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Stress Alleviation and Productivity Enhancement in Summer Mungbean Using Natural and Chemical Ameliorants

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ABSTRACT

The present investigation was conducted during the summer season of 2024. Eight different stress management treatments were evaluated in randomized block design with three replications. The treatments were soil application of herbal hydrogel (*Tragacanth katira*) at 5 kg/ha (T_1), soil application of herbal hydrogel at 7.5 kg/ha (T_2), two foliar sprays of salicylic acid (SA) at 200 ppm (T_3), soil application of herbal hydrogel at 5 kg/ha+two foliar sprays of SA at 200 ppm (T_4), soil application of herbal hydrogel at 7.5 kg/ha+two foliar sprays of SA at 200 ppm (T_5), two foliar sprays of KNO_3 at 10 ml/l (T_6), soil application of herbal hydrogel at 5 kg/ha+two foliar sprays of KNO_3 at 10 ml/l (T_7), soil application of herbal hydrogel 7.5 kg/ha+two foliar sprays of KNO_3 at 10 ml/l (T_8) and control (T_9). Application of herbal hydrogel at 7.5 kg/ha was found superior to at 5 kg/ha and salicylic acid at 200 ppm was more effective in order to increase the yield parameters than application of KNO_3. Among all stress management treatments, T_5 was found best in order to achieve higher yield attributes and yield of mungbean crop. The highest growth parameters and seed yield (1206 kg/ha) of mungbean crop were recorded from control treatment. Among the stress mitigation treatments, soil application of herbal hydrogel 7.5 kg/ha + two foliar sprays of SA 200 ppm resulted in maximum number and dry weight of nodules (15.8 and 43.6 mg) at harvest and also resulted in maximum seed yield (1027 kg/ha) followed by T_4 treatment. Maximum net returns and B:C were calculated from T_5 (Rs. 47868/ha and 2.10) and minimum from T_1 (Rs. 15444/ha and 1.37).

Key words: B:C ratio, growth, KNO_3, mung bean, salicylic acid, stress, yield

INTRODUCTION

Mungbean, [*Vigna radiata* (L.) Wilczek], also known as green gram and a member of Fabaceae family, has been grown in India since ancient times. It is an important short duration (60-65 days) legume crop of Asia and a major component of many cropping systems. Its seeds are good source of protein (21.5%), carbohydrates (63%), fiber (4.5%) and minerals like calcium, iron, and phosphorus (Balaso, 2024). Moreover, this crop fixes atmospheric nitrogen into the soil. During the 2023-24 season, mungbean was grown across 5.18 million hectares in India, yielding approximately 3.10 million tonnes, with an average productivity of 598 kg/ha, while in Haryana during 2023-24, the crop covered 32,320 hectares, resulting in a production of 21,880 tonnes and an average yield of 677 kg/ha (Indiastat, 2024).

Summer mung bean crop grows in dry land areas; summer crop requires more irrigation and water stress during summer when temperature is 45°C is the most crucial limiting factor for yield reduction especially in north India. Water stress is considered a worldwide problem and one of the most and major abiotic stresses. Over 25% of the world's agricultural lands are now affected and suffering from water stress (Abido and Zsombik, 2018). Among all abiotic stresses, drought is considered the most damaging natural disaster due to its prolonged and extensive socio-economic impacts (Ahmadalipour *et al*., 2019). Drought stress causes a broad range of physiological changes and impairments of metabolic processes, which result in accumulation of reactive oxygen species (Abid *et al*., 2018). The effect of water stress is more evident at vegetative stage than at reproductive stage. Water stress during

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vegetative phase limits root growth and reduces plant size, leaf area, accumulation of dry matter in pods, grain yield and harvest index.

