



RESEARCH ARTICLE

Screening of blackgram (*Vigna mungo* L.) germplasm for resistance to *Fusarium* wilt under multi-season field conditions

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Abstract

The present study evaluated forty blackgram germplasms across multiple seasons (kharif 2023, rabi 2023–24 and kharif 2024) and the results showed significant variation in how they responded to *Fusarium* wilt (*Fusarium solani*). The wide range of wilt incidence across the evaluated germplasm reflects considerable genetic diversity and varying levels of disease resistance within the population. Five germplasms, such as BGGP 20, BGGP 39, BGGP 47, IPU-94-4 and OBG-33 regularly exhibited very low wilt percentages ($\leq 1\%$) ($P < 0.05$), indicating stable and high-level resilience across seasons. Germplasm such as BGGP 11, BGGP 18, BGGP 22, BGGP 23, BGGP 25, IPU-11-02 and OBG-41 showed wilt levels between 3–9% with little seasonal variation, indicating a moderate level of resistance. Highly susceptible germplasms, on the other hand, like BGGP 13, BGGP 16, BGGP 49, Junagarh local and Lanjigarh local continuously showed high wilt incidence ranges from 21–24%, indicating their susceptibility to disease pressure. The existence of both vulnerable and resistant groups emphasizes how well multi-season screening works to find reliable sources of resistance. The high temperature with high rainfall was increasing the percentage of wilt incidence during kharif season comparatively rabi season. The identified resistant germplasms which are recommend for resistance breeding programme to develop *Fusarium* wilt-resistant blackgram varieties and increase blackgram production.

Keywords: blackgram; disease resistance breeding; *Fusarium* wilt; genetic variability; multi season screening

Introduction

Urdbean or blackgram (*Vigna mungo* L.), is a significant pulse crop that is predominately grown in India. It is prized for its high protein content, capacity to fix nitrogen in the soil and ability to adapt to a variety of agro climatic situations. With more than 70% of the world's production, India is the biggest producer and user of blackgram (1). Madhya Pradesh, Maharashtra, Uttar Pradesh, Tamil Nadu and Andhra Pradesh are among the states that are experiencing significant growth. The typical productivity ranges between 400 and 600 kg/ha. In India, the total area used for black gram production 2.46 lakh hectares in 2023–2024 (2). Black gram output is highest in Andhra Pradesh (3.62 lakh tonnes), followed by Maharashtra (3.27 lakh tonnes), Uttar Pradesh (2.88 lakh tonnes), Rajasthan (1.66 lakh tonnes) and Telangana (0.44 lakh tonnes) in 2023–2024 (3).

This *Fusarium* wilt has been documented in 32 countries across 6 continents (4). Important indicators of wilt include the collapse of diseased plants during the seedling stage and the drooping of petioles, rachis and leaflets in adult plants that are still dull green in color (5). Although there was no external rotting of the

wilting plants, the plants displayed significant brown xylem staining. In extremely susceptible varieties, symptoms manifest 25 days after planting (DAS). Early wilting resulted in greater losses than late wilting and seeds from chickpea plants exhibiting late wilt symptoms are lighter than seeds from healthy plants (6). In India the Bundelkhand region, monocropping of pulses year after year has increased the prevalence of weeds, insect pests and illnesses in pulse crops. *Fusarium* wilt is one of the major biotic factors influencing productivity in pigeon pea, chickpea and lentil crops (7). A recently identified fungal wilt induced by *Fusarium oxysporum* has resulted in a decrease in seed protein content by 4–5%. This disease is primarily found in the western undulating zones, specifically in the Nuapada and Bhawanipatna regions of Odisha and it causes a 15–20% yield loss in kharif and rabi. It was observed during the flowering to post-flowering stage (8). Blackgram productivity is significantly impacted by *Fusarium* wilt, a significant biotic limitation. Multi season and environmental screening methods to identify the stable resistant germplasm, variety against to *Fusarium* wilt under different environmental condition which is support to creating resistance through breeding for the production of sustainable pulses.

Materials and Methods

The experiment was conducted during kharif 2023, rabi 2023–2024 and kharif 2025 in wilt sick plot at the College of Agriculture Bhawanipatna, Kalahandi, Odisha which is situated at 19.92° N and 83.20° E longitude, 248 m above mean sea level of Western Undulating Zone of Odisha. The experimental site had clay loam soil with a pH of 6.7 and an annual rainfall of 1355 mm (278 mm for kharif 2023, 19 mm for rabi 2023–2024 and 294 mm for kharif 2024). The average maximum and minimum temperatures were 33 °C and 25 °C, respectively, with relative humidity (maximum and minimum) of 81 % and 80 % during kharif. During rabi, the average maximum and minimum temperatures were 30 °C and 16 °C, respectively, with relative humidity of 75 % and 59 %.

