International Journal of Bio-resource and Stress Management https://ojs.pphouse.org/index.php/IJBSM

Crossref

IJBSM January 2024, 15(1): 01-05

Article AR4989a

Research Article

Natural Resource Management

DOI: HTTPS://DOI.ORG/10.23910/1.2024.4989a

Evaluation of F_2 Mapping Population for Stem Rot Tolerance in Tossa Jute (*Corchorus olitorius*)

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ABSTRACT

Present investigation was undertaken at ICAR-CRIJAF, Barrackpore, West Bengal, India during summer season (Apr–July) of 2020 to identify the jute breeding lines resistant to stem rot which is one of the major problems in jute production. The identified resistant and susceptible jute accessions (RS-6 and OIJ-272, respectively) were crossed to develop a mapping population for the disease. The resultant F_2 population comprising 125 plants was screened for resistance to stem rot disease caused by *Macrophomina phaseolina* following artificial inoculation. The progress of infection was measured as the length of the infected stem portion (i.e., lesion length in cm) after 7, 14 and 21 days of inoculation (time replication). After stem inoculation investigation indicated that in the F_2 population of the cross OIJ-272×RS-6, only 14 plants (PL-100, PL-40, PL-99, PL-33, PL-89, PL-119, PL-1, PL-43, PL-118, PL-121, PL-6, PL-11, PL-55 and PL-86) were found moderately resistant (lesion length 2.0–3.0 cm). In contrast, 10 plants (PL-4, PL-31, PL-19, PL-27, PL-3, PL-50, PL-18, PL-26, PL-47, PL-51) were found highly susceptible (lesion length >5.0 cm). The remaining 101 plants exhibited moderate susceptible symptoms. While the parent OIJ-272 exhibited high susceptibility to stem rot with an average lesion length of 5.53 cm, the parent RS-6 exhibited moderate resistant reaction with an average lesion length of 2.30 cm. Because of good resistance under artificial stem inoculation of this fungi, these 14 F_2 plants of the cross can be further exploited for a resistance breeding programme against this deadly disease.

KEYWORDS: Mapping population, resistance, stem rot, tossa jute

***Citation* (VANCOUVER):** Meena et al., Evaluation of F_2 Mapping Population for Stem Rot Tolerance in Tossa Jute (*Corchorus olitorius*). *International Journal of Bio-resource and Stress Management,* 2024; 15(1), 01-05. HTTPS://DOI.ORG/10.23910/1.2024.4989a.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The authors have declared that no conflict of interest exists.

RECEIVED on 03rd November 2023 RECEIVED in revised form on 26th December 2023 ACCEPTED in final form on 09th January 2024 PUBLISHED on 21st January 2024

1. INTRODUCTION

Jute is a natural bast fibre crop belonging to malvaceae family of *Corchorus* genus (Benor, 2018). Tossa jute (*Corchorus olitorius* L.) and white jute (*Corchorus capsularis* L.) are the only two species of this genus that are commercially cultivated (Zhang et al., 2019). Jute fibre is a long, golden, lignocellulosic, eco-friendly and biodegradable fibre obtained from the bark of the plant (Meena et al., 2022). It is the second most important natural fibre after cotton in the world (Majumder et al., 2018). It is mainly cultivated for fibre purposes in South East Asia and as a vegetable in Europe and the African continent. In India, jute is mainly cultivated in the country's eastern states viz., West Bengal, Odisha, Bihar, Assam etc. (Majumder et al., 2020). India is the largest jute-producing country and exports a considerable amount of raw jute and diversified products (Mangal et al., 2023). Jute fibre is used for making bags, decorative, textiles, and geotextiles and its sticks are also used for fuel, door panels of automobiles and for making false ceiling boards (Adeyemo et al., 2021). Jute leaves are a good source of minerals, nutrients, vitamins and antioxidants (Choudhary et al., 2013).

Jute crop cultivation faces constraint of abiotic and biotic stresses that not only reduce fibre yield but also deteriorate fibre quality (Ashraf and Javaid, 2007). Among these diseases, stem rot is the most important economically and poses a significant threat to the successful cultivation of jute (Mandal et al., 2022) by affecting both yield and quality of fibre in both cultivated jute species (De, 2014).

