

Original Research Article

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## Evaluation of Barnyard Millet Advance Lines for Yield, Yield Contributing Traits and Grain Smut Disease at High Hills of Uttarakhand, India

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### ABSTRACT

Barnyard millet is a multipurpose crop grown in Uttarakhand hills for food and fodder uses. The present study was carried out during three consecutive seasons *i.e.* Kharif- 2017, Kharif- 2018 and Kharif- 2019, in which seven advance breeding lines and three check varieties *viz.*, PRJ 1 (local check), VL 207 (zonal check) and DHBM 99-3 (national check), selected from core set of barnyard millet germplasm maintained under ICAR- All India Coordinated Research Project on Small Millets at College of Forestry, Ranichauri, Uttarakhand, were taken for their evaluation with respect to yield, yield contributing traits and against grain smut disease at high hills of Uttarakhand. Wide range of variation was recorded for yield and yield contributing traits among studied lines. Out of all ten lines including check varieties, two lines (URJ-4 and PRJ 1©) were identified as high yielding, early maturing as well as grain smut resistant lines. It is, therefore, concluded that these two lines are of immense value for plant breeders in further crop improvement programme for developing grain smut resistant barnyard millet high yielding variety (s).

#### Keywords

Barnyard millet, Germplasm, Grain smut disease and immune

#### Article Info

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### Introduction

Barnyard millet (*Echinochloa* spp.) is one of the oldest domesticated millets in the semi-arid tropics of Asia and Africa. Barnyard millet domesticated form a wild species *Echinochloa colona* (L.) Link, popularly

known as Jungle rice (Sood, *et al.*, 2015). Yabuno, (1987) stated that barnyard millet is a staple food in those areas where climatic and edaphic conditions are unsuitable for rice cultivation. There are two cultivated species of barnyard millet *viz.*, Indian barnyard millet (*Echinochloa frumentacea*) and second

Japanese barnyard millet (*Echinochloa esculenta*). Dogget, (1989) reported that the Indian barnyard millet originated in India, and possibly also in Africa and cultivated in India, Central African Republic, Tanzania and Malawi while Japanese barnyard millet cultivated mostly in the temperate regions of Japan, Korea, China, Russia and Germany as stated by De Wet *et al.*, (1983).

Though in the recent years, the crop has gained renewed interest in the recent years due to its rich nutritional profile and high dietary fibre content. Watanabe (1999) stated that the demand of barnyard millet has increased due to its highly nutritious grains and presence of strong antioxidative compounds. In India, barnyard millet is grown from Deccan plateau in the south to higher Himalayan region in the North.

The major barnyard millet producing states in India are Uttarakhand, Madhya Pradesh, Karnataka, Uttar Pradesh and North east region of India. In Uttarakhand, barnyard millet occupies a unique position in the hilly cropping system because it is grown for food for human being and fodder for animal. Barnyard millet grown up to an altitude of 3000 m above sea level in both pure and mixed stands and under Jhuming (shifting) cultivation (Rawat, *et al.*, 2019).

In Uttarakhand, the barnyard millet crop is sown in the month of March-April and harvested in the month of September-October but in higher hills it take more time to mature than mid and lower hills because of early onset of winter, as a result of lower grain yield. In Uttarakhand, barnyard millet is grown in 46408 ha land area from which the total annual production of 64093 MT along with average grain yield of 13.81 q/ha was recorded in year 2019 (Directorate of Agriculture, Dehradun, 2019). The grain yield in the farmer's field is lower than the grain

yield in the research farm and it is because of poor adaptability of good agronomic practices, low quality seeds, sowing of local variety and intensity of grain smut disease.

Grain smut disease is a major disease in barnyard millet. In the infected panicles, the flower ovaries are round and hairy and may enlarge 2–3 times than normal size. Sometime, gall-like swellings are also observed on the nodes, axils of the older leaves and the stem as stated by Sood *et al.*, (2015). Phenotypic evaluation of germplasm or breeding lines may allow isolation of ideal germplasm or lines with diseases resistant. Therefore, the present investigation was carried out to evaluate the advance lines of barnyard millet for yield and its contributing traits as well as against grain smut disease at high hills of Uttarakhand.

## **Materials and Methods**

The experimental trials were carried out at Plant Breeding Block (2100 m above msl) of College of Forestry, Ranichauri, Tehri Garhwal, VCSG Uttarakhand University of Horticulture and Forestry for three consecutive seasons *i.e.* *Kharif* - 2017, *Kharif*- 2018 and *Kharif* -2019. Seven advance lines were selected from barnyard millet germplasm based on individual ear head selection and the seeds of selected ear head were hand threshed and bulk of each was maintained separately for multiplying in the next season.

