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Effect of synthetic compounds on growth, physiological traits and yield of pearl millet (*Pennisetum glaucum* L.) under heat stress conditions

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Abstract

Pearl millet (*Pennisetum glaucum* L.) is an important cereal crop grown in arid and semi-arid regions of India. High temperature stress during reproductive stages adversely affects crop productivity. A field experiment was conducted during 2025 at the Centre for Millets Research, Deesa to evaluate the effect of synthetic compounds on morpho-physiological traits and yield of pearl millet under heat stress conditions. The experiment was laid out in a split plot design with four replications. Three sowing dates were assigned to main plots, namely D₁ (second week of February), D₂ (first week of March) and D₃ (second week of March), while eight foliar spray treatments of synthetic compounds were assigned to subplots. The results revealed that sowing during the first week of March (D₂) significantly increased plant height (178.26 cm), leaf area (1000.21 cm² plant⁻¹), dry matter accumulation (14.23 g m⁻²) and SPAD value (61.73). Among foliar spray treatments, application of salicylic acid @ 100 ppm recorded significantly higher growth parameters and yield attributes including earhead length (25.66 cm), test weight (13.41 g), grain yield (4375 kg ha⁻¹) and stover yield (7526 kg ha⁻¹). The study indicates that optimum sowing time combined with foliar application of salicylic acid improves heat stress tolerance and productivity of pearl millet.

Keywords: Pearl millet, heat stress, salicylic acid, foliar spray, sowing date, yield

Introduction

Pearl millet (*Pennisetum glaucum* L.), commonly known as bajra, is one of the most important coarse cereals cultivated in tropical and semi-arid regions of India. It serves as a staple food and fodder crop due to its ability to withstand drought and poor soil fertility conditions. India produces approximately 9.13 million tonnes of pearl millet from 7.38 million hectares with an average productivity of 1237 kg ha⁻¹, with Rajasthan, Gujarat, Haryana, Madhya Pradesh and Maharashtra being the major producing states. High temperature stress is a major abiotic factor limiting crop productivity in arid and semi-arid regions. Climate projections indicate that global temperatures may increase by 1–3.4 °C by the end of the century, resulting in more frequent episodes of heat stress during crop growth stages.

Application of certain synthetic compounds such as potassium nitrate (KNO₃), calcium chloride (CaCl₂) and salicylic acid (SA) has been reported to enhance plant tolerance to abiotic stresses by regulating physiological and biochemical processes. Foliar application of these compounds may improve plant growth, membrane stability and yield under stress conditions. Therefore, the present investigation was conducted to evaluate the effect of different synthetic compounds and sowing dates on morpho-physiological traits and yield of pearl millet under heat stress conditions.

Materials and Methods

Experimental site

The field experiment was conducted during the summer season of 2025 at the Centre for Millets Research, Deesa, Sardarkrushinagar Dantiwada Agricultural University, Gujarat.

Experimental design

The experiment was laid out in a split plot design with four replications.

Main plot treatments (Date of sowing)D₁– Second week of FebruaryD₂– First week of MarchD₃ – Second week of March**Sub plot treatments (Foliar spray of synthetic compounds)**T₁–Potassium nitrate @ 1%T₂–Potassium nitrate @ 3%T₃–Calcium chloride @ 6 mMT₄–Calcium chloride @ 12 mMT₅–Salicylic acid @ 100 ppmT₆–Salicylic acid @ 300 ppmT₇–Water spray (control)T₈ – Absolute control

Foliar sprays were applied at booting and anthesis stages.

Crop details**Crop:** Pearl millet**Variety:** GHB 1351**Spacing:** 45 cm × 15 cm**Observations recorded**

The following observations were recorded during the crop growth period:

1. Plant height (cm)
2. Leaf area (cm² plant⁻¹)
3. Dry matter accumulation (g m⁻²)
4. SPAD value
5. Membrane stability index
6. Canopy temperature
7. Earhead length and girth
8. Number of effective tillers per plant
9. Seed setting percentage
10. Test weight (g)
11. Grain yield (kg ha⁻¹)
12. Stover yield (kg ha⁻¹)

Results and Discussion**Effect of sowing date on growth and physiological parameters**

Sowing date significantly influenced the growth and physiological traits of pearl millet. Sowing during the first week of March (D₂) resulted in significantly higher plant height, leaf area, dry matter accumulation and SPAD value compared with other sowing dates. The improved growth under this sowing time may be attributed to favourable temperature conditions during vegetative and reproductive phases of crop growth. Optimum temperature promotes better photosynthetic activity, leaf expansion and assimilate accumulation which ultimately enhances biomass production.