This disease is reported to cause fibre yield losses of 30–40% in India and Bangladesh (Roy et al., 2008; Islam et al., 2012). The causal agent of the disease (*Macrophomina phaseolina*) (Tassi) Goid, is a soil and seed-borne (Ghosh et al., 2018, Marquez et al., 2021), necrotrophic fungal pathogen which causes stem rot, root rot and charcoal rot diseases in both the cultivated species of jute (Meena et al., 2015). The pathogen can infect and damage the crop at all stages of plant growth, starting from seedling emergence up to maturation. It survives as micro-sclerotia in the soil and on infected plant debris, serving as the primary source of inoculum. It disrupts nutrient and water transport to the upper parts of the plant as it affects the vascular system of the roots and basal internodes, leading to wilting, premature death and reduces yield (Islam et al., 2012). Environmental factors, like cloudy weather, abundant rainfall, high atmospheric humidity and low soil temperature (<30°C), favour infection. The pathogen remains dormant in soil amidst crop debris (Mandal et al., 2021).

Though chemical control of disease by fungicides is an effective measure, the pathogen may gradually developed resistance mechanism against fungicide. Further, the factors of climate change and availability of alternate hosts have resulted in shifting of disease and pest status in jute and allied fibre crops. The mechanism of host resistance offers the most effective way to manage the disease (Meena et al., 2021). However, none of the cultivable jute varieties has shown complete resistance against *M. phaseolina* (Mahapatra et al., 1994, Mandal et al., 2000, Kar et al., 2009, Srivastava et al., 2011). However, few tolerant jute cultivars/germplasm lines were identified in tossa jute (*Corchorus olitorius*) gene pool which is being utilized in a further breeding programme (De et al., 1990, De and Mandal, 2012). However, in the changing scenario of disease management programme, there is a need to develop a mapping population for stem rot by taking contrasting parents and evaluating the resistant/tolerant lines against this disease. In this context, present study was undertaken to screen stem rot resistance in jute as well as identification of resistance degree in individual plants of F_2 mapping population evaluated against this disease under artificial stem inoculum conditions.

2. MATERIALS AND METHODS

In this investigation, F_2 mapping population derived from crossing jute accession RS-6 (resistant parent) with OIJ-272 (susceptible parent) was screened for resistance to stem rot disease. These parental lines were differentiated by stem colour as the parental line RS-6 had a red stem while the parent OIJ-272 had a green stem (Figure 1).

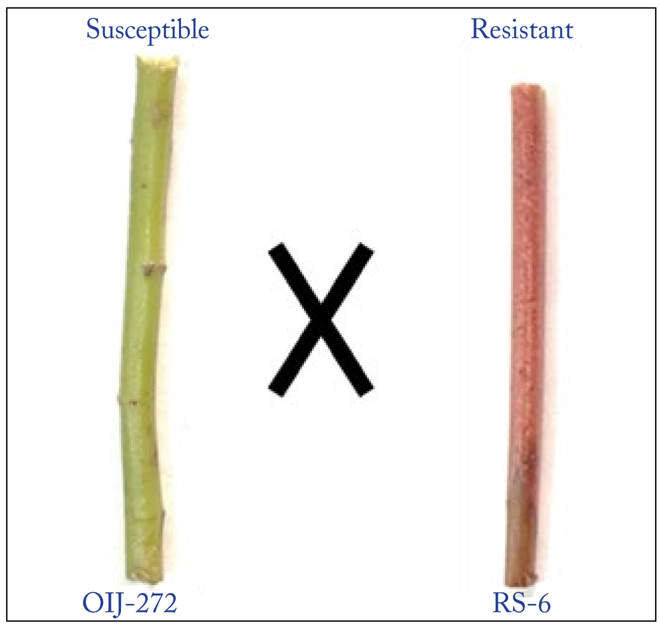

Figure 1: Susceptible and resistance parents

Initial cross was made during winter season (Nov-Dec) of 2018 to produce F_1s and subsequently F_1s were raised at ICAR-CRIJAF, Barrackpore, West Bengal, India (22°45'N and 88°26'E) during summer season (April-July) of 2019. The F_2 mapping population comprising 125 plants along with the parental lines was raised in summer (Apr-July) of 2020 and artificial stem inoculation of *Macrophomina* fungi was done (following Mandal et al., 2021) in each and every plant (Figure 2) and data were recorded.

