



RESEARCH ARTICLE

Optimising yield and blast resistance in finger millet through variety and planting time management in North Central Plateau Zone, Odisha

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Abstract

A field experiment was conducted during the kharif seasons of 2022 and 2023 at the Regional Research and Technology Transfer Station (RRTTS), Keonjhar, Odisha, India, to evaluate the effect of sowing dates and varieties on blast disease severity and yield of finger millet (*Eleusine coracana* (L.) Gaertn.) in the North Central Plateau Zone (NCPZ) of Odisha. The experiment was laid out in a split-plot design with 3 replications, comprising four sowing dates (20 June, 30 June, 10 July and 20 July) and 3 varieties (Bhairabi, Arjuna and Kalua). Leaf, neck and finger blast severities were assessed at critical crop growth stages using percent disease severity index and grain yield was recorded at physiological maturity. Delayed sowing from 20 June to 20 July resulted in a progressive increase in blast severity, with finger blast severity ranging from 6.23–30.01 % in 2022 and 4.65–27.63 % in 2023, depending on variety. Among the varieties, Kalua recorded the highest blast severity (up to 30.01 %), whereas Bhairabi consistently showed lower disease severity (< 22.5 %) across both seasons. Early sowing on 20 and 30 June reduced blast severity by 30–45 % compared to late sowing and resulted in higher grain yield, with Bhairabi producing the maximum yield of 10.31 q ha⁻¹ under early sowing. Blast severity showed significant positive correlations with temperature and relative humidity, while grain yield was negatively correlated with disease intensity. The study demonstrates that early sowing combined with tolerant varieties such as Bhairabi can effectively reduce blast severity and enhance finger millet productivity under rainfed conditions, providing a practical strategy for climate-resilient millet cultivation.

Keywords: blast disease; finger millet; sowing dates; varieties

Introduction

Finger millet (*Eleusine coracana* (L.) Gaertn.) is an important small millet cultivated mainly in Asia and Africa under rainfed and marginal agro ecosystems. Globally, finger millet is grown on about 4–5 million hectares with an annual production of nearly 4–5 million tonnes, highlighting its role in food and nutritional security in semi-arid regions (1, 2). India is the largest producer of finger millet, accounting for nearly half of the global production, with the crop cultivated over approximately 1.0–1.2 million hectares and annual production ranging between 1.5 and 2.5 million tonnes (3). Major finger millet-growing states in India include Karnataka, Tamil Nadu, Uttarakhand, Odisha, Maharashtra and Andhra Pradesh. Owing to its high adaptability to drought-prone environments, ability to perform well on poor soils and superior nutritional profile rich in calcium, dietary fibre and essential micronutrients, finger millet plays a vital role in enhancing

livelihood security and climate resilience of vulnerable farming systems (4, 5).

Despite being hardy, finger millet is susceptible to a range of diseases such as blast, sheath blight and seedling blight. Among these, blast caused by *Magnaporthe oryzae* (syn. *Pyricularia grisea*) is the most devastating and can result in complete yield loss if infection occurs before grain filling. Studies indicate average yield losses in India due to blast range from 30–40 %, with localised outbreaks causing losses up to 80–90 % (6). The disease affects all growth stages, with seedlings in nursery beds being particularly vulnerable under favourable conditions of high humidity and low light, leading to a burnt appearance (7).

Timely sowing and use of resistant varieties are effective strategies to manage blast disease. Early sowing reduces the crop's exposure to favourable conditions for pathogen spread and helps avoid peak disease periods. According to recent findings,

sowing finger millet in the second fortnight of June significantly reduces the incidence of blast, likely because the panicle emergence stage highly susceptible to infection does not coincide with the peak period of conducive environmental conditions (8). The blast pathogen thrives in conditions of low temperature (< 20 °C), high relative humidity (> 80 %) and frequent rainfall. Such microclimates often prevail during late sowing, especially after mid-July, making the crop highly vulnerable (9). Additionally, delayed sowing reduces the vegetative growth period and biomass accumulation, ultimately leading to lower yields (10). Optimally timed sowing ensures that the crop benefits from longer daylight duration, moderate temperatures and better resource utilisation.

Location-specific studies on optimal sowing windows and varietal performance under prevailing agro-climatic conditions are essential to mitigate the impact of blast and enhance finger millet productivity. Such targeted agronomic interventions are necessary to sustain and improve finger millet cultivation amidst changing climate scenarios.