Higher leaf area under D₂ sowing contributed to increased interception of solar radiation and enhanced photosynthetic efficiency. The increased SPAD value indicates higher chlorophyll content, which directly improves photosynthetic rate and biomass accumulation. Similar results were reported by Yadav *et al.* (2012) ^[4] and Gupta *et al.* (2015) ^[3], who observed that optimum sowing time significantly improves growth and physiological performance of pearl millet under semi-arid conditions.

The results clearly indicate that delayed sowing exposes the crop to higher temperature stress during reproductive stages, leading to reduced physiological efficiency and lower biomass accumulation.

Effect of synthetic compounds on morpho-physiological parameters

Foliar application of synthetic compounds significantly improved morpho-physiological parameters of pearl millet under heat stress conditions. Among the treatments, salicylic acid @ 100 ppm (T₅) recorded the highest plant height, leaf area, dry matter accumulation and SPAD value. Salicylic acid acts as a signalling molecule in plants and plays an important role in stress tolerance by regulating physiological and biochemical processes. It enhances antioxidant activity, improves membrane stability and maintains chlorophyll content under stress conditions. This leads to better photosynthetic efficiency and improved plant growth.

The increase in dry matter accumulation observed under salicylic acid treatment may be due to improved photosynthesis and efficient translocation of assimilates from source to sink. Similar findings were reported by Hayat *et al.* (2010) ^[1] and Khan *et al.* (2015) ^[2], who reported that foliar application of salicylic acid significantly improves growth and physiological traits of crops under abiotic stress conditions.

Effect on yield and yield attributes

Yield attributes such as earhead length, girth of earhead, number of effective tillers per plant and seed setting percentage were significantly influenced by sowing date and foliar spray treatments.

The highest grain yield and stover yield were recorded under salicylic acid @ 100 ppm, which may be attributed to improved physiological efficiency and better reproductive development. Salicylic acid improves pollen viability, seed setting and assimilate partitioning, which ultimately leads to higher grain yield.

Higher test weight under salicylic acid treatment indicates improved grain filling due to better translocation of photosynthates during the reproductive stage. Similar results were reported by Singh *et al.* (2018) ^[5] and Rao *et al.* (2017) ^[6] who reported that exogenous application of salicylic acid enhances yield and yield components in cereal crops under stress conditions.

Table 1: Effect of foliar spray on Morpho-physiological parameters of pearl millet (*Pennisetum glaucum* L.) under heat stress condition

Treatment	Plant height (cm)	Leaf area (cm ² /plant)	Dry matter accumulation (cm)	SPAD Value
	Deesa	Deesa	Deesa	Deesa
A. Main Plot: Date of sowing				
D ₁ : 2 nd Week of February	129.11	648.47	12.75	59.48
D ₂ : 1 st Week of March	178.26	1000.21	14.23	61.73
D ₃ : 2 nd Week of March	167.93	706.52	13.27	60.36
S.Em. ±	2.94	14.85	0.30	0.40
CD at 5%	10.19	51.46	1.05	1.39
CV%	10.50	10.70	12.82	3.74
B. Sub Plot: Foliar spray				
T ₁ : Potassium Nitrate @ 1%	154.95	756.63	13.42	59.90
T ₂ : Potassium Nitrate @ 3%	152.25	793.59	13.63	59.78
T ₃ : Calcium chloride @ 6 mM	160.88	890.20	14.05	62.95
T ₄ : Calcium chloride @ 12 mM	155.57	772.09	13.50	59.68
T ₅ : Salicylic acid @ 100 ppm	167.83	823.81	13.86	64.32
T ₆ : Salicylic acid @ 300 ppm	157.88	756.78	13.23	59.74
T ₇ : Control with water spray	163.42	771.39	13.24	59.24
T ₈ : Absolute control	154.67	716.12	12.43	58.58
S.Em. ±	1.99	24.84	0.26	0.66
CD at 5%	5.62	70.25	0.74	1.86
Interaction (D x T)	NS	NS	1.27	NS
CV%	4.34	10.00	6.71	3.77

Table 2: Effect of foliar spray on Morpho-physiological parameters of pearl millet (*Pennisetum glaucum* L.) under heat stress condition