Screening under wilt sick plot

The screening in wilt sick plots has been demonstrated in previous studies (9–12). The experimental material used in this study consisted of forty blackgram germplasm and variants. A randomized complete block design (RCBD) with 3 replications per entry, a plant distance of 10 cm by 30 cm and a row length of 3.5 m was used to set up the field experiment. Observations of wilt incidence were made 25–30 DAS, just following the onset of disease. Wilt incidence was recorded by counting the total number of plants and number of plants wilted. The disease incidence can be calculated using the following equation given below (13), the results are provided in Table 1.

$$\text{Disease incidence (\%)} = \frac{\text{Number of infected plants}}{\text{Total number of plants}} \times 100$$

Statistical analysis

The data collected from each experiment was analyzed separately and each experiment was subjected to a two-way ANOVA analysis utilizing the mean percentage of wilting of three replicates per germplasm. Data were analyzed using Grapes software and differences between the means were assessed using Tukey's HSD multiple comparisons with $P < 0.05$.

Table 1. Each germplasm's sensitivity and degree of resistance were assessed using the IIPR1999 modified 1 to 9 disease rating scale (14)

Rating scale	Wilt incidence percent	Reaction
1	1 % or less plants wilted	Resistant (R)
3	2-10 % plants wilted	Moderately Resistant (MR)
5	11-20 % plants wilted	Moderately Susceptible (MS)
7	21-50 % plants wilted	Susceptible (S)
9	Above 50 % plants wilted	Highly Susceptible (HS)

Table 2. Reaction of blackgram germplasm and varieties to *Fusarium* wilt across different season

Reaction	Germplasm		
	kharif 2023	rabi 2023-2024	kharif 2024
Resistant ($\leq 1\%$)	BGGP 20, BGGP 39, BGGP 47, IPU-17-1, IPU- 94-4, OBG-33	BGGP 20, BGGP 21, BGGP 39, BGGP 47, IPU- 02-43, IPU-94-4, IPU- 17-1, OBG-33	BGGP 20, BGGP 39, BGGP 47, IPU-94-4, OBG-33
Moderately resistant (2-10%)	BGGP 3, BGGP 7, BGGP 11, BGGP 18, BGGP 21, BGGP 22, BGGP 23, BGGP 24, BGGP 25, BGGP 26, BGGP 27, BGGP 28, BGGP 29, BGGP 30, BGGP 32, BGGP 38, BGGP 48, IPU-11-02, IPU-02-43, IPU-13-1, OBG-41, LBG-754	BGGP 3, BGGP 7, BGGP 8, BGGP 11, BGGP 18, BGGP 19, BGGP 22, BGGP 23, BGGP 24, BGGP 25, BGGP 26, BGGP 27, BGGP 28, BGGP 29, BGGP 30, BGGP 32, BGGP 34, BGGP 38, BGGP 42, BGGP 48, IPU-11-02, IPU-13-1, OBG -41, LBG-754	BGGP 3, BGGP 11, BGGP 18, BGGP 21, BGGP 22, BGGP 23, BGGP 24, BGGP 25, BGGP 26, BGGP 27, BGGP 30, BGGP 34, BGGP 38, BGGP 48, IPU- 11-02, IPU-02-43, IPU-13-1, OBG-41, LBG-754
Moderately susceptible (11-20 %)	BGGP 8, BGGP 10, BGGP 16, BGGP 19, BGGP 34, BGGP 42, BGGP 45, PU10-23	BGGP 10, BGGP 13, BGGP 16, BGGP 45, BGGP 49, PU10-23	BGGP 7, BGGP 8, BGGP 10, BGGP 19, BGGP 28, BGGP 29, BGGP 32, BGGP 42, BGGP 45, PU10-23
Susceptible (21-50 %)	BGGP 13, BGGP 49, Junagarh local, lanjigarh local	BGGP 49, Junagarh local, lanjigarh local	BGGP 13, BGGP 16, BGGP 49 Junagarh local, lanjigarh local

