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Effect of Salicylic Acid to Mitigate The High Temperature Stress in Indian Mustard (*Brassica juncea* L.)

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Abstract A field experiment was conducted to evaluate the effect of sowing time, varieties and salicylic acid (SA) application on yield and quality of Indian mustard. The experiment was laid out in split plot design and replicated thrice. The experiment consisted of three sowing dates [20th October (timely sowing), 15th November (late sowing) and 30th November (very late sowing)], two varieties [RGN-236, RGN-229] and four levels of salicylic acid (Control, SA 50 ppm, SA 100 ppm and SA 150 ppm). Results were revealed that effect of different sowing time, varieties and concentration of SA has shown significant effect on yield attributes, yield and quality of Indian mustard. Results were revealed that growth parameters, yield attributes viz. siliquae per plant (178.82), number of seeds / siliqua (14.99), test weight (4.71) and grain yield (1,671 kg/ha) were higher with 20th October followed by 15th November sowing. Incase of varieties, highest growth parameter, yield attributes and grain yield (1,557 kg/ha) were recorded with variety RGN-229, which was significantly superior to RGN-236. The maximum oil content (41.6%) was observed with 20th October sowing followed by 15th November. Between the varieties, the variety RGN-229 was recorded significantly superior to RGN-236 in respect of oil content. The application of 150 ppm SA at flowering and siliqua formation stage recorded higher yield and oil content in all treatments.

Keywords Salicylic acid, High temperature, Indian mustard.

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Introduction

Indian mustard is the most important winter season oilseed crop grown under diverse agro-ecological situations. Sowing of this crop is often delayed to second fortnight of November in multiple/intensive cropping system leading to reduced growth period. Low temperature during winter suppresses vegetative growth and with the rise in temperature during mid February the reproductive phase is shortened as such the crop experiences terminal heat stress during reproductive stage. High temperature hampers translocation and assimilates partitioning leading to yield losses. According to Lobell and Asner [1] each degree centigrade increase in average growing season temperature may reduce yield upto 17%. Therefore rapid and effective measures of plant treatments are necessary so that deterioration of crops due to heat stress can be countered successfully. Production potentiality of any crop can be fully exploited with suitable agronomic practices and genotypes. Among the different agronomic practices, optimum sowing time play an important role in fully exploiting the genetic potentiality of cultivars as it provides optimum growing conditions. The growth phase of the crop should synchronize with optimum environmental conditions for better expression of growth and yield. It is a fact that specified genotype does not exhibit the same pgenotypic characteristics in all environmental conditions. Growth response of different genotypes varies under different environmental conditions. Plant productivity is severely affected by several abiotic stresses including, salinity, drought, high and low temperature and heavy metals. Among these high temperature is an important constraint in mustard production. Thermo-tolerance using various genetic approaches can mitigate the adverse effects of heat stress. For this purpose, a thorough understanding of physiological responses of plants to high temperature and possible strategies for improving crop thermotolerance is imperative. The application of plant growth regulators is known to play an important role in plant response to stress. Salicylic acid plays diverse physiological roles in plants which include thermogenesis, flower induction and on physiological parameters [2]. Salicylic acid has been found to be involved in both basal and acquired-thermo-tolerance in plants [3]. Taking cognizance of the facts mentioned above, present investigation was conducted.

Materials and Methods

The present investigation was conducted at Agronomy Farm, SKN College of Agriculture, Jobner (26005´ N latitude, 75028´ E longitude and at an altitude of 427 m above mean sea level), Jaipur, Rajasthan, India during *rabi* season of 2013-14. The soil of the experimental site was classified as loamy sand in texture and alkaline in reaction. The climate of this region is typically semi-arid which is characterized by the aridity and extremity of temperature fluctuations in summer and winter. During summer, maximum temperature ranges between 35—46°C while in winter, it may falls down to as low as -1°C. The average rainfall of this locality is approximately 400 mm, most of which is received during rainy season from July to September.

