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Performance of Indian mustard as influenced by plant growth regulator-brassinosteroid under the Western Arid Region of Rajasthan

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Abstract

Water scarcity along with poor quality irrigation water is a major threat to mustard production in Western Rajasthan. The present study was conducted to assess the effect of a plant growth regulator (PGR) i.e., brassinosteroid on the performance of Indian mustard during the 2018-19 to 2019-20. A field experiment was conducted with two treatments i.e., a control (without PGR) and two foliar sprays of PGR-brassinosteroid (2 ppm) at 30 and 60 days after sowing and replicated at ten farmer's fields. The finding revealed that the mustard yield was significantly reported higher with PGR-brassinosteroid as compared to the control. The nutrient use efficiency and water productivity were significantly enhanced with PGR-brassinosteroid over the control. The net returns per unit of investment was recorded 3.21 with PGR-brassinosteroid which was significantly superior over the control. Thus, it can be concluded that the application of PGR-brassinosteroid may be one of the good options to sustain the productivity of mustard under water stress condition of Western Rajasthan.

Keywords: *Indian mustard, PGR-brassinosteroid, productivity, profitability, water productivity*

Introduction

Oilseed crops form the backbone of agricultural economy of India, since oilseed crops and their products are the second most sold commodities in the world trade (Verma *et al.,* 2014). India is the world's largest producer of edible oils yet it imports large quantities of oils (Langadi *et al.,* 2021). Mustard is cultivated in tropical and temperate zones and requires relatively cool temperatures for satisfactory growth. However, high temperature leads to loss in productivity. The total area under rapeseed-mustard in India was 6.80 mha with a production of 9.10 mt and productivity of 1345 kg/ha in the year 2019-20. Rajasthan state is situated at the Great Indian Thar Desert in the North-Western part of India and is susceptible to a loss of good quality water availability, causing the harsh impact of climate change. This state produced 20.38 % of the total oilseeds production of India in 2019-20 (GOI, 2023). Approximately 80 % of global mustard cultivation is undertaken in semi-arid and arid climatic conditions where the quality of groundwater is very poor and crop cultivation is dependent on monsoon rain or the early irrigation during the growing season (Bhanwaria *et al.*, 2022). Abiotic stresses (heat, drought, salinity, waterlogging, heavy metals toxicity, soil erosion, etc.) adversely affect the growth, development, and yield of plants resulting in higher economic losses at the expense of global food security (Sabagh *et al.,* 2021). Plant growth regulators (PGRs) are naturally biosynthesized by plants which modify crop plant growth like as enhance in shoot and root growth, alter fruit maturing, reproduction etc. and play a significant role in mitigating abiotic stresses (Choudhary *et al.*, 2023; Takahashi *et al.*, 2019). Brassinosteroids are an important group of plant hormones involved in regulating plant growth and development, and they help plants to adapt to the environment (Manghwar *et al.*, 2022). Brassinolide, 28-homobrassinolide, and 24-epibrassinolide are the most active brassinosteroids and are widely used in experimental studies (Siddiqui *et al.*, 2018). Brassinosteroids can participate in physiological processes in response to stress by tuning plant growth, and improving plant performance by interacting with plant growth regulators or other plant hormones (Trevisan *et al.*, 2020). Drought, salinity, extreme temperatures and oxidative stress are often interconnected, and may induce similar cellular damage. Exogenous application of brassinosteroids under stressful conditions is considered a promising approach to achieve gains in agricultural yield, as well as in environmental protection (Shahzad *et al.,* 2018). However, very little information is available regarding prior application of brassinosteroids to confer tolerance on the onset of high temperature stress in plants, particularly in Indian mustard.

Jaisalmer district comes under dryland, and wet season with most of the rainfall occurred during June to October. It usually experiences erratic rainfall. The soil is saline and black which is deep loamy to clay loam, moderately drained, neutral to alkaline in nature. The semi-arid condition directly poses a threat to the overall yield of the plants as they usually experience drought and sodicity stresses. The water used for irrigation is of poor quality and creates soil salinity or sodicity in agricultural land, which affects the significant areas of fertile tracts and causes significant reductions to crop production and soil productivity. Therefore, the aim of this study was to evaluate the effect of brassinosteroids on yield, water productivity and nutrient use efficiency of Indian mustard under abiotic stress conditions.

