Indian Journal of Agricultural Sciences **96** (5): 687–691, May 2026/Short Communication
https://doi.org/10.56093/ijas.v96i5.169097

Salicylic acid and sowing dates effect on linseed (*Linum usitatissimum*) under rainfed rice (*Oryza sativa*) fallow condition

DIPSIKHA BONIA[1], ANJAN K SARMAH[1]*, N T RAFIQUE[1], MARAMI DUTTA[1] and SANGITA DAS[1]

Assam Agricultural University, Jorhat, Assam 785 013, India

Received: 17 July 2025; Accepted: 09 April 2026

Keywords: Eastern India, Plant growth regulator, Thermal indices, Yield

Linseed (*Linum usitatissimum* L.) is an important dual-purpose crop cultivated for both oil and fibre. In eastern India including Assam, vast areas under rice (*Oryza sativa* L.)–fallow condition remain unutilised during the *rabi* season, offering significant scope for inclusion of oilseed crops like linseed. The rice–fallow areas of Assam are largely rainfed and characterised by residual soil moisture, making crop establishment and productivity highly dependent on prevailing climatic conditions. Linseed cultivation in rice–fallow condition is constrained by moisture stress and delayed sowing, as the harvest of long-duration winter rice often extends beyond the optimum sowing window i.e. mid-October to mid-November as per package of practices for *rabi* crops of Assam. Delayed sowing exposes the crop to sub-optimal temperature regimes and shortened growing periods, adversely affecting germination, growth, phenological development, and ultimately seed and oil yield. Although linseed is relatively tolerant to moisture stress, significant yield reductions have been reported under late-sown and rainfed condition. Plant growth regulators have emerged as a potential strategy to mitigate abiotic stresses in crops. Among them, salicylic acid (SA), a naturally occurring phenolic compound ($C_7H_6O_3$), plays a crucial role in regulating physiological and biochemical processes in plants, including photosynthesis, transpiration, ion uptake, and stress signalling.

External application of SA has been reported to enhance plant tolerance to abiotic stresses such as drought and temperature extremes by improving antioxidant activity, osmotic regulation, and membrane stability (Ku *et al.* 2018, Paul *et al.* 2024). Therefore, its application may be beneficial in improving the performance of linseed under delayed sowing and moisture stress conditions. In addition, thermal indices such as growing degree days (GDD) and heliothermal units (HTU) are important tools for quantifying crop growth and development in relation to temperature and radiation. These indices help in understanding crop phenology, heat use efficiency, and yield performance under varying sowing dates and environmental conditions. However, their systematic study in linseed under rice–fallow condition, particularly in relation to foliar application of salicylic acid, remains limited. Despite the importance of rice–fallow areas and the potential role of salicylic acid in stress mitigation, systematic information on the combined effect of delayed sowing and salicylic acid application on growth, productivity, and thermal indices in rice–fallow condition of Assam is lacking. Therefore, the present study was undertaken to evaluate the effect of salicylic acid application on linseed under different sowing dates beyond the optimum sowing window in rice–fallow condition of Assam.

The experiment was carried out during the winter (*rabi*) season of 2022–23 at Assam Agricultural University, Jorhat (26°43′N, 94°12′E; at an elevation of 86.7 m amsl), Assam under rainfed rice fallow condition. The soil of the site was acidic in reaction (*p*H 5.23) with organic carbon (0.67%), available nitrogen (247.43 kg/ha), available phosphorus (18.53 kg/ha) and available potassium (185.76 kg/ha). The experiment was laid out in split-plot design and each treatment was replicated thrice. The treatment consisted of three sowing dates (SD), viz. 20th November; 30th November; and 10th December in main plots and four SA concentrations @0, 50, 100 and 150 ppm in the sub-plots. The concentrations of salicylic acid were selected based on earlier studies showing beneficial effects of SA within this range on growth and stress tolerance in oilseed and field crops (Kazemi 2014, El-Nasharty *et al.* 2019). Seeds of linseed variety 'T-397' were sown @15 kg/ha in lines 25 cm apart. The plot size was 4.0 m × 3.0 m. Salicylic acid was applied as foliar spray at pre-flowering and seed ball formation stages using a hand sprayer with a uniform spray volume of 333 L/ha, ensuring proper crop coverage while only pure water was sprayed in control plots. The recommended dose of fertilisers (40 kg N/ha, 20 kg P_2O_5/ha

