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Screening of finger millet germplasm leading to identification of sources of resistance against blast diseases under natural field conditions

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Abstract
The study was conducted in *Kharif* 2019 at Research cum instructional Farm S.G. College of Agriculture and Research Station, Kumhrawand, Jagdalpur, Bastar IGKV Raipur (C.G.). To evaluate 85 accessions of finger millet genotypes were screened to identify the sources of resistance against blast, diseases. In screening of blast disease incidence, all three patterns namely leaf blast, neck blast and finger blast were recorded. For leaf blast incidence, only one genotype i.e., IC0477045 exhibited resistance. Among others, moderately resistant (30 genotypes), moderately susceptible (32), susceptible (15) and highly susceptible (7) reaction was seen. Neck blast disease incidence ranged from 17.8% to 66.0% indicated that none of the genotypes showed resistance against neck blast. 1 (one) genotypes IC0477787 were found to be moderately resistant, 9 genotypes Moderate susceptible, 51 genotypes susceptible and 24 genotypes highly susceptible. When plants began maturing, they were screened for finger blast disease where none of the genotypes were found to be resistant against the disease, and the percentage of infection ranged from 19.7% to 67.6% compared to 98.8% in susceptible check (GPU 28, Indira Ragi-1, GPU 67, CG Ragi -2). Among the genotypes evaluated Moderate resistance was observed in case of 4 genotypes *viz.* GEC247, IC0477673, GEC 396, and IC0587989. Moderate susceptible 23 genotypes, 48 genotypes susceptible and 10 genotypes exhibited highly susceptible reaction against finger blast disease.

Keywords: Finger millet, genotypes, blast disease

Introduction
Indian mustard (*Brassica juncea* L.) is an important *Rabi* oilseed crop extensively grown as rainfed crop in India. Mustard oil meets the one third of edible oil requirement of the country, to meet these needs the country highly depends on imports of vegetable oil. Import of vegetable oils during July 2019 is up by 26% to 14.12 lakh tones as compared to 11.19 lakh tones in July 2018, according to data compiled by the Solvent Extractors' Association of India (SEA). There is a need to decrease the Import of vegetable oils by expanding the area under oil seed crops. It is important to increase the yields of mustard crop by improving the available germplasm lines, for that we need to know various yield contributing characters and the relationship among them and with the seed yield. In this experiment, we studied correlation or mutual association among different yield contributing characters and the direct and indirect effects also estimated through path coefficient analysis. The inter-relationship between the yield components will be helpful to a breeder to assess the nature, extent and direction of selection pressure on characters.

Material and Methods
Finger millet (*Eleusine coracana* (L.) Gaertn) vernacular name *Ragi* or *mandua*; is an allotetraploid (2n = 4x = 36, AABB) crop of family Poaceae. It is annual herbaceous cereal crop, bearing autogamous flowering nature and having genome size of 1593 Mb (Goron and Raizada, 2015) [2]. The plant is annual tufted grass which grows up to 60-150cm in height and matures in 75-160 days. The leaves are narrow and grass-like which are capable of producing a lot of tillers or basal nodal branches. The ear (panicle in other crops) consists of fingers i.e., distally positioned spikes carrying spikelet. The spikelet comprised of 4-10 flowers, arranged serially on the finger. All flowers are complete flowers, except the terminal ones which may often be infertile. In the spikelet, the flowering continues from the bottom to the top, and in the finger, the flowering order is from the top spikelet down.

The fingers have between 1,500 and 3,000 flowers, and the flowering cycle ranges from six to seven to ten days, the maximum. The cause of self-pollination is the non-opening of flower during entire life cycle i.e., Cleistogamy; but sometimes chasmogamy has also been reported.

Finger millet is staple food crop of drought prone areas like Africa and Asia. Earlier it was considered to be diet of financially marginal people but now a days getting preference as nutraceutical crop. In India it's widely cultivated in southern states namely Karnataka, Tamil Nadu, Andhra Pradesh, Telangana, Madhya Pradesh, Chhattisgarh etc. The crop also has good acreage in hilly and water scarce regions of the country. Among other millets (including both course and small millets) finger millet occupies third position in production after sorghum and pearl millet. As per ICAR-AICRP Small Millets Annual Report 2019-20 finger millet is cultivated over 1016.11 thousand hectares over country with 1181.11 thousand tones production and 1363 kg/ha productivity (Anonymous 2019) [1]. In this, Chhattisgarh state contributes 6.30 thousand hectares in area and 1.50 thousand tones in production and 238 kg/ha in productivity (Anonymous 2019) [1]. There are two major reasons of wide range cultivation of this crop; firstly, adaptability to adverse climatic situations and soil type and secondly, nutraceutical properties, which is transforming this as modern life style food. Finger millet is suitable for dry and infertile soils even with poor water holding capacity. Therefore, it is frequently grown under adverse crop conditions like higher temperature, low and or irregular rainfall and short growing seasons. Most millets have dense, deep penetrating root biology and comparative shorter life cycle, and therefore grows rapidly even with low moisture level, as low as 300 mm (Changmei *et al*., 2014) [3].