Materials and Methods

A field experiment was conducted during the kharif seasons of 2022 and 2023 at the experimental block of the Regional Research and Technology Transfer Station (RRTTS), Keonjhar, Odisha, India, to evaluate the influence of sowing dates and varieties on blast disease incidence and yield of finger millet (*E. coracana*) under the North Central Plateau Zone (NCPZ) of Odisha. The experiment was laid out in a split-plot design with 3 replications, comprising two factors: sowing date (Factor A) and variety (Factor B). Four sowing dates were assigned to Factor A, namely D₁: 20 June, D₂: 30 June, D₃: 10 July and D₄: 20 July, while three finger millet varieties were assigned to Factor B, namely V₁: Bhairabi, V₂: Arjuna and V₃: Kalua, resulting in 12 treatment combinations.

The experimental field was located on medium high land with sandy loam soil having good drainage, a condition conducive for finger millet cultivation. The soil was slightly acidic in reaction with a pH of 6.5, electrical conductivity (EC) of 0.13 dS m⁻¹ and organic carbon content of 0.75 %. The soil was medium in available nutrients, containing 288.2 kg ha⁻¹ of available nitrogen, 18.4 kg ha⁻¹ of available phosphorus and 119.2 kg ha⁻¹ of available potassium. Each experimental plot measured 4.0 × 3.0 m (12 m²). Finger millet was sown in rows spaced 30 cm apart, with a plant-to-plant spacing of 10 cm maintained by thinning at 15 days after emergence. A seed rate of 10 kg ha⁻¹ was used to ensure optimum plant population across treatments. Farmyard manure (FYM) was applied at 7.5 t ha⁻¹ two weeks prior to sowing. A recommended fertiliser dose of 60:30:30 kg ha⁻¹ N:P₂O₅:K₂O was applied using urea, single superphosphate and muriate of potash. 50 % of nitrogen along with the full dose of phosphorus and potassium was applied as a basal dose at sowing, while the remaining nitrogen was top-dressed at 30 days after sowing (DAS). Standard agronomic practices were followed throughout the crop season and no fungicides or pesticides were applied to allow natural disease development. Border rows were maintained around each plot to minimise edge effects and yield observations were recorded from the net plot area, excluding border rows.

Blast disease scoring: Blast disease severity was recorded twice during the crop growth period at distinct and epidemiologically important growth stages. The first observation was taken at the

seedling stage (approximately 20–25 days after sowing, DAS), while the second observation was recorded at the booting stage (approximately 45–50 DAS), when the crop is highly susceptible to blast infection. At each observation, leaf blast severity was assessed using the standard evaluation system (SES) 0–9 scale, where 0 indicates no visible symptoms and 9 represents more than 75 % of the leaf area affected. Disease scoring was conducted by visually assessing 5–10 randomly selected plants per plot, based on lesion size, number and leaf area coverage. The mean disease score per plot was used for statistical analysis. This procedure follows the standard SES methodology (11) and its refinement for finger millet as described by previous researchers (12).

Neck and finger blast incidence: These were recorded at the dough stage and expressed as the percentage of infected panicles or fingers using the following formulas:

$$\text{Neck blast (\%)} = \frac{\text{Number of infected panicles}}{\text{Total number of panicles}} \times 100 \quad (\text{Eqn. 1})$$

$$\text{Finger blast (\%)} = \frac{\text{Number of infected fingers in five plants}}{\text{Total fingers in five plants}} \times 100 \quad (\text{Eqn. 2})$$

Harvesting and yield: The crop was harvested at physiological maturity, defined as when over 50 % of ear heads and straw turned brown. Straw and ear heads from net plots were harvested separately. Grain and straw were threshed and winnowed manually and their weights were recorded for yield estimation.

Meteorological data: Station meteorological data including rainfall, rainy days, maximum and minimum temperatures, relative humidity and bright sunshine hours were obtained from the farm observatory for the cropping period.

Statistical analysis: The data were subjected to analysis of variance (ANOVA) using a mixed-effects model, where sowing date and variety were treated as fixed effects and replication was considered a random effect. Treatment means were separated using the least significant difference (LSD) test at a 5 % level of significance. All statistical analyses were performed using R software (version 4.3.1) with the lme4 and agricolae packages (13, 14).