[1]Assam Agricultural University, Jorhat, Assam.
*Corresponding author email: anjankrishna.sarmah@aau.ac.in

and 10 kg K_2O/ha) were applied as basal dose to all the treatments.

Five representative plants were randomly selected and tagged in each plot for recording the biometric parameters. The total chlorophyll content was estimated by the spectrophotometric method as described by Arnon (1949). Leaf area index (LAI) was computed as the ratio of total leaf area to ground area (Watson 1952). Harvesting was done at physiological maturity corresponding to each sowing date. Threshing was carried out by foot trampling, and seed yield from each plot was recorded after sun drying to 9% moisture content. The oil content of seeds was estimated as per the method documented by AOAC (1960). Data were analysed using the split-plot design (SPD) method described by Panse and Sukhatme (1985). The accumulated growing degree days (AGDD) and accumulated heliothermal units (AHTU) were computed by summing the daily GDD and HTU values, respectively, over the crop growth period.

$$\text{Growing degree days (GDD)} = \{(T_{max} + T_{min})/2\} - T_b$$

Where Tmax and Tmin, Daily maximum and minimum temperatures, respectively; Tb, Base temperature or minimum threshold temperature.

$$\text{HTU} = \text{GDD} \times \text{Actual bright sunshine hours (°C)}$$

Weather data, including maximum and minimum temperature and sunshine hours were collected from the Department of Agrometeorology, Assam Agricultural University, Jorhat for the experimental period. GDD was calculated using a base temperature (Tb) of 10°C, following standard methodology adopted in Indian agrometeorological studies (Sreenivas *et al.* 2010).

Phenology of linseed: The sowing dates significantly affected the phenology of linseed (Table 1). It was recorded that the crop sown on 20th November required significantly a greater number of days to 50% flowering (76.42 days) followed by the crop sown on 30th November (72.58 days), while the crop sown on 10th December required significantly lesser number of days for 50% flowering (66.32 days). The number of days required for seed ball formation and highest number of days for physiological maturity were significantly higher in 20th November. The crop showed significant effect on days to 50% flowering, days to seed ball formation and days to physiological maturity due to application of SA. Salicylic acid sprayed at 100 ppm recorded the highest number of days to physiological maturity which was significantly different from the other three concentrations of SA. The significant variation in accumulated thermal units i.e. GDD and HTU might be responsible for the variation in crop phenology. The reduction in the number of days for the occurrence of various phenological events under the crop sown on 30th November and 10th December might be due to the lesser availability of thermal units which was in conformity with the results of Keerthi *et al.* (2016) and Bhagat *et al.* (2022).

Growth parameters: Among the sowing dates, the 20th November sown crop resulted in the highest plant height, number of branches/plant, leaf area index, dry matter production and total chlorophyll content (Table 2). The enhanced growth observed might be due to more favourable conditions, including better nutrient availability and residual soil moisture, combined with optimal climatic factors like GDD and HTU. Among the SA treatments, application of 100 ppm resulted the highest plant growth parameters over other concentrations. This improvement in growth parameter may be due to the water-soluble antioxidant properties of salicylic acid which regulate plant growth. The role of salicylic acid in enhancing the growth and physiological parameters of the plants was earlier reported by Muthulakshmi and Lingakumar (2016) and Tayyab *et al.* (2020).