In addition to yield *perse*, blast disease caused by *Pyricularia grisea* (Teleomorph: *Magnaporthe grisea*) is emerging as major biotic problem and causing the loss up to 50 percent (Lenne *et al*., 2007) [10] even there are reports of 90 percent crop damage under favorable conditions (Esele, 1993) [4]. Looking to biology of pathogen, it infects the plant at almost every growth stage i.e., at seedling stage (leaf blast), tillering and later stage (neck blast) and grain filling and or maturity stage (finger blast) (Nagaraja *et al.*, 2007) [5]. But the isolates that cause leaf, neck and finger blast on finger millet are genetically similar, indicating the function remains same in different types of incidence (Mgonja *et al.* 2011) [6]. Now a day's perfect fungicides are available to manage this major disease but still have variable results for the crops like finger millet. Additionally, availability and willingness to spray (especially by tribal and poor farmers) is always a challenging task and equally have risk of emerging newer biotypes. Considering all these aspects, the available germplasm or plant genetic resource may have long lasting solution for this biotic problem due to presence of variable degree of tolerance brought about by differential genetic architecture than the cultivated variety. Evaluation of such genotypes may lead to identification of some promising ones which can give us tolerant plant type and even we may get some high grain and fodder yielders in addition. Blast disease was screened at three phases of the crop i.e. at seedling stage (35-40 days old plant) for leaf blast and at dough stage (70-75 days old plant) for neck and finger blast.

Materials and Methods

The experiment was conducted in *Kharif* 2019 at the Research cum Instructional Farm of S.G. College of Agriculture and Research Station (SGCARS), Kumhrawand, Jagdalpur, Bastar (C.G.) situated in 19°4'0" N and 82°2'0"E. The city is nestled on the Bastar Plateau and is positioned at a height of around 552 meters from the mean sea level.

Scoring and analysis for blast disease incidence

Among the diseases, blast caused by *Pyricularia grisea* (Cooke) Sacc. is very prominent one, and affects the productivity, utilization and trade of finger millet. The most susceptible stage for blast is seedling stage, whereas for neck and finger blast incidence is seen at pre-flowering stage. All the test genotypes were scored on the scale of 0-5 for leaf blast, 1- 5 for neck blast and 0-5 for finger blast. On the basis of the score the genotypes were considered as susceptible, moderately resistant and resistant. The details for scoring are given in Table 1, 2 and 3.

Table 1: Scoring for leaf blast disease

Score	Description	Reaction
0	No lesions/symptoms on leaves	No disease /HR
1	Small brown specks of pinhead to slightly elongate necrotic grey spots with a brown margin less than 1% area affected	R
2	A typical blast lesion elliptical 5-10 mm long 1-5% of area affected	MR
3	A typical blast region elliptical 1-2 cm long 6-25% of area affected	MS
4	26-50% leaf area affected	S
5	More than 50% of leaf area affected with coalescing lesions	HS

Neck blast (%) and finger blast (%) was calculated by using the following formula:

Formula

$$\text{Neck blast (\%)} = \frac{\text{No.of infected panicles}}{\text{Total no.of panicles}} \times 100$$

$$\text{Finger blast (\%)} = \frac{\text{No.of infected fingers}}{\text{Avarage no.of fingers} \times \text{Total no.of panicles}} \times 100$$

Table 2: Scoring for neck blast disease

Score	Lesion size on neck	Host response
1	No lesions to pin head size of lesions	Resistant
2	0.1 to 2.0 cm size of typical blast lesion on the neck region	Moderately resistant
3	2.1 to 4.0 cm size of typical blast lesion on the neck region	Moderately susceptible
4	4.1 to 6.0 cm size of typical blast lesion on the neck region	Susceptible
5	> 6.0 cm size of typical blast lesion on the neck region	Highly susceptible

Table 3: Scoring for finger blast disease

Score	Percent finger or ear affected	Host response
	No incidence	
1	0.1-2%	Resistant
2	2.1-10%	Moderately resistant
3	10-25%	Moderately susceptible
4	25.1-50%	Susceptible
5	>50%	Highly susceptible

Results and Discussion

Scoring and interpretation of blast disease incidence

In *Kharif* season, due to continuous heavy rainfall, high Humidity and warm temperature, the crop is heavily infested by blast disease (c.o. *Pyricularia grasea*) incidence. It is a major constraint to the production of finger millet, resulting in direct crop losses in most of growing areas. It becomes more severe in the regions where all three forms of disease like leaf blast, neck blast and finger blast prevail. Use of high yielding resistant/tolerant cultivars is the most viable, environmentally safe and economically sound and proven less expensive approach for the management of this disease.