Figure 2: Stem inoculation in jute plants

The F_2 mapping population and parents were planted in row to row and plant to plant distance of 30 cm and 5 cm, respectively. Plants were evaluated for disease resistance based on lesion length and categorised into different groups from susceptibility to resistance (Figure 3).

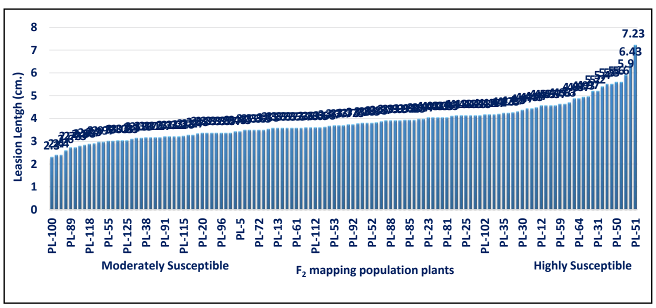

Figure 3: Description of F_2 mapping population plants based on lesion length (cm) of *M. phaseolina* pathogen infection

3. RESULTS AND DISCUSSION

3.1. Development of mapping population

The key approach to resistance breeding is identifying various resistant accessions in both wild and cultivated germplasm resources which is then used in developing resistant lines by introgression in adapted varieties. In jute, resistant sources to stem rot, including released varieties, are not known, and only a few reports about the inheritance of this deadly disease are published.

In this study, F_2 mapping population derived from the cross, OIJ-272×RS-6, was evaluated against the pathogen of stem rot (*M. Phaseolina*) in the summer-2020 cropping season. The parent OIJ-272 exhibited high susceptibility to stem rot with an average lesion length of 5.53 cm, while the parent

Table 1: Screening of parents for *M. phaseolina* based on stem inoculation

Parents	Lesion length (cm)			
	After 7 days post inoculation (7 DPI)	After 14 days post inoculation (14 DPI)	After 21 days post inoculation (21 DPI)	Reaction type
O I J - 272	5.6	5.2	5.8	Susceptible
RS-6	2.3	2.1	2.5	Moderate resistance

RS-6 exhibited moderate resistant reaction with an average lesion length of 2.30 cm (Table 1). The results confirm the previous reports of De and Mandal (2012) and Meena et al. (2015), in which the evaluation of jute genotypes for stem rot resistance has been reported.

3.2. Screening of F_2 population

Selected 125 F_2 plants derived from the cross OIJ-172×RS-6 were screened for resistance against stem rot disease caused by *Macrophomina phaseolina* using the stem inoculation method in the summer of 2020. Progress of infection was measured as the length of the infected stem portion (i.e., lesion length in cm) after 7–14- and 21 days post-inoculation (DPI).

After seven days of infection, maximum damage or maximum lesion length (6.7 cm) was reported in the plant (PL-51), while minimum lesion length (2.3 cm) was noted in the plant (PL-100). After 14 and 21 days of infection plant PL-51 showed lesion lengths of 8.0 cm. and 7.0 cm. respectively. Similarly, the plant PL-100 showed 2.2 cm and 2.4 cm lesion lengths after 14 and 21 days of infection, respectively. The F_2 plants were categorized in three categories based on lesion length after 21 days of inoculation. The lesion length was the smallest (2.0–3.0 cm) in 14 plants, small (3.1–4.0 cm) in 66 plants, medium (4.1–5.0 cm) in 35 plants, large (5.1–6.0 cm) in 8 plants and largest (>6.0 cm) in 2 plants (Table 2). A total of 14 Plants recorded the smallest lesion (PL-100, PL-40, PL-99, PL-33, PL-89, PL-119, PL-1, PL-43, PL-118, PL-121, PL-6, PL-11, PL-55 and PL-86) can be considered as the resistant sources and can be used in the further breeding programme after evaluation of other agronomic characters. Similarly, 66 plants that exhibited small lesions and 35 that recorded medium lesions can be categorised as moderate susceptible for stem rot. The remaining 10 plants exhibiting large and largest lesions were categorised as highly susceptible to the fungus.