Table 1 Phenological stages of linseed under different sowing dates and salicylic acid application

Treatment	Days to emergence	Days to 50% flowering	Days to seed ball formation	Days to physiological maturity
Sowing dates				
20th November	6.42	76.42	92.17	120.75
30th November	7.67	72.58	86.08	116.83
10th December	8.50	66.32	78.83	112.92
SEM±	0.16	1.16	1.65	1.04
CD (p=0.05)	0.61	3.56	5.03	3.15
Salicylic acid				
Control	6.22	66.33	79.56	109.95
50 ppm	6.56	73.78	88.03	115.56
100 ppm	6.89	78.11	91.34	119.62
150 ppm	6.44	70.78	85.67	111.22
SEM±	0.24	1.10	1.06	1.02
CD (p=0.05)	NS	3.30	3.20	3.08
Interaction (SD × SA)	NS	NS	NS	NS

SD, Sowing date; SA, Salicylic acid; NS, Non-significant.

Yield attributes and yield: The crop sown on 20th November showed significant increase in the number of capsules/plant and seeds/capsule over the other dates (Table 3). This improvement in yield attributes for the 20th November sowing might be due to better crop growth and development, higher dry matter accumulation, and optimal utilisation of resources and thermal units. The crop sown on 20th November achieved the highest seed yield of 680.42 kg/ha and oil yield (180.72 kg/ha). In contrast, delaying sowing to 30th November and 10th December resulted in significant reductions in seed yield by 6.06% and 29.35%, respectively compared to the 20th November. These results are consistent with the findings from Bhagat *et al.* (2022).

Among the SA concentrations, 100 ppm SA led to significant increase in yield attributes and yield with

Table 2 Effect of sowing dates and salicylic acid on growth parameters of linseed

Treatment	Plant height at harvest (cm)	Number of branches/plant at harvest	Leaf area index at 90 DAS	Dry matter accumulation at harvest (g/plant)	Total chlorophyll content at 90 DAS (mg/g fresh weight)
Sowing dates					
20th November	55.15	10.29	2.74	1.64	3.02
30th November	44.59	8.74	2.23	1.57	2.87
10th December	37.63	5.39	1.41	1.43	1.83
SEM±	1.14	0.43	0.09	0.05	0.05
CD (p=0.05)	3.45	0.98	0.20	0.11	0.14
Salicylic acid					
Control	45.71	7.45	1.70	1.46	2.45
50 ppm	46.60	8.26	2.29	1.58	2.61
100 ppm	48.93	8.67	2.53	1.62	2.76
150 ppm	45.40	8.18	1.99	1.53	2.52
SEM±	0.73	0.16	0.07	0.007	0.03
CD (p= 0.05)	2.27	0.36	0.15	0.020	0.11
Interaction (SD × SA)	S	NS	NS	NS	NS

DAS, Days after sowing; SD, Sowing date; SA, Salicylic acid; S, Significant; NS, Non-significant.

highest seed yield and stover yield. The enhanced yield attributes, including the number of capsules/plant and seeds/capsule contributed to the higher yields observed with 100 ppm SA. These results are consistent with the findings of Kazemi (2014) and El-Nasharty *et al.* (2019). Salicylic acid stimulates the physiological processes, leading to improved vegetative growth and more efficient translocation of photosynthetic products. The effect of sowing dates on oil yield was found significant whereas the effect of SA application was non-significant. The interaction between the sowing dates and salicylic acid was found significant for plant height and seed yield (Fig. 1). The crop sown on 20th November and treated with 100 ppm salicylic acid achieved the highest plant height (56.80 cm) and seed yield (694.24 kg/ha). This increase is likely due to the optimal sowing time combined with the precise application of salicylic acid which enhanced yield attributes and resulted in superior seed yield compared to other treatment combinations. Though early sowing provided the highest yield, the application of SA at 100 ppm consistently improved plant growth and yield components across all sowing dates, indicating its potential in mitigating stress in the late sown condition. The comparatively lower performance of 150 ppm SA application might be attributed to a possible inhibitory effect at higher concentration. Salicylic acid exhibits a dose-dependent effect on plant growth, with high concentrations often causing inhibition (Li *et al.* 2022).