Results

Meteorological conditions during the crop period

A clear variation in meteorological conditions was observed across different sowing dates (Table 1). Rainfall during the crop period showed a gradual decline with delayed sowing, decreasing from 101.0 mm in the 20th of June sowing to 78.0 mm in the 20th of July sowing. Similarly, afternoon relative humidity (RH-II) decreased from 59.6 to 51.8 %, while maximum temperature increased from 31.5–32.2 °C and evaporation rose from 4.4 mm to 5.6 mm as sowing was delayed. Minimum temperature also declined slightly under later sowing windows. Correlation analysis revealed a strong positive association of grain yield with minimum temperature ($r = 0.986$) and evaporation ($r = 0.826$).

Blast disease incidence in finger millet

Blast disease caused by *Magnaporthe oryzae*, is one of the most destructive diseases affecting finger millet and occurs in multiple forms leaf blast, neck blast and finger blast depending on the crop

Table 1. Meteorological data of the crop periods recorded during experimentation at Regional Research and Technology Transfer Station (RRTTS), Keonjhar

Date of sowing	Mean Met. data of crop periods	Rainfall (mm)	Max. temp °C	Min. temp °C	RH-I	RH-II	EVP (mm)	BSS (hr)	WS km/hr
20 th June	20 June–01 Oct	101.0	31.5	21.4	84.4	59.6	4.4	4.7	4.7
30 th June	30 June–11 Oct	95.1	31.5	21.4	84.4	60.2	4.6	5.1	4.8
10 th July	10 July–23 Oct	86.0	31.6	20.8	83.4	57.6	4.5	4.7	4.5
20 th July	20 July–4 Nov	78.0	32.2	20.0	82.2	51.8	5.6	4.7	4.3
Correlation coefficient (<i>r</i>)		0.702	0.553	0.986	0.472	0.138	0.826	0.537	-0.299

RH: relative humidity; EVP: evaporation; BSS: bright sunshine hours; WS: wind speed

growth stage. The present study evaluated the response of three varieties (Bhairabi, Arjuna and Kalua) sown on four different dates (20th June, 30th June, 10th July and 20th July) over two consecutive seasons (2022 and 2023) to assess variations in blast incidence.

The increased blast severity observed under delayed sowing can be mechanistically linked to progressive changes in microclimatic and crop phenological conditions. Late-sown crops encountered higher temperatures, reduced rainfall and altered relative humidity during critical growth stages, which are known to favour sporulation, conidial dispersal and infection by *M. oryzae*. Additionally, delayed sowing often resulted in prolonged leaf wetness periods and denser crop canopies during the reproductive phase, creating a favourable microenvironment for pathogen establishment and disease progression. In contrast, early-sown crops experienced relatively balanced temperature-moisture regimes that restricted pathogen activity and enhanced host tolerance.

Neck blast incidence

Neck blast severity varied significantly with sowing dates and varieties in both years (Table 2). In 2022, the highest neck blast severity was recorded in Kalua (17.50 %) under 20th July sowing, followed by Arjuna (12.32 %) and Bhairabi (9.21 %). A similar trend was observed in 2023, with Kalua recording the highest severity (21.31 %) under delayed sowing. Bhairabi consistently exhibited

the lowest neck blast incidence, with values as low as 0.02 % under 20th June sowing in 2023.

Delayed sowing (10th July and 20th July) resulted in higher neck blast incidence across all varieties. The interaction between variety and sowing date was statistically significant (CD at 0.05: 7.37 in 2022 and 6.93 in 2023).

Leaf blast incidence

Leaf blast severity showed significant variation among varieties and sowing dates (Table 3). In 2022, Kalua recorded the highest severity (up to 10.65 %) under 10th July sowing, whereas Bhairabi showed the lowest severity (1.33 %). In 2023, Bhairabi recorded the minimal leaf blast incidence, with severity as low as 0.95 % under early sowing.

Kalua consistently showed the highest susceptibility to leaf blast in both years, particularly under late sowing, while Arjuna exhibited moderate susceptibility across sowing dates.

