of both grain and fodder (Joshi *et al.,* 2021 and Kumar *et al.,* 2021). These unique qualities have made them as a choice crop to rainfed, tribal and hill agriculture where options of crops are limited. Besides this now a day awareness regarding nutrition is increased which also increased the demand of small millets as a 'Nutricereal'. However, little millet is raised on lands where no other crop worth mentioning can give a reasonable quantity of nutritionally balanced grain and valuable straw yields (Paschapur *et al.,* 2021). It is a good source of protein, very rich in carbohydrates, fat, mineral and vitamins and should be considered as essential food for nutritional security (Patil *et al*., 2018).

Small millets are grown on diverse soil types in the area with a wide difference for thermo and photoperiod. The area under these crops in the country has come down substantially in the last 20 years and is probably going down further in coming years; particularly in other small

millets except finger millet. (Meena *et al.,*2021) Little millet is a hardy crop which can withstand drought better than most of the other cereal crops and water logging to a certain degree, also. In Gujarat, generally little millet crop is grown in a hilly tract of Dangs and Valsad district and locally known as 'Vari / Moreyo'. The productivity of other hill millets except for finger millet is low due to poor soil fertility and age-old cultivation methods. (Patil *et al.*, 2019).

The variety 'Gujarat Vari-1' (GV-1) released during 1995, 'Gujarat Vari-2' (GV-2) was identified during 2008 but both genotypes had long duration maturity with low yield. While the variety 'Gujarat Navsari Vari-3' (GNV-3) identified during 2016 was higher in yield but lower in fodder production. On account of these advantages, there is a need to enhance genetic yield potential and evolve a new high yielding variety for little millet growing areas in Gujarat. In view of this, Hill Millet Research Station, Waghai had selected this genotype 'WV-126' through pure line selection from the collection of local land races. The newly released variety 'GV-4' is high grain yielding, better fodder yielding, early to medium maturing, bold grain, multi tillering, moderately resistant to disease and pest, also assures reasonable economic return even under adverse growing conditions of Gujarat. GV-4 (Ambika) is a good source of protein, very rich in carbohydrates, fat, minerals, vitamins and may be useful as essential food for nutritional security. Considering the present need, a high grain as well as fodder yielding with diseases and pest resistance new genotype 'Gujarat Vari-4' (AMBIKA) is released for commercial cultivation during 2021.

MATERIALS AND METHODS

The little millet genotype 'WV-126' was evolved at Hill Millet Research Station, Navsari Agricultural University, Waghai, Dangs, Gujarat and released as Gujarat Vari-4 (GV-4). It is a pure line selection from the germplasm accession. A single plant with desirable traits and high yield with medium maturing and resistant to Blast (Leaf, Neck and Panicle) and moderately resistant to grain smut and sheath blight was selected from the germplasm accession and was forwarded as a single plant to progeny rows. The promising culture was evaluated over seven years at Waghai location with checks including multilocation trials at Waghai, Vanarasi and Dahod starting from 2017-18 to 2020-21 and also tested in All India Co-ordinated trials under AICRP-Small millets in five states across eight locations from 2016-17 to 2018-19. The reaction of the cultures against important pests and disease was also screened and as per the standard procedures, the grain qualities were analyzed. The pedigree flow chart of little millet variety 'GV-4' (Ambika) is given in **Fig. 1.**