The experiment was conducted in split plot design with three replications. The experiment consisted of three sowing dates [20th October (timely sowing), 15th November (late sowing) and 30th November (very late sowing)], two varieties [RGN-236, RGN-229] and four levels of salicylic acid (control, SA 50 ppm, SA 100 ppm and SA 150 ppm). The crop was fertilized with 60 kg N and 40 kg P_2O_5 ha^{-1}. One half of nitrogen and full dose of phosphorus were given as basal application. The remaining dose of nitrogen was top dressed at first irrigation 30 days after sowing (DAS). The foliar spray of SA was applied at flowering and siliqua formation.

Results and Discussion

Tables 1 and 2 showed that different times of sowing, varieties and levels of SA bring significant effect on growth, yield and oil content of mustard. Days to 50% flowering were reduced with delayed sowing. Mustard sown on 20th October took the maximum number of days to reach to 50% flowering which was significantly superior to all other dates of sowing. The cultivar RGN-236 took more days to reach to 50% flowering. In case of SA application, increased dose of SA increases days to 50% flowering. Among SA levels, application of 150 ppm SA took the maximum number of days in 50% flowering (76 days) which was significantly superior to all other treatments. Mustard crop sown on 20th October was found at par with 15th November sown crop and recorded significantly taller plant than 30th November sown crop. Plant height was differed significantly under different cultivars of mustard. The cultivar RGN-229 produced the tallest plant (176.05 cm) followed by RGN-236. In case of SA, the maximum increase in plant height was observed with the application of 150 ppm (10.97%) at flowering and siliqua formation. Several studies have demonstrated that exogenous SA application enhances plant growth and development. This was mainly because favorable weather conditions prevailed during crop growth. These results are in close conformity with the observations of Khushu and Singh [4]. A beneficial effect of early planting on growth, yield and oil content as compared to later

Table 1. Effect of sowing time, genotypes and SA application on days to 50% flowering, plant height (cm), siliquae per plant, number of seeds/siliqua and test weight (g) of Indian mustard.

Treatments	Days to 50% flowering	Plant height (cm)	Siliquae per plant	Number of seeds/siliqua	Test weight (g)
Varieties					
RGN-236	74.0	168.43	236.21	13	4.58
RGN-229	68.0	176.05	251.45	13.9	4.7
SEm±	0.6	1.35	1.92	0.11	0.013
CD (p = 0.05)	2.0	3.82	5.43	0.31	0.036
Date of sowing					
Timely sowing	74.0	178.82	269.96	14.99	4.71
Late sowing	72.0	174	257.07	13.59	4.66
Very late sowing	67.0	163.9	204.46	11.77	4.55
SEm±	0.73	1.65	2.35	0.13	0.016
CD (p= 0.05)	2.0	4.68	6.65	0.38	0.044
Salicylic acid					
Control	67.0	163.37	210.2	11.5	4.33
SA 50 ppm	69.0	168.99	243.72	13	4.64
SA 100 ppm	73.0	175.3	253.47	13.8	4.73
SA 150 ppm	76.0	181.3	267.93	15.5	4.86
SEm±	0.85	1.91	2.71	0.15	0.018
CD (p= 0.05)	2.0	5.41	7.68	0.43	0.051

plantings might be due to more favorable environment prevailed during the entire growing season. The early planting accumulated more growing days. The crop might have higher interception of PAR for growth and development. Brief exposure of plants to heat stress during seed filling can accelerate senescence, diminish seed set and seed weight and reduce yield. This phenomena is a result of the plant tending to divert resources to cope with the heat stress at the expense of photosynthesis and ultimately plant growth and development. However, exogenous application of salicylic acid reverses the effect [5]. These results are in accordance with our findings. Fariduddin et al. [6] also showed that mustard plants sprayed with low concentrations of SA produced larger amounts of dry matter, taller plant and had higher photosynthetic rate in comparison with control plants. SA application to corn and soybean promoted leaf area and dry weight of plants [7]. In another study Hussein et al. [8] revealed that growth traits of wheat plants were improved as a result of SA spraying on the plants. In addition, Hayat et al. [9] reported that soaking of wheat grains in low concentrations of SA significantly promoted growth of wheat seedlings.