Finger blast incidence

Finger blast, the most yield-damaging phase of blast disease, directly affects the ear heads during the grain-filling stage and thereby causes substantial yield losses by impairing assimilate translocation and seed development. Infection at this stage disrupts normal grain filling by inducing spikelet sterility, shrivelled grains and premature drying of fingers, ultimately reducing both

Table 2. Effect of variety and dates of sowing on the incidence of neck blast disease of finger millet

Variety	Neck blast severity (%)							
	Planting dates, 2022				Planting dates, 2023			
	20 th June	30 th June	10 th July	20 th July	20 th June	30 th June	10 th July	20 th July
Bhairabi	4.05 (6.11)	6.54 (9.54)	7.11 (11.61)	9.21 (13.39)	0.02 (0.47)	2.11 (3.26)	5.02 (6.86)	9.72 (7.81)
Arjuna	7.15 (10.13)	13.64 (15.32)	8.35 (16.78)	12.32 (18.12)	6.68 (7.56)	7.11 (8.98)	11.12 (12.67)	15.51 (20.43)
Kalua	9.17 (14.24)	11.67 (18.97)	13.87 (19.65)	17.50 (24.56)	14.34 (9.36)	18.35 (12.73)	20.76 (19.88)	21.31 (23.25)
CD (0.05)								
Variety		2.86					1.98	
Date of sowing		3.60					2.89	
Variety × Date of sowing		7.37					6.93	

Data in parenthesis shows Arc sine percentage transformation average of 3 replications.

Table 3. Effect of variety and dates of sowing on the incidence of neck blast disease of finger millet

Variety	Leaf blast severity (%)							
	Planting dates, 2022				Planting dates, 2023			
	20 th June	30 th June	10 th July	20 th July	20 th June	30 th June	10 th July	20 th July
Bhairabi	1.33 (4.55)	2.67 (6.59)	4.67 (8.40)	6.98 (12.76)	1.10 (2.97)	1.56 (3.19)	0.95 (2.53)	2.73 (5.25)
Arjuna	4.56 (8.47)	3.41 (11.59)	6.63 (14.51)	8.77 (16.42)	3.10 (7.24)	2.43 (4.19)	2.11 (3.53)	7.89 (13.42)
Kalua	7.33 (13.29)	9.63 (14.95)	10.65 (19.11)	7.13 (23.17)	8.40 (12.14)	8.33 (13.59)	3.77 (9.33)	11.74 (17.44)
CD (0.05)								
Variety		2.42				2.99		
Date of sowing		3.89				2.49		
Variety × Date of sowing		8.78				7.76		

Data in parenthesis shows Arc sine percentage transformation average of 3 replications.

grain weight and harvest index. In the present study, finger blast severity followed patterns like those presented in Table 4, with late sowing dates (10th and 20th July) consistently recording significantly higher disease intensity across all varieties in both years.

In 2022, Kalua exhibited the highest finger blast severity (30.01 %), followed by Arjuna (24.56 %) and Bhairabi (21.23 %), while a comparable trend was observed in 2023, with Kalua again showing maximum severity (27.63 %), indicating its greater susceptibility during the reproductive phase. Elevated finger blast incidence under delayed sowing coincided with adverse weather conditions during flowering and grain-filling stages, which likely favoured pathogen colonisation of the fingers and restricted nutrient flow to developing grains. Conversely, early sowing (20th and 30th June) significantly reduced finger blast incidence, particularly in Bhairabi and Arjuna. The significant interaction between variety and sowing date (CD at 0.05: 7.56 in 2022 and 8.34 in 2023) further emphasises the need to align varietal choice with optimal sowing time to minimise finger blast severity and safeguard grain-filling efficiency.

Effect of sowing dates and varieties on yield

Pooled yield data indicated that sowing dates significantly influenced finger millet productivity (Table 5). The highest grain yield (10.31 q ha⁻¹) and straw yield (12.29 q ha⁻¹) were recorded under 20th June sowing. Yield declined progressively with delayed sowing, with the lowest yields observed under 20th July sowing.

Among varieties, Bhairabi recorded the highest grain and straw yields, followed by Arjuna and Kalua. The interaction between sowing dates and varieties was non-significant, indicating a similar yield response pattern across varieties despite differences in absolute yield levels.