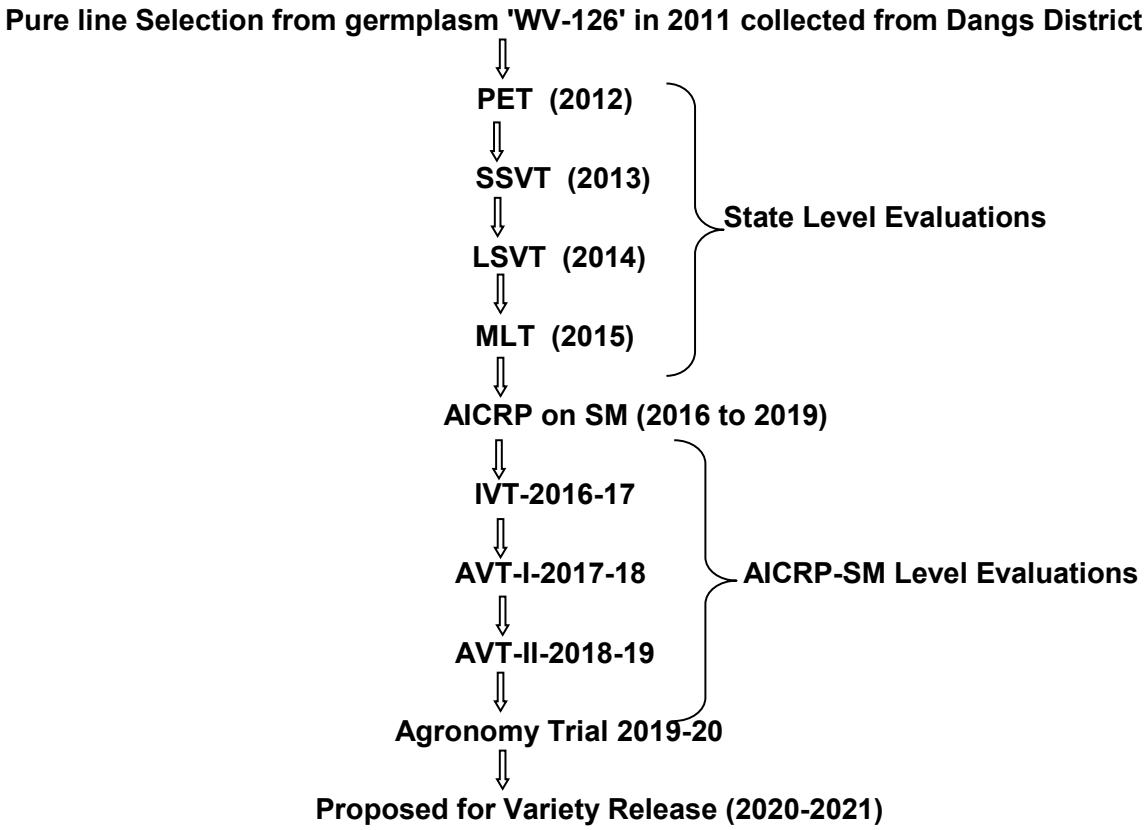

Fig. 1. Pedigree chart of Little millet variety GV-4 developed from genotype 'WV 126'

RESULTS AND DISCUSSION

The evaluation trial data of 'WV-126' along with local and national checks under station trials at Hill Millet Research Station, Navsari Agricultural University, Waghai, Dangs; Agricultural Research Station, NAU, Vanarasi and Agricultural Research Station, AAU, Dahod are presented in **Table 1**. The WV-126 was tested in station trials at Waghai from 2014-15 to 2015-16 and LSVT at Waghai, Vanarasi and Dahod locations from 2016-17 to 2020-21. In these trials, the WV-126 recorded an average grain yield of 2933 kg/ha whereas, the local check GV-2 and GNV-3 recorded 2420 kg/ha and 2578 kg/ha, respectively. While, national check CO-2 and OLM-203 recorded 2032 kg/ha and 2232 kg/ha grain yield, respectively which is 21.2 and 13.78 per cent increased yield over a local check and 44.39 and 31.44 per cent increased yield over national check CO-2 and OLM-203, respectively (**Table 1**). In all India, co-ordinated trials under the AICRP-Small millet networking projects during 2016-17 to 2018-19 at five states across eight locations *viz;* Andhra Pradesh, Gujarat, Jharkhand, Maharashtra and Odisha, the culture WV-126 gave 1581 kg/ha grain yield which was 23.6, 32.1 and 79.0 per cent increase over the national checks OLM-203, BL-6 and JK-8, respectively (**Table 2a**).

Also, WV-126 was found to be superior in fodder yield by producing 7397 kg/ha over existing national checks BL-6 by 10.2 per cent and JK-8 by 40.1 per cent in All India Coordinated trials conducted at Andhra Pradesh, Gujarat, Jharkhand, Maharashtra and Odisha**.** (**Table 2b**).The WV-126 topped the list at the state level as well as national level, provided with significantly higher in grain as well as fodder yield compared to the checks under *kharif* sown situations at Andhra Pradesh, Gujarat, Jharkhand, Maharashtra and Odisha. Sood *et al.*(2016) in the identification of white finger millet genotypes, Nandini *et al.* (2021) in the release of proso millet variety PMV 442, Intwala *et al.* (2017) in the release of finger millet variety GNN-6 and Patil *et al.* (2017) in the release of little millet variety GNV-3 also reported significant yield improvement in the new varieties as compared to pre-existing ones. Blast and grain smut are the major diseases of little millet crops. At state as well as National level evaluations, the genotype WV-126 is resistant to blast (Leaf, Neck and Panicle) and moderately resistant to grain smut and sheath blight (**Table 3a and 3b**) when sown in normal growing *kharif* season. Similarly, the culture WV-126 is also tolerant to shoot-fly incidence at first 21 DASE and 28 DASE, at state as well as National level screening under AICRP-Small millets (**Table 4a and 4b**).