Results and Discussion

Forty blackgram germplasm varieties were collected from Odisha University of Agriculture and Technology, Bhubaneswar and evaluated under sick plot field conditions during kharif 2023, rabi 2023–2024 and kharif 2024 using the standard procedure to identify the sources of resistance in blackgram for *Fusarium* wilt caused by *Fusarium solani*. Under natural epiphytotic conditions, all the 40 blackgram entries exhibited different reactions against *Fusarium* wilt during kharif 2023, rabi 2023–2024 and kharif 2024. However, 6 germplasm viz., BGGP 20, BGGP 39, BGGP 47, IPU-17-1, IPU- 94-4 and OBG-33, were found resistant (Table 2), with mean disease intensity of ≤ 1.0 % (SE (m): 0.342, CD (0.05): 6.881) during kharif 2023 and 8 germplasm viz., BGGP 20, BGGP 21, BGGP 39, BGGP 47, IPU- 02-43, IPU-94-4, IPU- 17-1 and OBG-33 found resistant (Table 2) with mean disease intensity of 1 % (SE(m): 0.384, CD(0.05): 6.628) during rabi 2023-24 (Table 3, Fig. 1), 5 germplasm viz., BGGP 20, BGGP 39, BGGP 47, IPU-94-4 and OBG-33 were found moderately resistant with mean disease intensity in the range of ≤ 1.0 % during kharif 2024 (Table 3, Fig. 1). Twenty two germplasm, variety lines viz., BGGP 3, BGGP 7, BGGP 11, BGGP 18, BGGP 21, BGGP 22, BGGP 23, BGGP 24, BGGP 25, BGGP 26, BGGP 27, BGGP 28, BGGP 29, BGGP 30, BGGP 32, BGGP 38, BGGP 48, IPU-11-02, IPU-02-43, IPU-13-1, OBG-41 and LBG-754 were found moderately resistant (Table 2) with mean disease intensity in the range of 3.0-9.0% during in kharif 2023, 23 germplasm, variety lines viz., BGGP 3, BGGP 7, BGGP 8, BGGP 11, BGGP 18, BGGP 19, BGGP 22, BGGP 23, BGGP 24, BGGP 25, BGGP 26, BGGP 27, BGGP 28, BGGP 29, BGGP 30, BGGP 32, BGGP 34, BGGP 38, BGGP 42, BGGP 48, IPU-11-02, IPU-13-1, OBG-41 and LBG-754 found moderately resistant with mean disease intensity in the range of 3.3-10.0 % at rabi 2023–2024 and respectively twenty germplasm, varieties were found moderately resistant with mean disease intensity of 5.0–10.0 % during kharif 2024 (Fig. 1, Table 2 & 3). Eight germplasm, variety were found moderately susceptible with mean disease intensity in the range of 11.0–17.0 % during kharif 2023; 6 germplasm, variety viz., BGGP 10, BGGP 13, BGGP 16, BGGP 45, BGGP 49, PU10-23 were found moderately susceptible with mean disease intensity of 11.3–16.0 % during rabi 2023–2024 respectively. Ten germplasm viz., BGGP 7, BGGP 8, BGGP 10, BGGP 19, BGGP 28, BGGP 29, BGGP 32, BGGP 42, BGGP 45 and PU10-23 were found moderately susceptible (Table 2) with mean disease intensity of 11.0–17.0 % during kharif 2024 (Fig. 1, Table 3). Four germplasm viz., BGGP 13, BGGP 49, Junagarh local and Lanjigarh local were found susceptible with mean disease intensity of 21.0–23.0 % during kharif 2023. Three germplasm viz., BGGP 49, Junagarh local and Lanjigarh local were found susceptible

with mean disease intensity of 21.0–22.0 % at during in rabi 2023–2024 respectively. Five germplasm viz., BGGP 13, BGGP 16, BGGP 49 Junagarh local and Lanjigarh local were found susceptible with mean disease intensity of 21.0–24.0 % (SE(m): 0.384, CD(0.05): 6.628) during kharif 2024 (Table 3, Fig. 1).