Table 4. Effect of variety and dates of sowing on the incidence of finger blast disease of finger millet

Variety	Finger blast severity (%)							
	Planting dates, 2022				Planting dates, 2023			
	20 th June	30 th June	10 th July	20 th July	20 th June	30 th June	10 th July	20 th July
Bhairabi	6.23 (11.87)	10.65 (13.43)	15.31 (19.87)	21.23 (25.40)	4.65 (9.54)	9.39 (10.33)	15.87 (19.99)	22.31 (23.67)
Arjuna	11.32 (18.65)	16.57 (21.45)	20.31 (24.87)	24.56 (27.88)	12.72 (17.76)	15.74 (20.65)	22.57 (25.11)	25.21 (28.34)
Kalua	16.02 (21.67)	18.75 (23.58)	21.34 (26.78)	30.01 (32.23)	14.14 (18.21)	16.33 (20.01)	17.83 (23.15)	27.63 (29.53)
CD (0.05)								
Variety			3.45				2.32	
Date of sowing			4.73			4.46		
Variety × date of sowing			7.56				8.34	

Data in parenthesis shows Arc sine percentage transformation average of 3 replications.

Table 5. Influence of date of sowing and varieties on yield of finger millet (Pooled data of 2022–23)

Treatments	Grain yield (q/ha)	Straw yield (q/ha)
Date of sowing		
D ₁ (20 th June)	10.31	12.29
D ₂ (30 th June)	9.70	11.81
D ₃ (10 th July)	8.78	11.00
D ₄ (20 th July)	8.20	10.24
S.Em. (±)	0.22	0.27
CD at 5 %	00.87	00.91
Varities		
V ₁ (Bhairabi)	10.31	12.79
V ₂ (Arjuna)	8.62	10.71
V ₃ (Kalua)	8.31	10.65
S.Em. (±)	0.17	0.21
CD at 5 %	0.62	0.71
Interaction		
S.Em. (±)	0.96	1.74
CD at 5 %	NS	NS

NS: Nonsignificant

Correlation analysis

Correlation analysis revealed cultivar-specific variation in the relationship between seed yield and agro-meteorological parameters across phenophases (P1–P6) (Table 6). Rainfall, temperature, relative humidity, evaporation, bright sunshine hours and wind speed exhibited variable correlations with yield depending on growth stage and cultivar.

Sowing date-wise correlation analysis (Table 7) indicated distinct patterns of crop-weather interactions across sowing windows (D1–D4), reflecting differences in climatic exposure during key phenological stages.

Discussion

The results clearly demonstrate that meteorological variability associated with sowing time plays a critical role in blast disease development and yield performance in finger millet. The increase in blast incidence under delayed sowing can be attributed to changes in temperature, relative humidity and canopy microclimate during susceptible growth stages, which favour pathogen infection and disease progression. Similar reductions in yield under late sowing have been reported earlier due to increased disease pressure and sub-optimal weather conditions (15–17). Correlation analysis revealed a strong positive association of grain yield with minimum temperature ($r = 0.986$) and evaporation ($r = 0.826$), indicating that favourable thermal and moisture regimes during early sowing contributed significantly to higher productivity. In contrast, reduced rainfall, lower humidity and increased evaporative demand under delayed sowing likely created less conducive conditions for crop growth and yield formation. These findings are consistent with

Table 6. Correlation coefficient between seed yield and weather parameters variables of cultivars of finger millet