The selected lines along with three check varieties viz., PRJ 1 (local check), VL 207 (zonal check) and DHBM 93-3 (national check) were planted in randomized block design (RBD) with three replications. The row to row spacing was maintained 22.5 cm while plant to plant spacing was maintained 10.0 cm through hand thinning after seed germination. During the experiment, good

agronomic package and practices were adopted and the observations *viz.*, days to 50 per cent flowering, number of productive tillers, plant height (cm), ear head length (cm), days to maturity, grain yield (q/ha), fodder yield (q/ha), 1000-grain weight (g) and grain smut disease were recorded during the years of experimentation. At grain filling stage, per cent grain smut incidence was calculated by counting the number of infected ear heads among the populations. On the basis of per cent grain smut incidence, tested lines were grouped as resistant (Less than 1% grains in a panicle affected), moderately resistant (1-5% grains in a panicle affected), moderately susceptible (6-25% grains in a panicle affected), susceptible (26-50% grains in a panicle affected) and highly susceptible (51-100% grains in a panicle affected). Pooled analysis of variance was performed for three seasons for yields and its contributing traits using appropriate statistical software. Means were compared by the least significant difference test (LSD) at 0.05 probability level.

**SES Scale for Grain smut disease of barnyard millet (Proceeding of Annual Group Meeting of AICRP on Small Millets, 2017):**

Score	Description	Reaction
0-1	Less than 1% grains in a panicle affected	Resistant (R)
1.1-3	1-5% grains in a panicle affected	Moderately resistant (MR)
3.1-5	6-25% grains in a panicle affected	Moderately susceptible (MS)
5.1-7	26-50% grains in a panicle affected	Susceptible (S)
7.1-9	51-100% grains in a panicle affected	Highly susceptible (HS)

**Results and Discussion**

**Yield and yield contributing traits**

Based on pooled analysis, significant variation was recorded among yield and its

contributing traits and grain smut disease at high hills of Uttarakhand. Significant differences were recorded for days to 50 per cent flowering during the tested years and their pooled analysis showed that the days to 50 per cent flowering ranged from 65.98 to 81.16 days across the tested lines (Table 1). None of the entries was identified as early flowering than local check variety PRJ-1 which took 65.98 days to 50 per cent flowering followed by URJ-4 (69.66 days), VL 207 (70.30 days) and URJ-2 (70.93 days) while maximum (81.16 days) days to 50 per cent flowering was recorded in DHBM 93-3 followed by URJ-5 (77.26 days), URJ-7 (76.34 days) and URJ-3 (75.99 days). Highest number (4.62) of productive tillers was recorded in URJ-6 and lowest number (3.36) of productive tillers was recorded in PRJ-1© followed by URJ-4 (3.78) and VL 207 (4.27). There was significant difference in plant height among evaluated barnyard millet lines with maximum (152.05 cm) plant height recorded in DHBM 99-3 followed by VL 207 (149.96 cm), URJ-7 (149.81 cm) and PRJ-1 (147.75 cm) while minimum (123.67 cm) plant height was recorded in URJ-4 followed by URJ-3 (125.91 cm) and URJ-2 (130.14 cm). The longest ear head length with 23.22 cm was measured in URJ-2 while smallest ear head length with 18.63 cm was measured in DHBM 99-3 (Table 2).

Significant variation was recorded in days to maturity that varied from 109.11 days to 140.12 days. Out of ten evaluated barnyard millet advance generation lines including three check varieties, two lines *viz.*, PRJ-1 © (109.11 days) and URJ-4 (113.70 days) were identified as early maturing lines in high hills of Uttarakhand while other lines took more than 125 days to maturity (Table 3). Maximum (21.07 q/ha) average grain yield was recorded in URJ-4 followed by PRJ-1 © with 19.60 q/ha while minimum (12.84 q/ha) average grain yield was recorded in DHBM

99-3© followed by URJ-5 (13.49 q/ha). Maximum (127.04 q/ha) average fodder yield was recorded in URJ-2 followed by URJ-7 (123.14 q/ha) and URJ-6 (123.08 q/ha) while minimum (99.27 q/ha) average fodder yield was recorded in DHBM 99-3© followed by VL 207 (99.66 q/ha).