Similar kind of findings are previously reported (15), out of 948 chick pea germplasm and breeding lines, 123 chick pea germplasm infected by *Fusarium* wilt with ≤ 10 % at first season 2003/04, 60 germplasm showed ≤ 10 % at second season 2004/05 and 57 germplasm with ≤ 10 % on third season 2005/06 and found 7 germplasm and 19 breeding are susceptible to *Fusarium* wilt three different seasons under sick plot condition. *Fusarium* wilt was shown that the chickpea crop cultivated in the Gorakhpur district suffered

more from wilt, with an average incidence of 14.08 % and an incidence of 15.12 %. The Varanasi district had the second-highest average wilt incidence, at 14.38 percent. The districts with average wilt incidence were Basti (14.36 %), Ghazipur (14.23%), Azamgarh (14.12 %), Mau (13.86 %) and Jaunpur (13.58 %). The district of Deoria had a comparatively low average wilt incidence of 12.90 % during rabi 2021–2022 (16).

Five germplasm, variety viz., BGGP 20, BGGP 39, BGGP 47, IPU- 94-4 and OBG-33 were found resistant to *Fusarium* wilt with ≤ 1.0 % of wilt incidence an all three constructive season and 3 germplasm, variety BGGP 49 Junagarh local, lanjigarh local were found susceptible to *Fusarium* wilt in all three season with mean disease intensity of 21.0–24.0 %.

Table 3. *Fusarium* wilt incidence (%) in blackgram during kharif 2023, rabi 2023-2024 and kharif 2024

Sl. No.	Germplasm	Percent wilt (%)		
		kharif 2023	rabi 2023-2024	kharif 2024
1	BGGP 3	9.0	6.7	10.0
2	BGGP 7	9.0	8.0	11.0
3	BGGP 8	14.0	10.0	17.0
4	BGGP 10	14.0	11.3	15.3
5	BGGP 11	7.0	6.3	9.0
6	BGGP 13	21.0	20	23.0
7	BGGP 16	17.0	16.0	21.0
8	BGGP 18	7.0	6.3	9.0
9	BGGP 19	11.0	10.0	14.3
10	BGGP 20	1.0	1.0	1.0
11	BGGP 21	3.3	1.0	5.0
12	BGGP 22	8.0	3.3	9.7
13	BGGP 23	6.0	6.3	8.0
14	BGGP 24	7.0	6.3	9.0
15	BGGP 25	6.0	3.3	8.0
16	BGGP 26	7.0	4.3	9.0
17	BGGP 27	6.0	3.3	8.0
18	BGGP 28	9.0	8.0	12.0
19	BGGP 29	8.0	5.3	11.0
20	BGGP 30	7.3	5.3	9.0
21	BGGP 32	9.0	8.3	12.3
22	BGGP 34	5.0	5.0	7.0
23	BGGP 38	8.0	3.5	9.0
24	BGGP 39	1.0	1.0	1.0
25	BGGP 42	15.0	10.0	11.0
26	BGGP 45	17.0	12.0	14.0
27	BGGP 47	1.0	1.0	1.0
28	BGGP 48	7.0	4.0	9.0
29	BGGP 49	23.0	21.0	23.0
30	IPU-11-02	4.0	2.0	7.0
31	IPU-94-4	1.0	1.0	1.0
32	IPU-17-1	1.0	1.0	3.3
33	IPU-02-43	4.0	1.0	6.0
34	IPU-13-1	5.0	3.3	7.0
35	OBG-33	1.0	1.0	1.0
36	OBG-41	5.0	3.3	8.0
37	LBG-754	5.0	3.0	7.0
38	PU10-23	11.0	10.0	12.0
39	Junagarh local	22.0	21.0	23.3
40	lanjigarh local	23.0	21.0	24.0
	SE(m)	0.342	0.384	0.384
	CD (0.05)	6.881	6.628	6.628