Data collected after three-week (21 days) indicated that no plant was immune (no disease) or highly resistant (lesion

Table 2: Screening of F_2 mapping population for resistance to *M. Phaseolina* based on stem inoculation

Lesion length range (cm)	Reaction types	Plants falling into the particular category
<2.0	Immune /Resistance	None
2.1–3.0	Moderate resistance	PL-100, PL-40, PL-99, PL-33, PL-89, PL-119, PL-1, PL-43, PL-118, PL-121, PL-6, PL-11, PL-55, PL-86
3.1–5.0	Moderate susceptible	PL-97, PL-111, PL-125, PL-117, PL-120, PL-124, PL-38, PL-56, PL-74, PL-75, PL-91, PL-93, PL-105, PL-108, PL-115, PL-24, PL-66, PL-7, PL-20, PL-39, PL-49, PL-84, PL-96, PL-101, PL-107, PL-2, PL-5, PL-21, PL-37,PL-58, PL-72, PL-95, PL-106,PL-9, PL-13,PL-22, PL-32, PL-54, PL-61, PL-82, PL-83, PL-90, PL-112, PL-113, PL-29, PL-45, PL-53, PL-67, PL-79, PL-73, PL-92, PL-122, PL-28, PL-36, PL-52, PL-65, PL-70, PL-71, PL-88, PL-109, PL-8, PL-76, PL-85, PL-873.93, PL-103, PL-104, PL-23, PL-44, PL-69, PL-77, PL-81, PL-110, PL-14, PL-17, PL-25, PL-34, PL-68, PL-94, PL-102, PL-116, PL-123, PL-15, PL-32 ,PL-62, PL-98, PL-114, PL-30, PL-42, PL-78, PL-41, PL-12, PL-16, PL-46, PL-57, PL-59, PL-60, PL-63, PL-48, PL-64, PL-10, PL-80
>5.0	Highly susceptible	PL-4, PL-31, PL-19, PL-27, PL-3, PL-50, PL-18, PL-26, PL-47, PL-51

length <2.0 cm). Only 14 plants of the population were moderately resistant (lesion length 2.0–3.0 cm), while the rest were either moderately susceptible or highly susceptible to stem rot disease (Table 2). Earlier studies (De et al., 1990, Gotyal et al., 2014, Palve et al., 2006, Sinha et al., 2006, Mandal et al., 2007, Rijal et al., 2022) also evaluated jute germplasm, F_1 hybrids as well as wild species for stem rot resistance. The screening of segregating the F_2 population of tossa jute (*Corchorus olitorius*) through stem inoculation in the present study indicated variable lesion sizes (2.30–6.70 cm). Significant differences in lesion lengths were observed at 7, 14 and 21 days post-inoculation (DPI) (Table 2). The lesion size of PL-100, PL-40, PL-99, PL-33, PL-89, PL-119, PL-1, PL-43, PL-118, PL-121, PL-6, PL-11, PL-55 and PL-86 plants were closer to the resistant group (lesion length <3.0 cm) than the susceptible ones PL-4, PL-31, PL-19, PL-27, PL-3, PL-50, PL-18, PL-26, PL-47 and PL-51 (lesion length >5.0 cm).

4. CONCLUSION

In this investigation, we identified 14 plants (PL-100, PL-40, PL-99, PL-33, PL-89, PL-119, PL-1, PL-43, PL-118, PL-121, PL-6, PL-11, PL-55 and PL-86) as moderately resistant against a deadly disease stem rot caused by *M. phaseolina*. These plants should be further exploited for developing resistant lines by using them in the breeding programme.