Table 1 showed that yield attributes of mustard were significantly influenced by different time of sowing, varieties and levels of SA. The number of siliqua per plant was drastically reduced with delayed sowing. Sowing of mustard on 20th October produced significantly highest number of siliqua per plant (269.96) as compared to delayed sowing. Mustard variety RGN-229 produced significantly higher number of siliquae per plant (251.45), which was 6.06% higher than RGN-236. The maximum increase in number of siliqua per plant was observed with increased dose of SA. The highest number of seeds per siliqua were recorded under early sown crop (20th October) over late sown (30th November). RGN-229 recorded significantly higher number of seeds per siliqua as compared to RGN-236. It was observed that with the application of 150 ppm SA increase in seeds per siliqua (34.78%) over control. The test weight of mustard was decreased gradually with delayed sowing. The highest test weight of mustard was recorded with the application of 150 ppm SA at flowering and siliqua formation.

The time of sowing brought out significant effect on seed yield, biological yield and harvest index of mustard. Highest seed yield (1671 kg/ha) was produced under 20th October sowing and it remained statistically at par with 15th November sowing. However, planting of mustard on 30th November produced significantly lower seed yield (1355 kg/ha), which was 20.06 and 11.21% lower than 20th October and 15th November sown crop respectively. In case of cultivars, RGN-229 remained at par with RGN-236. Increasing dose of SA also respond positively on seed yield.

Table 2. Effect of sowing time, genotypes and SA application on seed yield (kg/ha), biological yield (kg/ha), harvest index (%) and oil content (%) of Indian mustard.

Treatments	Seed yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)	Oil content (%)
Varieties				
RGN-236	1475	4899	30.64	39. 3
RGN-229	1557	5149	32.9	41.92
SEm±	5.09	21.58	0.25	0.22
CD (p= 0.05)	14.43	61.19	0.72	0.61
Date of sowing				
Timely sowing	1671	5583	33.96	41.6
Late sowing	1522	5027	31.77	40.86
Very late sowing	1355	4463	29.58	39.37
SEm±	6.23	26.44	0.31	0.26
CD (p= 0.05)	17.67	74.94	0.88	0.75
Salicylic acid				
Control	1361	4553	29	39.24
SA 50 ppm	1511	4951	30.08	40.13
SA 100 ppm	1570	5121	33	41.08
SA 150 ppm	1621	5473	35	41.99
SEm±	7.2	30.52	0.36	0.31
CD (p= 0.05)	20.4	86.54	1.01	0.87

The highest seed yield was recorded with the application of 150 ppm SA. Increase in seed yield with foliar spray of SA could be ascribed to the fact that crop yield is not an abstract entity but it is an outcome of positive interaction between vegetative and reproductive growth of the crop. Significant improvement in yield components of wheat crop under the influence of SA was also reported by Hassanein et al. [10]. The same trend was found in case of biological yield of mustard. Significant enhancement in stover yield under foliar spray of SA seems to be due to their direct effect on DMA by virtue of increased nutrient uptake and photosynthetic efficiency and plant height. Sowing time had significant effect on harvest index of mustard. Mustard sown on 20th October fetched significantly higher harvest index (33.96) as compared to 30th November sown crop, but it was found to be at par with 15th November sown crop. Mustard variety RGN-229 recorded significantly higher harvest index (32.90%) as compared to RGN-236 (30.64%). The highest harvest index was recorded with spraying of 150 ppm SA which was 20.68% more over control.