Thermal indices: The accumulated growing degree days (AGDD) and accumulated helio-thermal unit (AHTU) calculated at different phenological stages were influenced by different sowing dates (Table 4). The crop sown on 20th November availed significantly higher AGDD at 50% flowering (692.5ºC day) and days to physiological maturity (1,221.3ºC day) which was closely followed by the crop

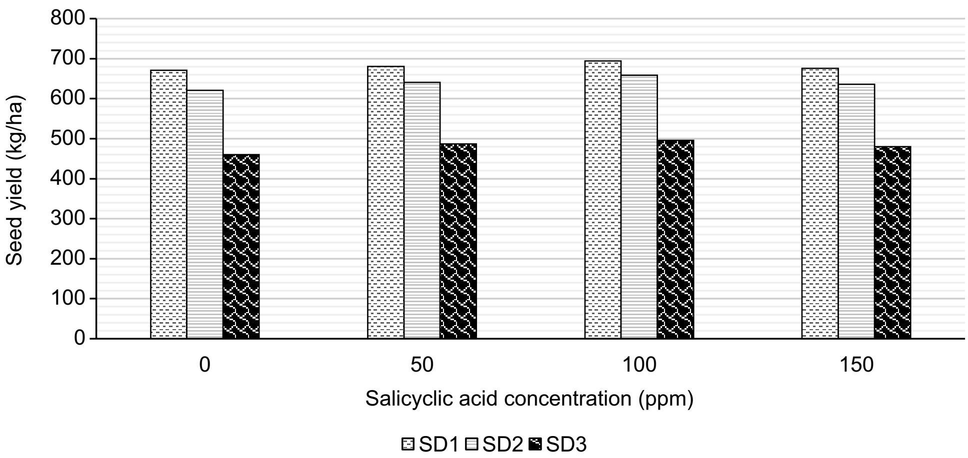

Fig. 1 Interaction effect of sowing dates and salicylic acid on seed yield of linseed. SD1, Sowing data 1 (20th November); SD2, 30th November; SD3, 10th December.

Table 3 Effect of sowing dates and salicylic acid on yield attributes and yield of linseed

Treatment	No. of capsules/ plant	No. of seeds/ capsules	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)	Oil yield (kg/ha)
Sowing dates						
20th November	26.98	10.78	680.42	1,792.47	37.02	180.72
30th November	22.83	8.47	639.12	1,725.10	33.89	162.69
10th December	18.58	5.61	480.71	1,415.77	29.39	139.96
SEM±	1.36	0.27	5.81	4.49	0.59	0.78
CD (p=0.05)	4.01	0.61	17.48	13.43	1.81	2.28
Salicylic acid						
Control	19.38	7.45	583.95	1,616.18	30.40	160.80
50 ppm	21.22	8.26	602.80	1,653.63	36.42	161.57
100 ppm	25.36	8.67	616.35	1,667.51	36.96	162.12
150 ppm	20.24	8.18	597.24	1,629.47	36.63	160.04
SEM±	1.07	0.16	3.91	3.52	0.23	0.59
CD (p= 0.05)	3.14	0.36	11.68	10.67	0.52	NS
Interaction (SD × SA)	NS	NS	S	NS	NS	NS

SD, Sowing date; SA, Salicylic acid; S, Significant; NS, Non-significant.

Table 4 Accumulated thermal units of linseed under different sowing dates

Phenology	AGDD (°C days)	AHTU (°C day h)
20th November		
Days to 50% flowering	692.50	4,363.31
Days to physiological maturity	1,221.30	6,518.87
30th November		
Days to 50% flowering	657.40	4,285.69
Days to physiological maturity	1,155.40	6,387.63
10th December		
Days to 50% flowering	614.00	4,276.29
Days to physiological maturity	1,093.80	6,137.39

sown on 30th November. Similar findings were observed incase of AHTU.