Materials and Methods

The on-farm experiments conducted at farmers' fields with mustard crop during 2018-19 to 2019-20 in the Pokaran, Jaisalmer district of Western Rajasthan. The climate is dry with long hot summer and short winter. An average annual rainfall of experimental site is 165 mm, while during the experimental period; the rainfall was very low or negligible. The lowest temperature was recorded 7–9°C during the month of January and highest temperature of 36–41°C in the month of June. The experimental soil belongs to the taxonomical great group cambids with sandy to loamy sand in texture. Soil properties of farmers' field showed high soil pH (8.6–9.2), normal electrical conductivity (0.28–0.45 dS/m) and low soil organic carbon (0.10 to 0.24%). While, the status of available nitrogen, phosphorus, potassium and micronutrients were low (124.6-159.1 kg/ha), medium (12-18 kg/ha), medium (210-260 kg/ha) and low, respectively.

The treatments were consisted control (without PGR) (T_1) and two foliar sprays of PGR-brassinosteroid (2 ppm) at 30 and 60 days after sowing (DAS) (T_2) which were replicated at ten farmer's fields under randomized block design. The size of selected fields for experiment was one acre (4000 m^2) at each farmer's fields. Indian mustard var. DRMRIJ 31 (Giriraj) was sown at second fortnight of October during both the consecutive years with recommended seed rate (4 kg/ha) and row spacing (45 cm). Recommended dose of fertilizers i.e. N:P:S @ 90:40:40 kg/ha were applied. Out of this 50 % N and 100 % P and S were applied as basal dose at the time of sowing and rest 50 % N was applied through top dressing after one month of sowing. Five irrigations were applied through sprinkler irrigation system as per crop requirement. Other cultivation processes were kept similar for all treatments. Yield of mustard was recorded on plot basis and expressed in kg/ ha. The irrigation water was measured by the discharge of irrigation water per irrigation and converted in depth of water applied and calculated total water use during the growing period. Water productivity (WP) was then calculated by dividing the grain yield by the total amount of water applied in the field (254 and 270 mm during first and second year, respectively) through irrigation and rainfall. Applied quantities of N, P and S through different fertilizers were calculated by following standard analytical procedures (Rana *et al.*, 2014). Then, the yield was divided by total applied quantity of each nutrient (N, P and S) to estimate the partial factor productivity (PFP).

A simple economic analysis took into the cost of inputs and return from selling of yield, which was computed using the procurement price i.e. Rs. 42 per kg seed (GOI, 2020) and 2 per kg stover as per market. The net income and benefit-cost ratio were calculated by using the following formula.

$$NR = GR - CC$$

$$B:C\ ratio = \frac{GR}{CC}$$

Where, NR = Net returns (Rs./ha); GR=gross returns (Rs./ ha); and CC= cost of cultivation (Rs./ha).

The observed data was statistically evaluated by using the analysis of variance (ANOVA) technique of RBD and significance of treatments mean was assessed by critical differences (CD) at 5 % level of probability (Gomez and Gomez, 1984).

Results and Discussion

The number of siliquae per plant and seeds per siliquae were recorded significantly higher under PGR-brassinosteroid applied treatment as compared to control (without PGR) during both the years (Table 1). Sharma and Bhardwaj (2007) reported that the yield attributes of Indian mustard also increased after treatment of seeds with epibrassinolide. The test weight of mustard was recorded non-significantly higher under PGR-brassinosteroid over the control (without PGR) during

Table 1: Effect of foliar application of brassinosteroid on yield attributes of Indian mustard

Treatments	No. of siliquae per plant			No. of seeds per siliqua			Test weight (g)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
Control	94	95	95	12.2	12.3	12.2	5.25	5.29	5.27
Brassinosteroid	106	105	105	12.6	12.7	12.6	5.28	5.31	5.29
SEm±	2.1	2.0	2.0	0.05	0.05	0.05	0.04	0.03	0.04
CD (p=0.05)	6.1	6.0	6.0	0.15	0.15	0.15	NS	NS	NS

2018-19 and 2019-20.

Perusal of data indicated that mustard yield significantly influenced through application of PGR-brassinosteroid. The percent increase of seed yield was recorded 3.70 and 4.72 % under PGR-brassinosteroid over the control during 2018-19 and 2019-20, respectively. The significantly higher stover yield of mustard (3181 and 3278 kg/ha during 2018-19 and 2019-20, respectively) was also observed with PGR-brassinosteroid. The pooled data of seed and stover yields also showed similar trend and reported 4.21 and 4.56 % higher under PGR-brassinosteroid as compared to control, respectively. The brassinosteroid improved the resistance of the plants against environmental stresses such as water stress, salinity stress, low temperature stress and high temperature stress probably because of their imperative participation in cell division and elongation (Alam *et al.*, 2020). The brassinosteroid induced the growth and yield of crops by induce more photosynthetic rates with higher translocation and accumulation and finally higher yield (Meena *et al.*, 2015).