However, average 1000-grain weight was found non-significant that ranged from 4.10 g to 4.19 g (Table 4). Variability in yield and its contributing traits provide basic information regarding the genetic properties of the population based on which breeding methods are formulated for further crop improvement. Upadhyaya *et al.*, (2006) stated that the

identification of accessions with desirable traits intended to be employed directly as cultivars or as trait donors for use in crop improvement programme.

The coefficient of variation 0.79 per cent for days to maturity to 36.43 per cent for basal tiller number in barnyard millet germplasm was reported by Sood *et al.*,(2015). They also identified several accessions with less than 64 days to maturity and stated that these accessions can be used in the breeding program for earliness in crop maturity. Manimekalai *et al.*, (2018) also reported the wide variation for yield and yield contributing traits among barnyard millet germplasm.

**Table.1** Evaluation of barnyard millet advance lines for days to 50 per cent flowering and number of productive tillers during three consecutive *Kharif* seasons i.e. 2017, 2018 & 2019

Entry	Days to 50 per cent flowering				Number of productive tillers			
	<i>Kharif</i> -2017	<i>Kharif</i> -2018	<i>Kharif</i> -2019	Pooled	<i>Kharif</i> -2017	<i>Kharif</i> -2018	<i>Kharif</i> -2019	Pooled
URJ-1	73.34	70.67	69.01	71.01	4.34	4.72	4.38	4.48
URJ-2	73.26	70.59	68.93	70.93	4.41	4.78	4.45	4.54
URJ-3	78.32	75.66	73.99	75.99	4.37	4.74	4.41	4.51
URJ-4	72.63	69.97	68.30	69.66	3.64	4.01	3.68	3.78
URJ-5	79.59	76.92	75.26	77.26	4.38	4.75	4.42	4.52
URJ-6	76.83	74.16	72.49	74.49	4.48	4.86	4.52	4.62
URJ-7	78.67	76.00	74.34	76.34	4.45	4.83	4.49	4.59
DHBM 93-3 ©	83.49	80.82	79.16	81.16	4.17	4.54	4.21	4.31
VL 207 ©	71.99	69.33	67.66	70.30	4.14	4.51	4.18	4.27
PRJ-1 ©	68.31	65.64	63.98	65.98	3.22	3.59	3.26	3.36
<b>General Mean</b>	<b>75.67</b>	<b>73.00</b>	<b>71.31</b>	<b>73.27</b>	<b>4.16</b>	<b>4.53</b>	<b>4.20</b>	<b>4.30</b>
<b>SEm (±)</b>	<b>1.70</b>	<b>1.73</b>	<b>1.66</b>	<b>1.67</b>	<b>0.16</b>	<b>0.14</b>	<b>0.14</b>	<b>0.14</b>
<b>LSD (0.05)</b>	<b>5.10</b>	<b>5.15</b>	<b>4.92</b>	<b>4.96</b>	<b>0.48</b>	<b>0.42</b>	<b>0.42</b>	<b>0.42</b>
<b>CV (%)</b>	<b>3.97</b>	<b>4.12</b>	<b>4.02</b>	<b>3.94</b>	<b>5.89</b>	<b>5.40</b>	<b>5.83</b>	<b>5.70</b>

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**Table.2** Evaluation of barnyard millet advance lines for plant height and ear head length during three consecutive *Kharif* seasons i.e. 2017, 2018 & 2019

Entry	Plant height (cm)				Ear head length (cm)			
	<i>Kharif</i> -2017	<i>Kharif</i> -2018	<i>Kharif</i> -2019	Pooled	<i>Kharif</i> -2017	<i>Kharif</i> -2018	<i>Kharif</i> -2019	Pooled
URJ-1	142.69	144.57	135.54	140.93	22.48	22.43	20.73	21.88
URJ-2	131.90	133.78	124.75	130.14	23.82	23.77	22.08	23.22
URJ-3	127.67	129.55	120.52	125.91	20.79	20.74	19.05	20.19
URJ-4	125.42	127.31	118.27	123.67	20.27	20.22	18.53	19.67
URJ-5	147.26	149.14	140.11	145.50	20.73	20.68	18.99	20.13
URJ-6	129.95	131.83	122.80	128.19	22.05	22.00	20.30	21.45
URJ-7	151.57	153.45	144.42	149.81	22.57	22.52	20.83	21.97
DHBM 93-3 ©	153.81	155.69	146.66	152.05	19.23	19.18	17.48	18.63
VL 207 ©	151.72	153.60	144.57	149.96	21.24	21.19	19.49	20.64
PRJ-1 ©	149.51	151.39	142.36	147.75	21.34	21.29	19.59	20.74
<b>General Mean</b>	<b>141.15</b>	<b>143.03</b>	<b>133.99</b>	<b>139.39</b>	<b>21.45</b>	<b>21.40</b>	<b>19.71</b>	<b>20.86</b>
<b>Sem (±)</b>	<b>2.58</b>	<b>2.54</b>	<b>2.50</b>	<b>2.50</b>	<b>0.86</b>	<b>0.79</b>	<b>0.82</b>	<b>0.82</b>
<b>LSD (0.05)</b>	<b>7.68</b>	<b>7.57</b>	<b>7.43</b>	<b>7.43</b>	<b>2.52</b>	<b>2.35</b>	<b>2.45</b>	<b>2.45</b>
<b>CV (%)</b>	<b>3.07</b>	<b>3.03</b>	<b>3.23</b>	<b>3.11</b>	<b>6.65</b>	<b>6.67</b>	<b>7.24</b>	<b>6.84</b>