5. ACKNOWLEDGEMENT

The authors are grateful to ICAR-CRIJAF, Barrackpore, for providing valuable materials and facilities for research work.

6. REFERENCES

Adeyemo, O.A., Ayodele, O.O., Ajisafe, M.O., Okinedo, U.E., Adeoye, D.O., Afanou, A.B., Akinsemoyin, F.A., Ogunjobi, O.O., Kasali, O.J., Chukwudiri, E.E., 2021. Evaluation of dark jute SSR markers and morphological traits in genetic diversity assessment of jute mallow (*Corchorus olitorius* L.) cultivars. South African Journal of Botany 137, 290–297.

Ashraf, H., Javaid, A., 2007. Effect of *Macrophomina phaseolina* on the cultivated spp. of jute. Mycopathology 5, 81–84.

Benor, S., 2018. Molecular phylogeny of the genus Corchorus (Grewioideae, Malvaceae sl) based on nuclear rDNA ITS sequences. The Crop Journal 6(5), 552–563.

Chaudhary, S.B., Sharma, H.K., Karmakar, P.G., Kumar, A.A., Saha, A.R., Hazra, P., Mahapatra, B.S., 2013. Nutritional profile of cultivated and wild jute (*Corchorus*) species. Australian Journal of Crop Sciences 7(13), 1973–1982.

De, D.K., Singh, R.D.N., Kaiser, S.A.K.M., 1990. Evaluation of some F_1 hybrids of jute to stem rot disease. Journal of the National Botanical Society 44(1–2), 55–58.

De, R.K., 2014. Search for new fungicides against stem rot of jute (*Corchorus olitorius* L. and *C. capsularis* L.) caused by *Macrophomina phaseolina* (Tassi). Journal of Mycopathological Research 52(2), 217–225.

De, R.K., Mandal, R.K., 2012. Identification of resistant sources of jute (*Corchorus olitorius* L.) against stem rot caused by *Macrophomina phaseolina* (Tassi) Goid. Journal of Mycopathological Research 50(2), 217–222.

Ghosh, T., Biswas, M.K., Dhara, S., Ghosh, C., 2018. Mechanisms involved in jute resistance to *Macrophomina phaseolina*: Strategies for developing resistant jute varieties. Plant Cell Biotechnology and Molecular Biology 19(3–4), 91–106.

Gotyal, B.S., Tripathi, A.N., Selvaraj, K., Babu, V.R., Meena, P.N., Satpathy, S., 2014. Screening of some jute (*Corchorus spp*.) germplasms against stem rot caused by *Macrophomina phaseolina* (Tassi) Goid. Journal of Mycopathological Research 52(2), 363–365.

Islam, M.S., Haque, M.S., Islam, M.M., Emdad, E.M., Halim, A., Hossen, Q.M.M., Alam, M.M., 2012. Tools to kill: Genome of one of the most destructive plant pathogenic fungi *Macrophomina phaseolina*. BMC Genomics 13(1), 1–6.

Kar, C.S., Kundu, A., Sarkar, D., Sinha, M.K., Mahapatra, B.S., 2009. Genetic diversity in jute (*Corchorus* spp.) and its utilization: A review. Indian Journal of Agricultural Sciences 79(8), 587–591.

Mahapatra, A.K., Mandal, R.K., Saha, A., Sinha, M.K., Roy, G., M.K., Kumar, D., Gupta, D., 1994. Field evaluation of white jute (*Corchorus capsularis* L.) germplasm for major diseases. Information bulletin, ICAR- CRIJAF, 1–31.

Majumder, S., Datta, K., Sarkar, C., Saha, S.C., Datta, S.K., 2018. The development of *Macrophomina phaseolina* (fungus) resistant and glufosinate (herbicide) tolerant transgenic jute. Frontiers in Plant Sciences 9, 920.

Majumder, S., Saha, P., Datta, K., Datta, S.K., 2020. Fiber crop, jute improvement by using genomics and genetic engineering. Advancement in Crop Improvement Techniques, 363–383.