There are two primary strategies to mitigate water stress: enhancing soil moisture retention and the application of chemical treatments such as herbal hydrogels, salicylic acid and potassium nitrate (KNO*f*). These stress mitigation treatments significantly enhance plant resilience and improve their ability to withstand adverse conditions. Herbal hydrogel was applied at the basal stage to enhance soil moisture retention, while salicylic acid and potassium nitrate are administered as foliar sprays to boost plant stress tolerance and nutrient uptake. Hydrogel is a polymer and its application to the soil in agriculture systems can reduce the need for frequent irrigation (Al-Jabari *et al*., 2019). The use of herbal hydrogel helps by enhancing soil water retention, providing a consistent moisture supply to the roots during drought conditions. Foliar application of salicylic acid improves the plant's stress tolerance by activating antioxidant defences and regulating physiological processes, helping the crop withstand high temperature and water deficit. KNO*f* provides essential nutrients, particularly nitrogen and potassium, which support healthy growth and improve yield. Therefore, keeping in view of the economic losses due to stress, the present experiment was conducted to assess the effect of stress management strategies on growth and yield of summer mung bean.

MATERIALS AND METHODS

A field experiment was conducted on mung bean at Research Farm of the Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala, Haryana during summer season of 2024 to find out effect of stress management strategies on growth and yield of summer mungbean [*Vigna radiata* (L.) Wilczek]. The experimental field featured well-drained, non-calcareous sandy loam soil characterized by low organic carbon content (0.37%) and an alkaline pH of 8.3. During the study period in 2024, daily maximum temperatures fluctuated between 29.5 and 44.4°C, while minimum temperatures ranged from 16.9 to 30.4°C (Fig. 1). A cumulative

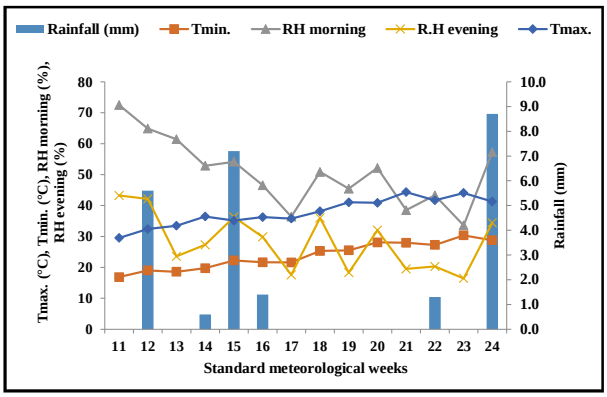

Fig. 1. Agro-meteorological data recorded during the crop growing season.

rainfall of 24.8 mm was recorded between the 11th and 24th meteorological weeks (March to June).

Mungbean variety MH 421 with crop duration of 60-65 days was sown on 18th March 2024. Field was prepared after pre-sowing irrigation to maintain proper soil moisture at the time of sowing to ensure proper germination. Plant to plant distance was maintained 10 cm in a row spacing of 30 cm. A quadrate was used to take observations on plant population through random sampling in each plot. The total number of nodules from three random plants were counted separately in each plot at 20, 40 DAS and at harvest. For dry matter of nodules, nodules collected from random plants were dried under the sun and then weighed (mg/ plant). Three random plants were selected from each plot at 20, 40 DAS at harvest to record observations on plant height and yield attributing characters.

Plant population was measured by counting the number of plants in one-meter row lengths at three random spots, and the average was calculated. Growth parameters were recorded at 15 days after sowing and at harvest. Plant height was measured from the base to the apex of plant using a meter scale at 20, 40 DAS and at harvest. To determine number and dry weight of nodules in mungbean, three healthy plants were carefully uprooted from different locations within the plot at 20, 40 DAS and at harvest. Roots were gently washed to remove soil, and visible nodules were counted. Nodules were collected in paper bags, oven-dried at 60-70°C for 48-72 h to a constant weight, and weighed using a digital balance. Harvesting and yield measurement were recorded by plants from the net plot area harvested,

bundled and sun-dried. The total weight was recorded (kg/ha), then seeds were separated by hand, and seed yield was calculated in kg/ha.

Economic analysis was carried out by calculating gross returns as the total monetary value of grain and straw yield (Rs./ha). Net returns were obtained by deducting the cost of cultivation from the gross returns. The benefit:cost (B:C) ratio was determined by dividing gross returns by the cost of cultivation.