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**Table.3** Evaluation of barnyard millet advance lines for days to maturity and grain yield during three consecutive *Kharif* seasons i.e. 2017, 2018 & 2019

Entry	Days to maturity (Days)				Grain yield (q/ha)			
	<i>Kharif</i> -2017	<i>Kharif</i> -2018	<i>Kharif</i> -2019	Pooled	<i>Kharif</i> -2017	<i>Kharif</i> -2018	<i>Kharif</i> -2019	Pooled
URJ-1	129.22	128.88	127.22	128.44	14.42	14.45	14.32	14.40
URJ-2	126.70	126.37	124.70	125.93	13.70	13.57	17.72	15.00
URJ-3	140.26	139.92	138.26	139.48	14.42	13.79	14.32	14.18
URJ-4	114.47	114.14	112.47	113.70	20.48	22.33	20.39	21.07
URJ-5	140.27	139.94	138.27	139.50	13.46	13.65	13.36	13.49
URJ-6	138.37	138.03	136.37	137.59	14.44	15.46	14.34	14.75
URJ-7	140.46	140.13	138.46	139.68	13.79	15.64	13.69	14.38
DHBM 93-3 ©	140.90	140.57	138.90	140.12	12.25	14.10	12.16	12.84
VL 207 ©	134.64	134.30	132.64	133.86	13.71	15.55	13.61	14.29
PRJ-1 ©	110.00	109.33	108.00	109.11	19.02	20.86	18.92	19.60
<b>General Mean</b>	<b>131.70</b>	<b>131.33</b>	<b>129.53</b>	<b>130.83</b>	<b>14.97</b>	<b>15.94</b>	<b>15.28</b>	<b>15.40</b>
<b>Sem (±)</b>	<b>1.98</b>	<b>1.95</b>	<b>1.96</b>	<b>2.02</b>	<b>0.90</b>	<b>0.84</b>	<b>0.66</b>	<b>0.70</b>
<b>LSD (0.05)</b>	<b>5.88</b>	<b>5.80</b>	<b>5.82</b>	<b>5.98</b>	<b>2.67</b>	<b>2.49</b>	<b>1.95</b>	<b>2.90</b>
<b>CV (%)</b>	<b>2.52</b>	<b>2.57</b>	<b>2.62</b>	<b>2.67</b>	<b>11.39</b>	<b>9.09</b>	<b>7.47</b>	<b>7.91</b>

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**Table.4** Evaluation of barnyard millet advance lines for fodder yield and 1000 grain weight during three consecutive *Kharif* seasons i.e. 2017, 2018 & 2019