Table 1. Comparative year wise performance of little millet culture 'WV-126' for grain yield in comparison with check varieties in Gujarat state.

Name of the experiment and year	Location	Proposed Entry WV-126	Check Varieties Grain Yield (kg/ha)				S.Em ±	CD at 5 %	CV %
			GV-2 (LC)	GNV-3 (LC)	CO-2 (NC)	OLM-203 (NC)			
SSVT-2014-15	WAG	2930 [a]	3119	--	2062	--	207	627	15.4
SSVT- 2015-16	WAG	2907 [a]	2486	--	1033	--	148	450	12.8
LSVT- 2016-17	WAG	3381 [ab]	2693	--	2802	--	131	398	7.5
LSVT- 2017-18	WAG	2388 [a]	2369	2789	1745	--	138	419	10.7
	Vanarasi	2038 [a]	1913	1972	1559	--	97	294	10.9
LSVT- 2018-19	WAG	2772 [abd]	2347	2551	2183	1833	140	416	9.3
	Vanarasi	3122 [abcd]	2473	2607	1864	1582	105	313	10.2
LSVT- 2019-20	WAG	3135 [abd]	2183	2718	2059	2590	165	493	11.7
	Vanarasi	3041 [abd]	2147	2586	2054	2105	175	520	12.9
	Dahod	3035 [abd]	2183	2684	2135	2524	153	455	10.8
LSVT- 2020-21	WAG	3205 [abd]	2560	2815	2410	2450	146	429	8.14
	Vanarasi	3055 [abd]	2450	2610	2255	2260	173	514	12.62
	Dahod	3125 [abcd]	2540	2450	2250	2510	124	369	8.61
Overall Mean		**2933**	**2420**	**2578**	**2032**	**2232**			
Overall % increase over checks			**21.2**	**13.78**	**44.39**	**31.44**			

Note: [a] significantly superior over GV-2 (LC)
[b] significantly superior over GNV-3 (LC)
[c] significantly superior over CO-2 (NC)
[d] significantly superior over OLM-203 (NC)

Table 2a. State wise– centre wise data on grain yield (kg/ha)

Name of the State	Name of the Centre	Year of testing	LMV-512 (WV-126)	National Check Varieties			CD at 5 %	CV %
				OLM- 203	BL-6	JK-8		
Andhra Pradesh	Vizianagaram	2016-17	985	1138	1396	1065	272	13.22
		2017-18	1997[abc]	840	1369	1085	335	16.81
		2018-19	1144[bc]	1409	992	985	248	13.62
		Mean	**1375**	**1129**	**1252**	**1045**	--	--
	Guntur	2016-17*	--	--	--	--	--	--
		2017-18	392	375	917	649	106	12.6
		2018-19*	--	--	--	--	--	--
		Mean	**392**	**375**	**917**	**649**	--	--
	Perumallapalle	2016-17	--	--	--	--	--	--
		2017-18	1969[abc]	741	1046	292	162	9.81
		2018-19	1352[bc]	1657	1131	884	243	10.54
		Mean	**1661**	**1199**	**1089**	**588**	--	--
	State Mean		**1307**	**1027**	**1142**	**827**	--	--
Gujarat	Waghai	2016-17	3479[abc]	2352	1487	613	359	10.47
		2017-18	2269[b]	2685	1396	2566	424	12.25
		2018-19	2662[abc]	1916	1546	444	317	10.59
		Mean	**2803**	**2318**	**1476**	**1208**	--	--
Jharkhand	Ranchi	2016-17	--	--	--	--	--	--
		2017-18	556[abc]	216	216	71	161	16.18
		2018-19	426[b]	358	42	457	136	17.19
		Mean	**491**	**287**	**318**	**584**	--	--
Maharashtra	Kolhapur	2016-17	975	1037	1444	1019	276	12.22
		2017-18	1179	1185	1142	1253	164	8.53
		2018-19	--	--	--	--	--	--
		Mean	**1077**	**1111**	**1293**	**1136**	--	--
	Igatpuri	2016-17	--	--	--	--	--	--
		2017-18	1250	1407	1157	1111	141	7.26
		2018-19	1870[abc]	1093	969	1451	277	10.61
		Mean	**1560**	**1250**	**1063**	**1281**	--	--
	State Mean		**1319**	**1181**	**1178**	**1209**	--	--
Odisha	Berhampur	2016-17	2035[abc]	1358	1531	523	425	18.87
		2017-18	1916[c]	1679	1669	785	408	19.74
		2018-19	1151[ac]	914	1022	499	218	15.62
		Mean	**1701**	**1317**	**1407**	**602**	--	--
	Overall mean (Five States-18 locations)		**1581**	**1279**	**1197**	**883**		
	% increase over checks			**23.6**	**32.1**	**79.0**		