Gross returns (Rs./ha) = Returns from grains + straw
Net returns (Rs./ha) = Gross returns (Rs./ha) – Cost of cultivation (Rs./ha)
B:C = Gross returns/Cost of culyivation

RESULTS AND DISCUSSION

A significant effect of different mitigation treatments on growth parameters, viz., plant population and plant height of mung bean at 15, 20, 40 DAS and at harvest was observed (Table 1). Plant population directly reflected the germination percentage of seeds. The maximum plant population (25.1 and 20.2) was recorded in soil application of herbal hydrogel 7.5 kg/ha+two foliar sprays of SA 200 ppm (T_5) at 15 DAS and at harvest. This might be due to the positive effect of herbal hydrogel in combination of salicylic acid on conserving soil moisture for longer period, which improved seedling establishment and survival of the seeds. Similarly, the maximum plant height (15.1, 31.0 and 41.2 cm) was recorded in soil application of herbal hydrogel 7.5 kg/ha+two foliar sprays of SA 200 ppm (T_5) at 20, 40 DAS and at harvest. These result were obtained because the combined application of salicylic acid and herbal hydrogel, improved water availability and stress tolerance, leading to robust plant growth. Similar results were reported by Meena *et al*. (2020) in which the application of hydrogel at 5.0 kg/ha, along with two sprays of salicylic acid at 200 ppm at flowering and siliqua formation stage led to significantly higher plant height in Indian mustard. Singh *et al*. (2017) also reported that the application of hydrogel at 5.0 kg/ha significantly increased the height of Indian mustard plants.

The number of nodules (6.4 and 25.7) and dry weight of nodules (13.7 and 98.4) was recorded maximum in soil application of herbal hydrogel 7.5 kg/ha+two foliar sprays of KNO_3 10 ml/l (T_8) and in treatment soil application of herbal hydrogel 7.5 kg/ha (T_2) at 20 and 40 DAS (Table 2). However, at harvest, the number of nodules/plant (15.8) and dry weight of nodules/plant (43.6) were found maximum with soil application of herbal hydrogel 7.5 kg/ha+two foliar sprays of SA 200 ppm (T_5). Irrigation was given on the 17th and 32nd day, so during that time the roots received sufficient water, which helped in forming a good symbiotic

Table 1. Effect of different stress mitigation strategies on plant population at 15 DAS and harvest stage and on plant height at 20, 40 DAS and at harvest of summer mungbean

Treatment	Plant population (m^2)		Plant height (cm)		
	15 DAS	At harvest	20 DAS	40 DAS	At harvest
T_1–Soil application of herbal hydrogel 5 kg/ha	24.7	18.7	14.3	29.3	35.9
T_2–Soil application of herbal hydrogel 7.5 kg/ha	24.1	19.2	14.8	30.8	37.4
T_3–0Foliar spray of salicylic acid (SA) 200 ppm	24.3	18.0	14.0	26.6	34.1
T_4–Soil application of herbal hydrogel 5 kg/ha+ two foliar sprays of SA 200 ppm	24.5	19.8	14.5	29.4	38.1
T_5–Soil application of herbal hydrogel 7.5 kg/ha+ two foliar sprays of SA 200 ppm	25.1	20.2	15.1	31.0	41.2
T_6–Two foliar sprays of KNO_3 10 ml/l	24.8	18.1	14.1	27.1	36.4
T_7–Soil application of herbal hydrogel 5 kg/ha+ two foliar sprays of KNO_3 10 ml/l	24.3	19.3	14.7	29.6	39.8
T_8–Soil application of herbal hydrogel 7.5 kg/ha+ two foliar sprays of KNO_3 10 ml/l	24.6	19.9	14.7	30.4	39.4
T_9–Control	24.2	21.4	14.4	33.2	43.7
S. Em±	0.91	0.81	0.25	0.51	1.3
C. D. (P=0.05)	NS	2.68	NS	1.61	3.9

NS–Not Significant.