The input use efficiency is one of the major aspects of this study and the results have been presented in Fig. 1. The water productivity (WP) was recorded 6.32, 6.13 and 6.23 kg/ha-mm under PGR-brassinosteroid during 2018-19, 2019-20 and pooled data which was significantly higher than control. The significantly higher partial factor productivity of N (PFP_N), P (PFP_P) and S (PFP_S) were observed with PGR-brassinosteroid during both the years. The pooled data of PFP_N, PFP_P and PFP_S were reported 4.24, 4.21 and 4.21 % higher under PGR-brassinosteroid as compared to control, respectively. The regression coefûcient of WP and seed yield of mustard

Table 2: Effect of foliar application of brassinosteroid on seed and stover yields of Indian mustard

Treatments	Seed yield (kg/ha)			Stover yield (kg/ha)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
Control	1549	1581	1565	3056	3120	3088
Brassinosteroid	1606	1656	1631	3181	3278	3229
SEm±	13.3	13.5	10.8	22.3	23.6	16.6
CD (p=0.05)	39.3	40.0	31.8	65.9	69.8	49.2

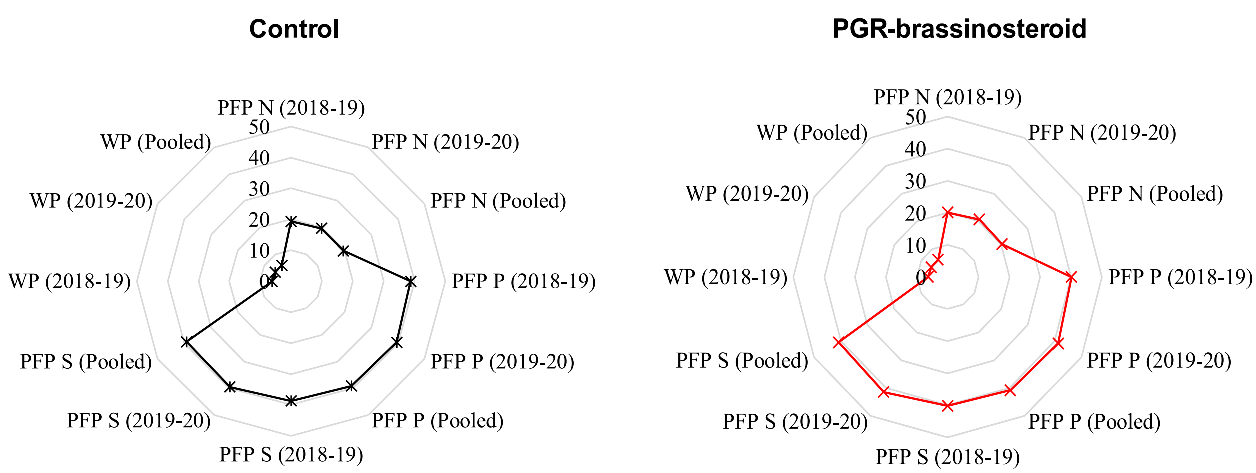

Fig. 1: Spider chart of partial factor productivity (kg/kg) of nutrients (N, P and S) and water productivity (kg/ha-mm) of Indian mustard as influenced under PGR-brassinosteroid and control