Entry	Fodder yield (q/ha)				1000-grain weight (g)			
	<i>Kharif</i> -2017	<i>Kharif</i> -2018	<i>Kharif</i> -2019	Pooled	<i>Kharif</i> -2017	<i>Kharif</i> -2018	<i>Kharif</i> -2019	Pooled
URJ-1	126.99	125.43	102.96	118.46	4.11	4.20	4.15	4.15
URJ-2	135.65	134.08	111.38	127.04	4.15	4.24	4.19	4.19
URJ-3	123.57	122.01	99.64	115.07	4.07	4.17	4.11	4.12
URJ-4	117.10	115.53	93.34	108.66	4.15	4.24	4.19	4.19
URJ-5	127.14	125.57	103.10	118.60	4.07	4.17	4.11	4.12
URJ-6	131.66	130.09	107.50	123.08	4.11	4.21	4.15	4.16
URJ-7	131.71	130.15	107.55	123.14	4.05	4.15	4.10	4.10
DHBM 93-3 ©	107.64	106.08	84.15	99.29	4.09	4.18	4.13	4.13
VL 207 ©	108.02	106.46	84.52	99.66	4.10	4.19	4.14	4.14
PRJ-1 ©	111.54	109.98	87.94	103.15	4.11	4.21	4.16	4.16
<b>General Mean</b>	<b>122.10</b>	<b>120.54</b>	<b>98.21</b>	<b>113.61</b>	<b>4.10</b>	<b>4.20</b>	<b>4.14</b>	<b>4.15</b>
<b>Sem (±)</b>	<b>5.21</b>	<b>6.26</b>	<b>6.09</b>	<b>6.21</b>	<b>0.09</b>	<b>0.05</b>	<b>0.07</b>	<b>0.05</b>
<b>LSD (0.05)</b>	<b>15.62</b>	<b>18.62</b>	<b>18.01</b>	<b>18.45</b>	<b>0.27</b>	<b>0.15</b>	<b>0.21</b>	<b>NS</b>
<b>CV (%)</b>	<b>8.89</b>	<b>9.01</b>	<b>10.74</b>	<b>9.47</b>	<b>2.14</b>	<b>2.10</b>	<b>2.12</b>	<b>2.12</b>

**Table.5** Screening of barnyard millet advance lines for grain smut disease from 2017 to 2019 at high hills of Uttarakhand

Entry	Grain smut incidence (%)				Response
	<i>Kharif</i> -2017	<i>Kharif</i> -2018	<i>Kharif</i> -2019	Pooled	
URJ-1	8.37	13.89	13.56	11.94	MS
URJ-2	16.34	16.67	19.54	17.52	MS
URJ-3	10.89	16.93	16.57	14.80	MS
URJ-4	0.00	0.00	0.00	0.00	R
URJ-5	24.37	23.38	22.54	23.43	MS
URJ-6	12.93	16.50	17.42	15.62	MS
URJ-7	12.52	19.22	15.87	15.87	MS
DHBM 93-3 ©	12.30	19.91	18.44	16.88	MS
VL 207 ©	23.96	26.31	23.80	24.69	MS
PRJ-1 ©	0.00	0.00	0.00	0.00	R
<b>General Mean</b>	<b>12.17</b>	<b>15.28</b>	<b>14.78</b>	<b>14.08</b>	
<b>Sem (±)</b>	<b>1.05</b>	<b>1.17</b>	<b>1.96</b>	<b>0.88</b>	
<b>LSD (0.05)</b>	<b>3.12</b>	<b>3.48</b>	<b>5.82</b>	<b>2.60</b>	
<b>CV (%)</b>	<b>14.93</b>	<b>13.28</b>	<b>22.97</b>	<b>10.78</b>	

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## Disease screening

Grain smut in grains is seen after few days of flowering and the infected grains can be seen scattered at random in the ear. The affected ovaries are transformed into velvety greenish gall like bodies which are several times bigger in size than the normal healthy grains. In present experiment, two barnyard millet lines *i.e.* URJ-4 and PRJ-1© were identified as resistant (R) for grain smut disease while remaining evaluated barnyard millet advance lines showed 11.94 per cent to 24.69 per cent grain smut and grouped into moderately susceptible (MS) response (Table 5). Nagaraja and Mantur (2008) evaluated the barnyard millet accessions for grain smut and none of the tested barnyard millet accessions was immune to grain smut in Karnataka.

However, Anonymous (2001) reported that accessions PRB 9402 and PRB 9602 were completely resistant to grain smut disease. Gupta *et al.*, (2009) screened 257 barnyard millet accessions for grain smut at Almora. They observed lowest grain smut incidence in advance breeding lines, while highest grain smut incidence in local germplasm collected from Uttarakhand. They also stated that the smut resistance along with grain yield in barnyard millet can be enhanced by adopting proper breeding strategies; therefore, in segregating generations, selection should be carried out for both characters simultaneously.

Based on three seasons' evaluation at high hills of Uttarakhand, URJ-4 was identified as high yielding, early maturing as well as grain smut resistant line and that can be used in crossing programme for transfer of grain smut resistant gene(s) in the locally well adapted high yielding variety and/or can be released after testing in coordinated trails for cultivation in the barnyard millet growing regions.

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