V₁(Bhairabi)						
	P1	P2	P3	P4	P5	P6
Rainfall	-0.648**	0.878**	0.707**	-0.789**	0.986**	....
Rainy days	-0.671**	0.934**	0.726**	-0.968**	0.968**	....
Max temp	0.984**	-0.906**	-0.548*	-0.985**	-0.942**	0.973**
Min temp	0.843**	0.717**	0.997**	-0.084	0.976**	0.984**
RH-I	-0.896**	0.944**	-0.392	0.691**	0.997**	0.965**
RH-II	-0.843**	0.932**	0.943**	0.877**	0.997**	-0.754**
Evp	0.942**	-0.883**	-0.991**	-0.777**	-0.975**	0.961**
BSS	0.713**	-0.865**	-0.997**	-0.101	-0.931**	-0.966**
Wind speed	-0.299	-0.725**	0.855**	0.983**	0.678**	-0.066
V₂(Arjuna)						
Rainfall	-0787**	0.536*	0.791**	-0.542*	0.901**	....
Rainy days	-0.463*	0.702**	0.877**	-0.844**	0.842**	....
Max temp	0.716**	-0.454*	-0.878**	-0.992**	-0.831**	0.964**
Min temp	0.784**	0.721**	0.714**	0.786**	0.646**	0.660**
RH-I	-0.522*	0.817	-0.206	0.929**	0.963**	0.957**
RH-II	-0.691**	0.622**	0.984**	0.935**	0.957**	-0.294
Evp	0.826**	-0.661**	-0.908**	-0.950**	-0.876**	0.968**
BSS	0.298	-0.383	-0.984**	-0.615**	-0.832**	-0.727**
Wind speed	-0.827	-0.927**	0.942**	-0.622**	0.801**	0.085
V₃(Kalua)						
Rainfall	-0.762**	0.560**	0.835**	-0.532*	0.879**	....
Rainy days	-0.417	0.795**	0.937**	-0.791**	0.795**	....
Max temp	0.844**	-0.473*	-0.881	-0.983**	-0.927**	0.895**
Min temp	0.691**	0.802**	0.947**	-0.092	0.889**	0.903**
RH-I	-0.661**	0.771**	-0.104	0.726**	0.947**	0.992**
RH-II	-0.696**	0.614**	0.994**	0.932**	0.959**	0.064
Evp	0.832**	-0.642**	-0.899**	-0.984**	-0.887**	0.846**
BSS	0.537*	0.214	0.032	-0.888**	-0.862**	-0.828**
Wind speed	-0.802**	-0.927**	0.915**	0.211	0.916**	-0.351

*.5 % significant; **.1 % significant; P1: Sowing to germination; P2: Germination to vegetative stage; P3: Vegetative stage to flowering stage; P4: Flowering stage to heading stage; P5: Heading stage to grain filling stage; P6: Grain filling stage to maturity stage; RH: Relative humidity; Evp: Evaporation; BSS: Bright Sunshine hours

Table 7. Correlation coefficient between seed yield and weather parameters variables of different sowing dates of finger millet

D ₁ (20 th June)						
	P1	P2	P3	P4	P5	P6
Rainfall	0.053	0.832*	-0.820**	-0.837**	0.837**	....
Rainy days	0.837**	0.545*	-0.545*	....	....	....
Max Temp	0.545*	-0.694**	0.545*	0.997**	0.756**	-0.891**
Min temp	-0.035	-0.074	-0.053	-0.038	-0.067	-0.120
RH-I	-0.997**	0.638**	-0.837**	-0.720**	-0.891**	-0.593**
RH-II	-0.577**	0.638**	-0.891**	-0.991**	-0.291	-0.791**
Evp	-0.053	-0.756**	0.891**	0.990**	0.545*	-0.891**
BSS	-0.417	-0.986**	-0.772**	0.904**	0.914*	0.827**
Wind speed	0.053	0.998**	0.891**	0.390	0.011	0.990**
D ₂ (30 th June)						
Rainfall	0.833**	0.793**	0.893**	-0.793**	0.923**	....
Rainy days	0.923**	-0.131	0.131	....	-0.793**	....
Max temp	0.971**	0.793**	0.893**	0.793**	0.793**	0.047
Min temp	-0.413	0.793**	-0.893**	0.793**	0.793**	-0.993**
RH-I	-0.472*	-0.793**	0.923**	-0.793**	0.793**	-0.793*
RH-II	-0.977**	-0.793**	0.893**	0.793*	-0.693**	0.591**
Evp	0.793**	-0.693**	0.793**	0.793*	0.923**	-0.793**
BSS	0.961**	-0.893**	0.793**	-0.793**	-0.923**	0.923**
Wind speed	0.905**	0.905**	-0.964**	0.793*	0.965**	-0.997**
D ₃ (10 th July)						
Rainfall	0.914**	-0.953**	0.921**	-0.811**	....	....
Rainy days	0.914**	-0.914**	0.101	0.914**	....	....
Max temp	0.201	0.983**	-0.811**	0.994**	-0.101	-0.817**
Min temp	-0.811**	-0.811**	-0.957**	-0.996**	-0.916**	0.813**
RH-I	-0.914**	0.914**	-0.101	-0.811**	-0.101	-0.914**
RH-II	0.914**	-0.813**	0.914**	-0.811**	-0.711**	0.914**
Evp	0.914**	0.983**	0.914**	0.811**	0.914**	0.811**
BSS	-0.914**	0.991**	0.583**	0.303**	-0.101**	0.584**
Wind speed	-0.811**	0.914**	-0.914**	-0.410	0.811**	0.914**
D ₄ (20 th July)						
Rainfall	0.972**	-0.870**	0.972**	-0.278	....	....
Rainy days	-0.690**	-0.972**	0.972**	-0.278	....	....
Max temp	-0.972**	0.972**	-0.278	0.690**	-0.238	-0.278
Min temp	-0.402	-0.041	-0.181	-0.721**	-0.348	-0.346
RH-I	0.870**	-0.972**	-0.278	-0.279	-0.378	0.278
RH-II	-0.972**	-0.972**	-0.690**	-0.690**	0.690**	0.238
Evp	-0.972**	0.972**	0.870**	0.690**	-0.690**	-0.690**
BSS	-0.972**	0.998**	-0.995**	0.972**	-0.690**	0.690**
Wind speed	-0.972**	-0.278	0.972**	-0.721**	-0.690**	0.278