Note: [a] significantly superior over OLM-203, [b] significantly superior over BL-6 and [c] significantly superior over JK-8 * * **data not considered for analysis.**

Table 2b.State wise– centre wise data on straw yield (q/ha)

State	Centre	Year of testing	LMV-512 (WV-126)	Check Varieties		
				OLM 203	BL 6	JK 8
Andhra Pradesh	Vizianagaram	2016-17	125.33	117.66	70.63	103.90
		2017-18	71.16	54.63	81.88	43.12
		2018-19	75.73	75.33	71.49	40.15
		Mean	**90.74**	**82.54**	**74.67**	**62.39**
	Guntur	2016-17	--	--	--	--
		2017-18	17.01	55.59	33.47	19.93
		2018-19	--	--	--	--
		Mean	**17.01**	**55.59**	**33.47**	**19.93**
	Perumallapalle	2016-17	--	--	--	--
		2017-18	108.19	154.45	100.58	43.60
		2018-19	55.17	78.30	44.18	27.16
		Mean	**81.68**	**116.38**	**72.38**	**35.38**
	State Mean		**75.43**	**89.33**	**67.04**	**46.31**
Gujarat	Waghai	2016-17	102.61	107.89	95.63	90.73
		2017-18	103.24	158.47	59.26	31.28
		2018-19	92.84	95.36	50.86	12.25
		Mean	**99.56**	**120.57**	**68.58**	**44.75**
Jharkhand	Ranchi	2016-17	--	--	--	--
		2017-18	132.72	131.48	151.85	69.14
		2018-19	84.88	148.15	112.65	81.79
		Mean	**108.80**	**139.82**	**132.25**	**75.47**
Maharashtra	Kolhapur	2016-17	12.28	13.21	18.40	12.96
		2017-18	--	--	--	--
		2018-19	--	--	--	--
		Mean	**12.28**	**13.21**	**18.40**	**12.96**
	Igatpuri	2017-18	15.74	23.89	19.63	18.80
		2017-18	--	--	--	--
		2018-19	--	--	--	--
		Mean	**15.74**	**23.89**	**19.63**	**18.80**
	State Mean		**14.01**	**18.55**	**19.02**	**15.88**
Odisha	Berhampur	2016-17	86.47	66.57	73.09	32.35
		2017-18	53.04	60.20	65.48	37.68
		2018-19	34.67	27.95	29.58	15.60
		Mean	**58.06**	**51.57**	**56.05**	**28.54**
	Overall mean (Five States)		**71.17**	**81.97**	**68.59**	**42.19**

Table 3 a. Reaction of WV- 126 against diseases at Waghai location for the year 2017- 18 to 2019-2020.

S. No.	Name of entry	Reaction to blast disease (%)								Reaction to grain smut									
		Leaf Blast				Neck blast				Grain smut (GS)			Grain smut severity (%)			Severity index			
		2017	2018	2019	DR	2017	2018	2019	DR	2017	2018	2019	2017	2018	2019	2017	2018	2019	DR
1.	WV- 126	8.17	8.10	8.24	R	3.22	4.44	4.67	R	0.66	0.33	0.00	0.15	0.28	0.17	0.32	0.28	0.12	R
2.	GV-2 LC	7.63	9.50	8.37	R	3.41	3.70	4.23	R	0.33	1.00	1.67	0.30	0.50	0.40	0.92	0.52	0.42	R
3.	GNV- 3 LC	7.77	8.85	8.07	R	3.45	3.50	3.04	R	1.33	2.00	3.66	1.60	1.20	1.40	2.25	2.40	0.78	R
4.	CO-2 NC	9.55	10.50	11.78	MR	5.20	4.80	2.99	R	2.00	1.66	0.33	0.55	0.65	0.90	0.88	0.95	0.99	R
5.	OLM-203 NC	10.66	11.25	11.93	MR	5.64	4.80	4.56	R	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	HR
6.	JK-8 NC	10.33	8.60	12.75	MR	4.41	3.85	3.41	R	28.33	27.83	36.33	8.50	6.50	7.80	14.50	20.25	11.12	S

Note: Leaf sheath occurrence at waghai location is very low, hence data was not considered for further analysis.