Table 2. Effect of different stress mitigation strategies on number of nodules and dry weight of nodules (mg/plant) of mungbean

Treatment	Number of nodules			Dry weight of nodules (Mg/plant)		
	20 DAS	40 DAS	At harvest	20 DAS	40 DAS	At harvest
T_1–Soil application of herbal hydrogel 5 kg/ha	5.6	21.3	12.9	10.8	78.8	33.5
T_2–Soil application of herbal hydrogel 7.5 kg/ha	6.2	25.7	14.8	13.1	98.4	40.4
T_3–Foliar spray of salicylic acid (SA) 200 ppm	5.0	16.1	9.3	9.1	58.1	23.3
T_4–Soil application of herbal hydrogel 5 kg/ha+ two foliar sprays of SA 200 ppm	5.8	22.4	13.9	11.3	82.9	36.1
T_5–Soil application of herbal hydrogel 7.5 kg/ha+ two foliar sprays of SA 200 ppm	6.1	25.4	15.8	13.1	98.0	43.6
T_6–Two foliar sprays of KNO_3 10 ml/l	4.7	16.7	8.1	8.6	61.3	20.8
T_7–Soil application of herbal hydrogel 5 kg/ha+ two foliar sprays of KNO_3 10 ml/l	5.4	22.0	12.6	10.5	79.2	31.5
T_8–Soil application of herbal hydrogel 7.5 kg/ha+ two foliar sprays of KNO_3 10 ml/l	6.4	24.3	14.5	13.7	89.9	37.7
T_9–Control	5.2	26.7	18.2	12.4	105.7	52.1
S. Em±	0.17	0.45	0.28	0.28	1.00	0.58
C. D. (P=0.05)	0.54	1.38	0.85	0.86	3.04	1.76

relationship, resulting in good number and dry weight of nodules by 40 DAS in soil application of herbal hydrogel 7.5 kg/ha (T_2). However, during harvesting, soil application of herbal hydrogel 7.5 kg/ha+two foliar sprays of SA 200 ppm (T_5) showed the maximum number and dry weight of nodules because salicylic acid was sprayed at the flowering and pod formation stages to control water stress.

Application of herbal hydrogel at 7.5 kg/ha was more superior to at 5 kg/ha and salicylic acid at 200 ppm was more effective in order to increase the yield parameters than application of KNO_3.The number of pods per plant, number of seeds per pod and seed and stover yield were found maximum in control (T_9) treatment. Among the stress mitigation treatments, the treatment soil application of herbal hydrogel 7.5 kg/ha+two foliar sprays of salicylic acid 200 ppm (T_5) recorded the significantly maximum number of pods per plant (17.9), number of seeds per pod (11.9) and seed (1027 kg/ha) and stover (2363 kg/ha) yield at harvest (Table 3). The greater number of pods per plant, number of seeds per pod, seed and stover yield with the addition of herbal hydrogel and salicylic acid were due to immediate availability of stress mitigation treatments to the plants at critical stages (flowering and pod formation stages). Hydrogel kept the soil consistently moist, while salicylic acid boosted the antioxidants, which helped the mungbean to cope up with stress.

Table 3. Effect of different stress mitigation strategies on yield and yield attributes of mungbean

Treatment	Pod/plant	Seeds/pod	Seed yield (kg/ha)	Stover yield (kg/ha)
T_1–Soil application of herbal hydrogel 5 kg/ha	15.3	9.8	639	1513
T_2–Soil application of herbal hydrogel 7.5 kg/ha	16.7	10.4	696	1632
T_3–Foliar spray of salicylic acid (SA) 200 ppm	15.6	10.3	658	1565
T_4–Soil application of herbal hydrogel 5 kg/ha+ two foliar sprays of SA 200 ppm	17.3	11.1	899	2087
T_5–Soil application of herbal hydrogel 7.5 kg/ha+ two foliar sprays of SA 200 ppm	17.9	11.9	1027	2363
T_6–Two foliar sprays of KNO_3 10 ml/l	15.5	10.1	581	1382
T_7–Soil application of herbal hydrogel 5 kg/ha+ two foliar sprays of KNO_3 10 ml/l	16.7	10.5	779	1835
T_8–Soil application of herbal hydrogel 7.5 kg/ha+ two foliar sprays of KNO_3 10 ml/l	17.2	11.3	893	2074
T_9–Control	19.4	13.7	1206	2598
S. Em±	0.27	0.28	13	23
C. D. (P=0.05)	0.82	0.85	39	70