It is observed that the oil content of mustard was also influenced significantly by times of sowing varieties and levels of SA. Oil content of mustard was decreased by delayed sowing. Sowing of mustard on 20th October recorded significantly higher oil content in seed (41.60%) than 30th November sown crop (39.37%) but found statistically similar with 15th November sown crop (40.86%). Mustard cultivar RGN-229 recorded significantly higher oil content (41.92%) followed by RGN-236 (39.30%). In case of SA, with increasing dose of SA the oil content was increased. The maximum oil content was recorded with spraying of 150 ppm SA which was 7.00% more over control. It was reported that the foliar application of salicylic acid to soybean also enhanced the flowering and pod formation [11]. Flowering is another important parameter that is directly related to yield and productivity of plants. Salicylic acid has been reported to induce flowering in a number of plants. In cucumber and tomato, the fruit yield enhanced significantly when the plants were sprayed with lower concentrations of salicylic acid [12]. The significant improvement in various yield attributes of the crop seems to be on account of fully exploiting environmental resources (above and below ground) for synthesis of photosynthates under early planting. Besides adequate supply of growth inputs (nutrients and water), the favorable weather conditions seem to have helped plants to use their full potential for reproductive growth. The production of higher amount of photosynthates in early planting helped the plant to develop larger nutrient sink in order to accumulate synthesized photosynthates. This resulted improvement in each component in early planting. In early planting (20th October) yield attributes were quite high and seeds of higher weight, which positively contributed to higher yield. High temperature during grain development in late planting caused forced maturity of the crop resulting in development of seeds with lower weight which is evident from the low test weight. On account of favorable weather conditions, improvement in growth and yield attributes, the crop sown on 20th October produced significantly higher seed yield over subsequent sowings. Higher temperature during later phases of growth shortened the crop period and forced maturity resulted in reduced unit weight of seed and ultimately the lower seed yield under subsequent sowings. With the foliar application of salicylic acid the percentage of shriveled seeds declined, fully developed seeds increased thereby enhancing the number of seeds per siliqua.

It can be concluded from the present study that timely sowing (20th October) of *Brassica juncea* variety RGN-229 with foliar spray of 150 ppm SA at flowering and siliqua formation stage proved supremacy over other treatments for yield and oil content.

References

1. Lobell DB, Asner GP (2003) Climate and management contribution to recent trends in US agricultural yields. Sci 299 : 1032.
2. Hayat Sand Ahmad A (2007) Salicylic acid : A plant hormone. Springer Publ, Dordrecht, The Netherlands.
3. Dat JF, Foyer CH, Scott JM (1998) Changes in salicylic acid and antioxidants during induction of thermo-tolerance in mustard seedlings. Pl Physiol 118 : 1455—1461.
4. Khushu MK, Singh M (2005) Thermal response of mustard under rainfed condition of Jammu. Environ Ecol 23 : 683—686.
5. Cong L, Chai T–Y, Zhang Y–X (2008) Characterization of the novel gene BjDREB1B encoding a DRE-binding transcription factor from *Brassica juncea* L. Biochem Biophys Res Commun 371 : 702—706.
6. Fariduddin Q, Hayat S, Ahmad A (2003) Salicylic acid influences net photosynthetic rate, carboxylation efficiency, nitrate reductase activity and seed yield in *Brassica juncea*. Photosynthetica 41 : 281—284.
7. Khan W, Prithviraj Band, Smith DL (2003) Photosynthetic responses of corn and soybean to foliar application of salicylates. J Pl Physiol 160 : 485—492.
8. Hussein MM, Balbaa LK, Gaballah MS (2007) Salicylic acid and salinity effects on growth of maize plants. Res J Agric Biol Sci 3 : 321—328.
9. Hayat S, Fariduddin Q, Ali B, Ahmad A (2005) Effect of salicylic acid on growth and enzyme activities of wheat seedlings. Acta Agron Hung 53 : 433—437.
10. Hassanein R, Abdelkader AF, Ali H, Amin AA, Rashad EM (2012) Grain primary and foliar pretreatment enhanced stress defense in wheat (*Triticum aestivum* var Gimaza) plants cultivated in drought land. Aust J Crop Sci 6 : 121—129.
11. Hayat Q, Hayat S, Irfan M, Ahmad A (2010) Effect of exogenous salicylic acid under changing environment. Environ Experim Bot 68 : 14—25.
12. Larque-Saavedra A, Martin-Mex R (2007) Effect of salicylic acid on the bio-productivity of plants. In: Hayat S, Ahmad A (eds). Salicylic acid. A plant hormone. Springer Publ. Dordrecht. The Netherland.