Table 3 b. Reaction of WV- 126 to diseases in AICRP-SM project

Parameters	Year of testing	Number of trials/ locations	Proposed variety LMV-512 (WV-126)	National Checks		
				OLM-203	BL-6	JK-8
Cercospora Leaf Spot	2017-18	1	4.25	5.83	6.11	6.67
	Scale		**2**	**2**	**3**	**3**
Brown spot (G)	2016-17	3	3.00	3.11	3.67	3.72
	2017-18	2	3.99	1.45	0.50	1.00
	2018-19	1	2.00	1.67	1.00	1.67
	Mean	**06 (Total)**	**3.00**	**2.08**	**1.72**	**2.13**
	Scale		**2**	**2**	**2**	**2**
Banded blight (PDI)	2016-17	5	36.00	26.00	26.00	20.00
	2017-18	5	59.78	48.82	43.09	48.83
	2018-19	3	29.85	39.46	22.23	34.82
	Mean	**13 (Total)**	**41.88**	**38.09**	**30.44**	**34.55**
	Scale		**2**	**2**	**2**	**2**
Grain smut (%)	2016-17	2	0.00	0.00	0.00	13.00
	2017-18	1	0.00	0.00	0.00	51.97
	Mean	**03 (Total)**	**0.00**	**0.00**	**0.00**	**32.49**
	Scale		**1**	**1**	**1**	**4**

Table 4 a. Reaction to major pests in AICRP-SM level

Parameters	Year of testing	Number of trials / locations	Proposed variety LMV-512 (WV-126)	National Checks		
				OLM-203 (NC)	BL-6 (NC)	JK-8 (NC)
Shoot fly damage (% dead-heart 21 DASE).	2017-18	4	6.03	10.70	6.82	11.69
	2018-19	4	10.52	11.37	13.32	12.62
	Mean	**8 (Total)**	**8.28**	**11.04**	**10.07**	**12.16**
		Scale	**2**	**2**	**2**	**2**
Shoot fly damage (% dead-heart 28 DASE).	2016-17	4	22.00	11.00	12.00	12.00
	2017-18	4	9.70	19.47	12.44	14.72
	2018-19	5	13.6	9.75	18.65	15.14
	Mean	**13 (Total)**	**15.10**	**13.41**	**14.36**	**13.95**
		Scale	**2**	**2**	**2**	**2**

Table 4 b. Reaction of WV-126 against pests of little millet at waghai, Gujarat

S. No.	Name of entry	Shoot fly damage (% dead heart)	
		21 DASE	28 DASE
1.	WV-126	5.25	5.75
2.	GV-2 (LC)	6.22	6.84
3.	GNV-3 (LC)	5.65	5.78
4.	CO-2 (NC)	7.26	8.04
5.	OLM-203 (NC)	9.16	11.25
6.	JK-8 (NC)	7.14	8.02

Table 5. Nutritional value / data on quality characteristics of WV-126 (GV-4) compared to local and national checks.

S. No.	Quality parameters	Proposed variety WV-126	Local variety GNV-3	National Check OLM-203	National Check JK-8
Parameters					
a)	**Nutritional Quality**				
1.	Protein (g/100g)	12.91	12.70	12.5	11.81
2.	Carbohydrate(g /100g)	70.40	71.5	71.7	72.3
3.	Crude fiber (%)	7.5	7.7	7.7	6.1
4.	Crude fat (%)	3.3	3.3	3.4	3.3
5.	Mineral matter (g/100g)	2.7	2.4	2.1	2.3
6.	Calcium (mg/100g)	17.1	16.8	17.0	16.5
7.	Iron (mg/100g)	11.60	11.40	11.50	11.30
8.	1000 grain weight (g)	2.28	2.10	2.24	1.33
b)	**Sensory evaluation score (1-10 score) and Milling value**				
1.	Colour & appearance	9.5	9.0	9.0	8.0
2.	Flavour	9.5	9.0	9.5	8.0
3.	Texture	10.0	9.5	8.0	8.5
4.	Taste	9.5	9.0	9.5	8.0
5.	Grain Shape	Oval	Oval	Oval	Oval
6.	Grain Size	Bold	Bold	Medium Bold	Medium Bold
7.	Milling value (%) (Decortications value)	72.50	71.50	70.00	64.50