Mandal, K., Ghosh, D., Kar, C.S., 2022. Stem rot of jute (*Corchorus* spp.): New insight on its causal organisms. Plant Pathology 72(2), 322–333.

Mandal, K., Kumar, A.A., Ghosh, D., 2021. Development of screening techniques to evaluate response of jute (*Corchorus olitorius*) to *Macrophomina phaseolina*. Australian Journal of Plant Pathology 50, 621–630.

Mandal, R.K., De, R.K., 2007. Scoring technique for screening of jute germplasm lines for tolerance to stem rot pathogen *Macrophomina phaseolina*. Jaf News 5(2), 3.

Mandal, R.K., Sarkar, S., Saha, M.N., 2000. Field evaluation of white jute (*Corchorus capsularis* L.) germplasm against *Macrophomina phaseolina* (Tassi) Goid. Environment and Ecology 18, 814–818.

Mangal, V., Bhandari, H., Meena, J.K., Kumar, A.A., Thribhuvan, R., Chourasia, K.N., Kar, C.S., 2023. Genetic diversity analysis for seed yield attributing traits in white jute (*Corchorus Capsularis* L.). Indian Journal of Plant Genetic Resources 36(1), 31–36.

Marquez, N., Giachero, M.L., Declerck, S., Ducasse, D.A., 2021. *Macrophomina phaseolina*: General Characteristics of Pathogenicity and Methods of Control. Frontier in Plant Science 12, 634397.

Meena, J.K., Bhandari, H.R., Mangal, V., Chourasia, K.N., Thribhuvan, R., Kar, C.S., Mitra, J., 2022. Genetic diversity analysis by D^2 clustering of yield and yield attributing traits in Jute (*Corchorus olitorius*) germplasm lines. Vegetos 35**,** 196–203.

Meena, J.K., Dikshit, H.K., Aski, M., Gupta, S., Singh, A., Tripathi, A., Thribhuvan, R., Chourasia, K.N., 2021. Molecular mapping of a gene conferring *Fusarium* wilt resistance in lentil (*Lens culinaris* Medikus subsp. *culinaris*) using Bulked-segregant analysis. Legume Research-An International Journal, 1–6.

Meena, P.N., De, R.K., Roy, A., Gotyal, B.S., Satpathy, S., Mitra, S., 2015. Evaluation of stem rot disease in jute (*Corchorus olitorius*) germplasm caused by *Macrophomina phaseolina* (Tassi) Goid. Journal of Natural and Applied Science 7(2), 857–859.

Palve, S.M., Sinha, M.K., Mandal, R.K., 2006. Evaluation of wild species of jute (*Corchorus* spp.) for fibre yield and resistance to stem rot [*Macrophomina phaseolina* (Tassi) Goid.] and stem weevil (*Apion corchori* Marshall). Indian journal of Genetics and Plant Breeding 66(02), 153–154.

Rijal, T.R., Karki, S., 2022. Evaluation of promising jute (*Corchorus olitorius*) germplasm against stem rot caused by (*Macrophomina phaseolina*) (Tassi) Goid. International Journal of Applied Agricultural Sciences 8(5), 192–195.

Roy, A., De, R.K., Ghosh, S.K., 2008. Diseases of bast fibre crops and their management. Jute and Allied Fibre Updates, 217–241.

Sinha, M.K., Mandal, R.K., Palve, S.M., 2006. Preliminary evaluation of wild species of jute (*Corchorus* species). PGR Newsletter FAO-Bioversity, 134, 10–12.

Srivastava, R.K., Singh, R.K., Singh, R.B., Maurya, K.L., 2011. Screening for tolerant capsularis jute (*Corchorus capsularis*) germplasm against major diseases. Indian Phytopathology 64(2), 199.

Zhang, L., Ibrahim, A.K., Niyitanga, S., Zhang, L., Qi. J., 2019. Jute (*Corchorus* spp.) Breeding. Advances in Plant Breeding Strategies: Industrial and Food Crops 6, 85–113.