Treatment	Membrane stability index	Canopy temperature (°C)
	Deesa	Deesa
A. Main Plot: Date of sowing		
D ₁ : 2 nd Week of February	59.30	31.23
D ₂ : 1 st Week of March	61.14	31.16
D ₃ : 2 nd Week of March	63.75	31.18
S.Em. ±	1.21	0.14
CD at 5%	NS	NS
CV%	11.18	2.52
B. Sub Plot: Foliar spray		
T ₁ : Potassium Nitrate @ 1%	60.80	31.25
T ₂ : Potassium Nitrate @ 3%	60.23	31.19
T ₃ : Calcium chloride @ 6 mM	65.37	31.14
T ₄ : Calcium chloride @ 12 mM	60.50	31.33
T ₅ : Salicylic acid @ 100 ppm	68.13	30.92
T ₆ : Salicylic acid @ 300 ppm	60.38	31.33
T ₇ : Control with water spray	57.95	31.08
T ₈ : Absolute control	57.82	31.25
S.Em. ±	2.07	0.20
CD at 5%	5.84	NS
Interaction (D x T)	NS	NS
CV%	11.66	2.26

Table 3: Effect of foliar spray on yield and yield attributing parameters of pearl millet (*Pennisetum glaucum* L.) under heat stress condition

Treatment	Length of earhead (cm)	Girth of earhead	No. of Effective tillers per plant	Seed setting percentage
	Deesa	Deesa	Deesa	Deesa
A. Main Plot: Date of sowing				
D ₁ : 2 nd Week of February	23.76	28.51	4.96	70.93
D ₂ : 1 st Week of March	25.49	31.84	6.62	92.47
D ₃ : 2 nd Week of March	24.47	31.02	5.28	91.10
S.Em. ±	0.34	0.38	0.13	0.55
CD at 5%	1.17	1.33	0.44	1.91
CV%	7.82	7.12	12.67	3.67
B. Sub Plot: Foliar spray				
T ₁ : Potassium Nitrate @ 1%	23.40	29.89	5.25	85.10
T ₂ : Potassium Nitrate @ 3%	24.22	29.92	5.63	84.50
T ₃ : Calcium chloride @ 6 mM	25.09	31.52	5.55	87.10
T ₄ : Calcium chloride @ 12 mM	24.35	30.07	4.97	83.14
T ₅ : Salicylic acid @ 100 ppm	25.66	32.00	6.18	88.22
T ₆ : Salicylic acid @ 300 ppm	24.33	30.42	6.55	84.94
T ₇ : Control with water spray	24.78	30.01	5.83	83.40
T ₈ : Absolute control	23.66	29.82	4.97	82.29
S.Em. ±	0.35	0.47	0.14	0.79
CD at 5%	0.99	1.32	0.40	2.25
Interaction (D x T)	NS	NS	0.70	3.89
CV%	4.96	5.30	8.82	3.24

sTable 4: Effect of foliar spray on yield and yield attributing parameters of pearl millet (*Pennisetum glaucum* L.) under heat stress condition

Treatment	Test Weight (g)	Stover Yield (kg/ha)	Grain yield (kg/ha)
	Deesa	Deesa	Deesa
A. Main Plot: Date of sowing			
D ₁ : 2 nd Week of February	11.81	4524	3084
D ₂ : 1 st Week of March	12.02	7553	4334
D ₃ : 2 nd Week of March	12.00	6324	4256
S.E.m. $\pm$	0.32	236.35	85.37
CD at 5%	NS	668.49	295.80
CV%	10.94	13.35	12.41
B. Sub Plot: Foliar spray			
T ₁ : Potassium Nitrate @ 1%	12.08	5916	3582
T ₂ : Potassium Nitrate @ 3%	11.76	5730	3927
T ₃ : Calcium chloride @ 6 mM	12.16	6865	3817
T ₄ : Calcium chloride @ 12 mM	11.74	5993	3945
T ₅ : Salicylic acid @ 100 ppm	13.41	7526	4375
T ₆ : Salicylic acid @ 300 ppm	11.90	5670	3469
T ₇ : Control with water spray	11.38	5823	4138
T ₈ : Absolute control	11.11	5544	3876
S.E.m. $\pm$	0.21	124.99	180
CD at 5%	0.61	433.06	510
Interaction (D x T)	NS	NS	NS
CV%	6.23	11.53	10.08

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