Table 6. Descriptive morphological characters of WV-126 (GV-4) with local checks as per DUS test

S. No.	Morphological traits	WV-126	GNV-3 (LC)	OLM-203 (NC)
1.	Plant Growth Habit	Erect	Erect	Erect
2.	Basal tillers: Number	Medium (10-20)	Medium (10-20)	Medium (10-20)
3.	Days to 50 % Flowering	Late (more than 60)	Late (more than 60)	Late (more than 60)
4.	Plant pigmentation at leaf sheath	Absent	Absent	Present
5.	Leaf sheath pubescence	Absent	Absent	Present
6.	Ligule blade pubescence	Absent	Absent	Absent
7.	Leaf blade pubescence	Absent	Absent	Present
8.	Inflorescence shape	Arched	Arched	Globose-Elliptic
9.	Peduncle length	Long (more than 20)	Long (more than 20)	Medium (10-20)
10.	Flag leaf blade: length	Medium (20-30)	Medium (20-30)	Short (less than 20)
11.	Flag leaf blade: Width	Medium (1-2)	Medium (1-2)	Narrow(less than 1)
12.	Clum: branching	Absent	Absent	Present
13.	Panicle length	Long (40-50)	Long (40-50)	Medium (30-40)
14.	Panicle compactness	Compact	Compact	Intermediate
15.	Lodging	Absent	Absent	Absent
16.	Plant : Height	Tall (120-160)	Tall (120-160)	Semi Dwarf (80-120)
17.	Seed Shattering	Absent	Absent	Absent
18.	Grain Colour	Golden Yellow	Golden Yellow	Straw White/ cream
19.	Grain Shape	Oval	Oval	Oval
20.	1000 Grain Weight	Medium (2-3)	Medium (2-3)	Medium (2-3)

Panicle View of GV-4

Grain of GV-4

Field View of GV-4

GV-4 at Maturity

Fig. 2. Sigle palnt and field view of GV 4

Table 7. Performance of GV-4 in farmers field (OFT)

Year	Area (ha)	Demonstration grain yield (q/ha)	Farmers field yield (q/ha)	% increase over farmers field yield
2019-20	10	34.8	25.4	37.01
2020-21	10	30.2	23.4	29.05
Average of 2019 & 2020	10	32.5	24.4	33.19

The WV-126 / GV-4 is rich in calcium (17.1 mg/100g), protein (12.91 g/100g), iron (11.60 mg/100g), fat (3.3 %), minerals (2.7 g/100g), crude fiber (7.5 %) and carbohydrates (70.40 g/100g) as compared to all the checks (**Table 5**) (Chetan and Malleshi, 2007). It showed better superiority as compared to local checks. Similarly, Patil *et al.* (2017) also reported superior nutritional quality in little millet variety GNV-3.

The WV-126 matures in 125-130 days. It has an erect plant habit with 120-160 cm plant height. The panicle is compact with a panicle length 40-50 cm. The grain is medium bold and 1000 seed weight is 2.28 g. The colour of the grain is golden yellow. Descriptive morphological/ botanical characters of WV-126 (GV-4) with local checks as per DUS guidelines given in **Table 6** and **Fig.2**

The WV-126 recorded 33.19 per cent higher grain yield (kg/ha) as compared with locally grown genotype in demonstration plots (OFT) conducted during *kharif*, 2019 & 2020 on farmers fields at Dangs districts of Gujarat. Farmers' response to this variety is better and demanded this variety which led to high farmer exchange of seed. Kant *et al*. (2020) reported similar results in the release of wheat variety VL Gehun 953. The year wise grain yield data of little millet production under on farm demonstrations was given and results are presented in **Table 7** (Anonymous, 2019).

Considering the superior performance of the little millet culture 'WV-126' over the local check varieties namely GV-2 and GNV-3 as well as national check variety CO-2 and OLM-203, the WV-126 was released as a new variety GV-4 (Gujarat Vari-4/ Ambika) for large scale cultivation in Gujarat during 2021.

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