Blast disease was screened at three phases of the crop i.e., at seedling stage (35-40 days old plant) for leaf blast and at dough stage (70-75 days old plant) for neck and finger blast. The scale adopted was 0-5, where 0 represented no incidence and 5 represented more than 50 percent area of target plant part covered by the disease (Table 4, 5, 6). For leaf blast incidence, none of the genotypes exhibited highly resistance reaction and only one genotype i.e., IC0477045 exhibited resistance. Among others, 30 genotypes were recorded as moderately resistant, 32 genotypes as moderately susceptible, 15 susceptible and 7 to be highly susceptible against leaf blast. When plants were 70-75 days old, they were observed for incidence of neck blast disease. The disease incidence ranged from 17.8 to 66.0% indicated that none of the genotypes showed resistance against neck blast. 1 (one) genotypes IC0477787 were found to be moderately resistant, 9 genotypes Moderate susceptible, 51 genotypes susceptible and 24 genotypes highly susceptible. When plants began maturing, they were screened for finger blast disease where none of the genotypes were found to be resistant and the percentage of infection ranged from 19.7% to 67.6% compared to 98.8% in check varieties (GPU 28, Indira Ragi-1, GPU 67, CG Ragi -2). Among the genotypes evaluated, moderate resistance was observed in case of 4 genotypes *viz*., GEC247, IC0477673, GEC 396, and IC0587989. Moderate susceptible 23 genotypes, 48 genotypes susceptible and 10 genotypes exhibited highly susceptible reaction against finger blast disease. In previous studies, Bal *et al*. (2020) [7] screened eighteen genotypes under field conditions, out of which eight genotypes namely GPU 67, BR 14-3, L 352, KOPN 942, PR 202, VR 708, PR 10-35 and GPU 45 manifested similar reaction against finger blast and neck blast. Patro *et al*. (2018) [12] also reported parallel score for all three kind of blast disease in his study with 25 genotypes.

Summarily, none of the genotypes were observed to be either immune or resistant for the three types of blast i.e., leaf blast, neck blast and finger blast. Another attempt was made to analyze the genotype with higher yield along with the acceptable blast disease score. Genotype IC0477913 had recorded grain yield of 10.01 g/plant and it was observed to be moderately resistant for leaf blast, susceptible for neck blast and moderately susceptible for finger blast. GEC-122, Another good genotype with respect to grain yield also recorded susceptible score for leaf and neck blast, and highly susceptible for finger blast. The similar pattern of susceptible/ moderately susceptible score was seen for other potentially good genotypes namely GEC-396, GEC-249, GEC-259, IC0477654, GPU-28, GEC-79, IC0477604 and so on. Recalling the morphological characterization data, the grain yield per plant was observed in "high" scale among 54 percent accessions; this indicated that the susceptibility of to blast disease was not solely genotypic in nature but mainly brought about by the prevailing weather parameters. This interpretation is also supported by Netam *et al*. (2014) [11] and John (2017) [13], as the Bastar plateau (experimental region) is the "hot-spot" for the blast disease and the symptoms will definitely produced in most of the genotypes, but if the grain yield level is fair, the genotypes can be considered as good.

The objective of screening in available breeding stock was to find out resistant source against the nationally important disease. The resistant genotypes so obtained can be deployed further in breeding programme and should be subject to revalidation under controlled conditions and/or molecular level (Babu *et al*., 2013; Khadka *et al.*, 2013) [8]. Further susceptible genotype may be corrected by either back cross breeding of other approach, if high yielder and agronomically suitable.

HR, R, MR, MS, S, HS

Fig 1: Leaf blast

Fig 2: Neck blast

Fig 3: Finger blast

Table 4: Disease Reaction of Finger millet entries for resistance to Leaf Blast disease under Natural field conditions

Score	Disease Reaction	Number of entries	Name of Germplasm
0	HR	0	
1	R	1	IC0477045
2	MR	30	GEC241, IC0587982, IC077161-X, IC0477632, GEC104, GEC 259, IC0477503, IC0587982, IC0476937, GEC270, IC0476495, GEC274, IC0476864, IC0476404, GEC65, IC077325, GEC432, IC0477569, GEC25, IC0476753, GPU-67, GEC469, GEC485, IC0477328, IC0477195, IC0477913, GEC363, IC0476378, GEC415, GEC517,
3	MS	32	IC0476541, GEC51, GEC181, IC0477507, GEC440, IC0476921, IC0477491, IC04769291, GEC421, GEC67, IC0477299, GEC378, IC0476669-X, GEC296, IC0477951, GEC197, GEC297, IC0477405, GEC280, C.G. Ragi-2, GEC342, IC0476216, GEC62, GEC 187, IC0587989, GEC 275, GEC453, GEC511, GEC79, GEC161, GEC106, GEC23
4	S	15	GEC 425, IC0477152, Indira Ragi-1, IC0477787, GEC394, IC0477604, GEC 197, IC0587947, GEC 319, IC0476663, GEC 244, GEC 249, GEC 122, IC0477963, GPU 28
5	HS	7	GEC 58, GEC 393, IC0477673, GEC321, GEC 396, IC0477264, IC0476464