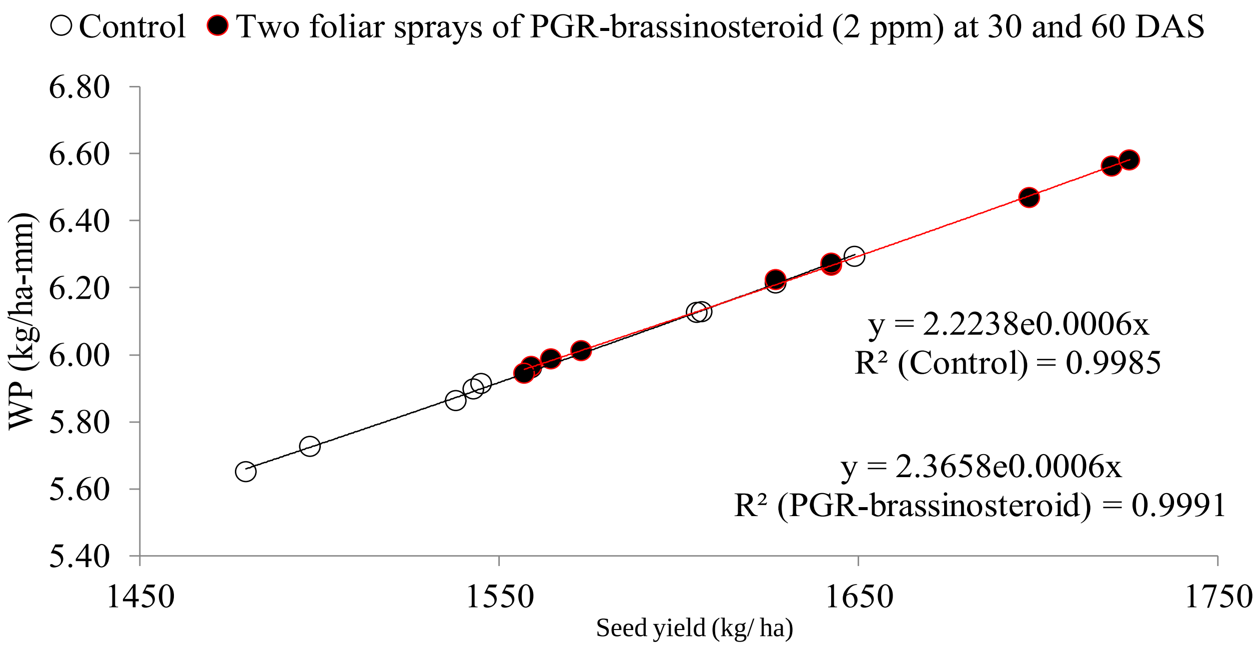

Fig. 2: Relationship between water productivity (WP) and seed yield of mustard (n = 10 and p value = 0.05)

Table 3: Economic of Indian mustard as influenced by the foliar application of PGR-brassinosteroid

Treatments	Gross return (Rs./ha)			Net return (Rs./ha)			B:C ratio		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
Control	71171	76195	73683	46827	51374	49100	2.92	3.07	3.00
Brassinosteroid	73826	79811	76818	50377	55440	52908	3.15	3.27	3.21
SEm±	602	644	496.97	602	644	497	0.02	0.03	0.02
CD (p=0.05)	1781	1908	1471	1781	1908	1471	0.07	0.08	0.06

was calculated during both years (Fig. 2). These equations indicated that the WP of mustard was increased at increasing rate with response to increased yield of mustard. The result stated that the WP and partial factor productivity of applied nutrients were improved through two foliar applications of brassinosteroid on the crop because it was directly correlated with crop yield. Pereira *et al*. (2019) investigated the application of brassinosteroid in soybean subject to water deficit, obtained an increase of 273 % in WUE as compared to un-treated crop field. Similarly, Fariduddin *et al.* (2014) obtained higher WUE of *B. juncea* with the application of homobrassinolide as compared to control under water deficit condition.

The economic feasibility of the study was decided that whether the present study is adoptable for the farmers or not. Economics of the study revealed that higher gross returns (76818 Rs./ha) and net returns (52908 Rs./ha) were recorded under PGR-brassinosteroid which were significantly higher than control (Table 3). The returns per investment also followed the similar trend since, the pooled value of B:C ratio was recorded 3.21 under PGR-brassinosteroid which was significantly higher than control (3.00). This was mainly occurred due to the higher seed and stover yields of mustard observed with the PGR-brassinosteroid.

Conclusion

The study has been concluded that two foliar applications of PGR-brassinosteroid (2 ppm) at 30 and 60 DAS on the mustard crop improved yield and profitability as compared to the control. Further, it also improved the efficiency of applied critical inputs *i.e.* fertilizer and water which are positively correlated with yield of crop. The present study reveals a new insight that application of PGR-brassinosteroid overcame the adverse effect of the arid conditions of soil and promoted the yield and its attributes of mustard. Therefore, it is recommended for the researchers and scientific community to identify the future scope of brassinosteroid and other PGRs which might be a support in sustaining the production of mustard as well as other crop(s) under stress condition of desert region of Western India.

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