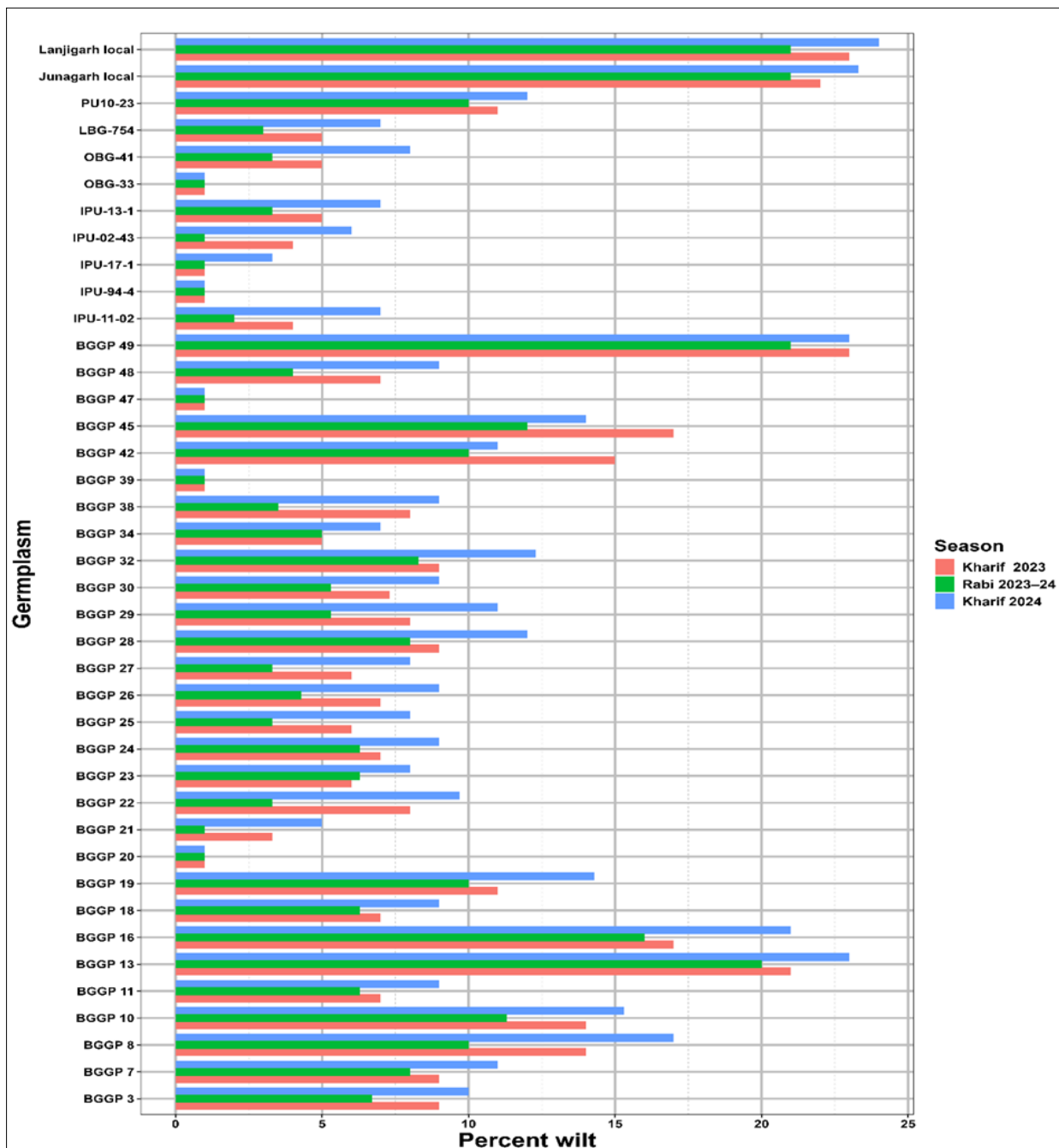


Fig. 1. *Fusarium* wilt incidence in blackgram (%) during kharif 2023, rabi 2023-2024 and kharif 2024.

Conclusion

Multi seasonal screening of forty blackgram germplasm, varieties responses to *Fusarium* wilt under sick plot condition showed significantly variation. The lasting resistance capacity of five germplasm BGGP 20, BGGP 39, BGGP 47, IPU-94-4 and OBG-33 was consistently resistant all over the seasons with minimum wilt incidence ($\leq 1\%$) and 3 germplasm (BGGP 49, Junagarh local, Lanjigarh local) variety showed susceptible to *Fusarium* wilt in all three season with 21.0–24.0 % wilt incidence. Above mentioned five resistant germplasm, varieties were found stable performance under different environmental conditions against *Fusarium* wilt, to create high-yielding, wilt-resistant blackgram varieties and support sustainable pulse production and disease control in wilt-prone areas.

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Authors' contributions

The conceptualization and development of the index, along with the design of the research methodology, were primarily undertaken by BS¹ under the guidance of NR. RLM contributed to literature review, concept formulation, methodological design, data validation, coordination with experts and overall manuscript refinement. SM and MKR supported statistical analyses, interpretation of results and visualization of findings. BS², KCS and SB assisted in drafting the manuscript and ensuring clarity, coherence and consistency. All authors read and approved of the final manuscript. [BS¹ stands for Balakrishnan Subramani and BS² stands for B Sinha].

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

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