SUMMARY

A field experiment was conducted during the winter (*rabi*) season of 2022–23 at ICR Farm of Assam Agricultural University, Jorhat, Assam to assess the effect of salicylic acid on rainfed late sown linseed under different sowing dates in rice–fallow condition. The experiment was laid out in split-plot design with three sowing dates in main plot and four salicylic acid concentrations in sub-plots. Different sowing dates and salicylic acid concentrations significantly affected the growth and yield of linseed. Although sowing on 20th November was most favourable for linseed growth and yield, application of salicylic acid @100 ppm at pre-flowering and seed ball formation stage improved crop performance even under late sowing condition. Thus, salicylic acid application @100 ppm may be recommended as a crop management strategy to mitigate the effects of delayed sowing of linseed in rainfed rice–fallow condition.

REFERENCES

AOAC. 1960. *Official Method of Analysis*, 10th edn. Association of Official Agricultural Chemist, Washington DC.

Arnon D I. 1949. Copper enzymes in isolated chloroplasts. Polyphenol oxidase in *Beta vulgaris*. *Plant Physiology* **24**: 1–15.

Bhagat R, Singh M, Sharma B C and Shankar U. 2022. Effect of sowing environments on yield attributes and yield of gobhi sarson (*B. napus*) cultivars under sub-tropics of Jammu region. *Journal of Oilseed Brassica* **13**(1): 7–10.

El-Nasharty A B, El-Nwehy S S, Aly E, El-nour A B O U and Rezk A I. 2019. Impact of salicylic acid foliar application on two wheat cultivars grown under saline conditions. *Pakistan Journal of Botany* **51**(6): 1939–44.

Kazemi M. 2014. Foliar application of salicylic acid and methyl jasmonate on yield, yield components and chemical properties of tomato. *The Indian Journal of Agricultural Sciences* **10**(4): 771–78.

Keerthi P, Pannu R K, Singh R and Dhaka A K. 2016. Thermal requirements, heat use efficiency and plant responses of Indian mustard (*Brassica juncea*) for different levels of nitrogen under different environments. *Journal of Agrometeorology,* **18**: 201–05.

Ku Y S, Sintaha M, Cheung M Y and Lam H M. 2018. Plant hormone signaling crosstalks between biotic and abiotic stress responses. *International Journal of Molecular Sciences* **19**(10): 3206.

Li A, Sun X and Liu L. 2022. Action of salicylic acid on plant growth. *Frontiers in Plant Science* **13**: 878076. https://doi.org/10.3389/fpls.2022.878076

Muthulakshmi S and Lingakumar K. 2016. Salicylic acid induced responses on growth and biochemical constituents in *Vigna mungo* (L.) Hepper. *European Journal of Experimental Biology* **6**(1): 9–14.

Panse V G and Sukhatme P V. 1985. *Statistical Methods for Agricultural Workers.* Indian Council of Agricultural Research, New Delhi.

Paul A, Kakoti M, Dutta P, Hazarika B, Robertson A, Talukdar N and Ray S. 2024. Role of salicylic acid in mitigating stress and improving productivity of crops: A review. *Journal of Advances in Biology and Biotechnology* **27**(7): 1351–61.

Sreenivas G, Reddy M D and Reddy D R. 2010. Agrometeorological indices in relation to phenology of aerobic rice. *Journal of Agrometeorology* **12**(2): 241–44.

Tayyab N, Naz R, Yasmin H, Nohseen A, Keyani R, Sajjad M, Hassan M N and Roberts T H. 2020. Combined seed and foliar pre-treatments with exogenous methyl jasmonate and salicylic acid mitigate drought-induced stress in maize. *PLoS ONE* **15**(5): e0232269.

Watson D J. 1952. The physiological basis of variation in yield. *Advances in Agronomy* **4**: 101–45.