Where: R = Resistance, HR = Highly Resistance, MR = Moderate Resistance, MS = Moderate susceptible, S = Susceptible, HS = highly susceptible

Table 5: Disease Reaction of Finger millet entries for resistance to Neck Blast disease under Natural field conditions

Score	Disease Reaction	Number of entries	Name of Germplasm
0	HR	0	
1	R	0	
2	MR	1	IC0477787
3	MS	9	GEC104, IC0477951, IC0476937, IC0477637, IC0476864, IC0477325, GEC342, GEC321, GEC67
4	S	51	GEC425, IC0476541, GEC223, IC0477507, IC0477632, IC0477503, IC0587982, IC0477491, IC0476921, GEC378, IC0476669-X, IndiraRagi-1, GEC394, IC0477604, IC0587947, GEC58, GEC270, IC0476495, GEC274, IC0476663, IC0477405, GEC244, GEC421, IC0477045, GEC432, IC0476404, GEC249, IC0476216, GEC62, GEC25, IC0476753, GEC187, IC0477299, GEC511, IC0477561, GEC469, GEC485, IC0477328, GEC122, IC0587989, IC0477913, GEC275, GEC161, GEC363, IC0476464, IC0477963, IC0476378, GEC415, GEC23, GEC517, GPU28
5	HS	24	GEC241, GEC51, IC0477152, GEC181, GEC440, GEC259, IC0477161-X, GEC378, GEC296, IC0477654, GEC197, GEC297, GEC319, GEC393, C.G. RAGI-2, GEC65, IC0477569, IC0477299, GEC396, GEC106, GEC 106, IC0477264, GEC453, GPU67

Table 6: Disease Reaction of Finger millet entries for resistance to finger Blast disease under Natural condition

Score	Disease Reaction	Number of entries	Name of Genotypes
0	HR	0	
1	R	0	
2	MR	4	GEC247, IC0477673, GEC396, IC0587989
3	MS	23	GEC425, IC0477507, IC0476669-X, IC0477787, IC0587947, IC0476937, GEC319, GEC393, IC0476495, IC0476663, GEC432, GEC321, IC0477299, IC047764, GEC453, GEC79, GEC485, IC0477328, IC0477913, GEC106, IC0476464, IC0476378, GEC415
4	S	48	GEC223, GEC241, GEC51, IC0477152, GEC181, GEC440, IC0477632, IC0477503, IC0527982, IC0476921, GEC378, GEC296, Indira Ragi-1, IC0477787, IC0477795, GEC394, IC0477654, GEC297, IC0477604, GEC58, GEC279, GEC58, GEC270, IC0477405, GEC280, GEC244, C.G.Ragi-2, IC0476864, GEC421, IC0477045, IC0476404, GEC65, IC0477325, GEC249, GEC342, GEC62, GEC25, GEC187, IC0477264, GPU67, GEC511, IC0477591, GEC469, IC0477195, GEC363, GEC23, GEC517, GPU28.
5	HS	10	IC04776541, GEC104, GEC259, IC0477491, GEC197, IC0476864, IC0476216, IC0477569, IC0476753, GEC122

Table 7: Parallel comparison of Disease incidence and Grain yield

Genotypes	Leaf blast	Neck blast	Finger blast	Yield (g/plant)
IC0477913	MR	S	MS	10.01
GEC122	S	S	HS	9.88
GEC 396	HS	HS	MR	8.57
GEC249	S	S	S	8.43
GEC 259	MR	HS	HS	8.29
IC0477654	MS	HS	S	7.10
GPU 28	S	S	S	7.05
GEC 79	MS	S	MS	7.70

IC0477604	S	S	S	7.89
GEC 223	MS	S	S	7.43
IC0477264	HS	HS	S	7.64

Conclusion

The study revealed significant differences among the finger millet accessions and evaluate existed in the collected germplasm. To evaluate 85 accessions of finger millet genotypes were screened to identify the sources of resistance against blast, diseases. In screening of blast disease incidence, all three patterns namely leaf blast, neck blast and finger blast were recorded. The conservation and further improvement of these germplasm is a need of an hour and the targeted finger millet improvement programme may be undertaken in future.

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