Table 4. Effect of different stress management strategies on cost of cultivation, gross returns, net returns and B-C ratio of summer mung bean crop

Treatment	Cost of cultivation	Gross returns	Net returns	B:C
T_1–Soil application of herbal hydrogel 5 kg/ha	41546	56990	15444	1.37
T_2–Soil application of herbal hydrogel 7.5 kg/ha	42546	62058	19512	1.46
T_3–Foliar spray of salicylic acid (SA) 200 ppm	40666	58702	18036	1.44
T_4–Soil application of herbal hydrogel 5 kg/ha+ two foliar sprays of SA 200 ppm	42666	80121	37455	1.88
T_5–Soil application of herbal hydrogel 7.5 kg/ha+ two foliar sprays of SA 200 ppm	43666	91534	47868	2.10
T_6–Two foliar sprays of KNO_3 10 ml/l	41421	51824	10403	1.25
T_7–Soil application of herbal hydrogel 5 kg/ha+ two foliar sprays of KNO_3 10 ml/l	43421	69468	26047	1.60
T_8–Soil application of herbal hydrogel 7.5 kg/ha+ two foliar sprays of KNO_3 10 ml/l	44421	79604	35183	1.79
T_9–Control	47420	107303	59883	2.26

Singh *et al*. (2024) reported that foliar spraying of 150 ppm salicylic acid resulted in increasing the number of pods per plant (39.77), the number of seeds per pod (5.40), seed yield per plant (6.70 g), and seed yield per hectare (21.30 q). Abdelaal *et al*. (2020) reported that the number of grains per spike and spike length were both increased by foliar spraying SA 0.5 mM. Jat *et al*. (2018) reported that application of hydrogel 5.0 kg/ha resulted in the highest number of siliquae per plant, number of seeds per siliqua, and mustard seed production.

The gross returns, net returns and benefit to cost ratio of 2.26 were recorded maximum in treatment control (T_9). Among the stress mitigation treatments, soil application of herbal hydrogel 7.5 kg/ha+two foliar sprays of salicylic acid 200 ppm (T_5) resulted in maximum financial gains, gross returns Rs. 91534/ha, net returns Rs. 47868/ha and benefit to cost ratio 2.10. This might be attributed to the combined application of herbal hydrogel and salicylic acid, which enhanced soil-root water relations and strengthened physiological responses, resulting in higher productivity, net returns, gross returns, and an improved benefit–cost ratio. Similar results were reported by Ram *et al*. (2018) that application of herbal hydrogel was at 5 kg/ha resulted in significant increase in the net returns and benefit to cost ratio of lentils. Kumawat *et al*. (2021) also reported that the application of hydrogel at 5.0 kg/ha combined with salicylic acid 100 ppm at flowering and siliqua production periods resulted in highest gross (Rs. 47,082/ha) and net returns (Rs. 29,202/ha) for taramira. Singh *et al*. (2018) found the highest B:C ratio and net returns by applying of hydrogel at 7.5 kg/ha in wheat crop (Table 4).

CONCLUSION

Based on a one-year study, it was concluded that among the stress management treatments, the soil application of gond-katira (*Tragacanth katira*) 7.5 kg/ha coupled with two foliar sprays of salicylic acid 200 ppm at flowering and pod formation stages of summer mungbean proved most effective in alleviating stress and enhancing yield attributes and overall yield, which was closely followed by the soil application of gond-katira at 5 kg/ha with two foliar sprays of salicylic acid at 200 ppm. In terms of economic performance, the gross returns, net returns and B:C were recorded maximum under the no stress (T_9) treatment. Among the stress mitigation treatments, the benefit to cost ratio (2.10) was registered maximum with soil application of gond-katira 7.5 kg/ha along with two foliar sprays of salicylic acid.

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