*-5 % significant; **-1 % significant; RH: Relative humidity; EVP: Evaporation; BSS: Bright sunshine hours

earlier reports which documented declining finger millet yield under hotter and drier late-season sowing environments (15).

Among the varieties, Bhairabi consistently exhibited lower severity of neck, leaf and finger blast across years and sowing dates, indicating stable resistance. In contrast, Kalua showed high susceptibility to all blast forms, particularly under late sowing conditions, suggesting a strong genotype $\times$ environment interaction. These findings align with earlier reports highlighting varietal differences in blast resistance and disease response (18, 19).

Early sowing (20–30th June) significantly reduced blast incidence and resulted in higher yields, likely by enabling the crop to escape peak periods of pathogen activity and adverse weather. This confirms earlier findings that appropriate sowing windows are crucial for minimising blast damage and maximising productivity in finger millet (20, 21).

The correlation analysis further revealed complex interactions between yield and agro-meteorological variables across phenophases. Rainfall and relative humidity showed both positive and negative influences depending on growth stage, emphasising the importance of rainfall distribution rather than total rainfall. Temperature parameters, particularly minimum temperature, showed strong associations with yield, highlighting their role in crop growth and disease dynamics (22–24).

Sowing date-wise correlation patterns indicated that delayed sowing exposed the crop to unfavourable thermal and moisture regimes during reproductive stages, leading to reduced yield potential. These observations reinforce previous recommendations that mid-June to early July represents the optimum sowing window for finger millet cultivation in tropical and sub-tropical regions (25).

Overall, the study highlights the combined importance of timely sowing and cultivar selection for effective blast management and yield optimisation in finger millet under the agro-climatic conditions of the NCPZ of Odisha.

Conclusion

The study revealed that delayed sowing of finger millet from 20th June to 20th July was associated with reduced rainfall, minimum temperature and relative humidity, along with increased evaporation and heat stress, which collectively exerted adverse effects on crop growth, yield and blast disease development. Strong positive correlations of grain yield with minimum temperature and evaporation highlighted the importance of favourable thermal and moisture regimes during critical growth stages. Among the tested varieties, Bhairabi consistently exhibited lower blast incidence and relatively stable yield across sowing dates, indicating better adaptability and tolerance under the agro-climatic conditions of the North Central Plateau Zone (NCPZ) of Odisha, whereas Kalua showed higher susceptibility, particularly under delayed sowing. Early sowing around 20th June provided the most favourable climatic conditions and effectively minimised blast severity, making it the optimal sowing window for the region. Overall, timely sowing combined with the selection of relatively resistant and stable varieties such as Bhairabi can substantially enhance yield stability and climate resilience of finger millet under rainfed conditions. These findings provide valuable insights for developing adaptive and sustainable millet-based production strategies in vulnerable agro-ecosystems.

Authors' contributions

MR and RK carried out the conceptualisation and methodology of the study. MR and AN conducted the field experiment and data collection. Statistical analysis was performed by MR, RK, ST, MM and BS. Manuscript writing, reviewing and editing were carried out by MR, ST and AN. All authors have read and approved the final manuscript.

Compliance with ethical standards

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

Ethical issues: None

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