Journal of AgriSearch, 10 (3): 163-167
An Open Access International Peer Reviewed Quarterly

ISSN : 2348-8808 (Print), 2348-8867 (Online)
https://doi.org/10.21921/jas.v10i03.13767

Influence of Stress Mitigating Chemicals and Sulphur on Growth and Yield of Green gram

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ABSTRACT

A field experiment entitled was conducted to assess the effect of stress mitigating chemicals and sulphur on growth and yield of *mungbean* during *kharif* season of 2019 and laid out in factorial randomized block design (FRBD) with sixteen treatment combinations and replicated thrice. The treatments were taken in the investigation *viz.* stress mitigating chemicals control, salicylic acid @ 75 ppm, salicylic acid @ 75 ppm + 2% urea and thiourea @ 500 ppm and four levels of sulphur. The result indicated that application of thiourea @ 500 ppm at flower initiation stage of mungbean significantly registered higher growth well as significantly more yield followed by salicylic acid @ 75 ppm + 2% urea at flower initiation stage, which was statistically at par with each other with respect yield of *mungbean*. Results further revealed that among doses of sulphur, 40 kg sulphur/ha was at par with 30 kg sulphur/ha with respect to all parameters taken during experiment.

Keywords: Thiourea, Salicylic acid, Mungbean, Sulphur, Yield

ARTICLE INFO

Received on	:	02.05.2023
Accepted on	:	14.09.2023
Published online	:	30.09.2023

INTRODUCTION

Mungbean [*Vigna radiata* (L.) Wilczek] is synonymously known as 'golden gram or green gram' belongs to the sub-family *papilionaceae* under the family leguminoseae. Mungbean is the third most important pulse crop after chickpea and pigeonpea grown and consumed in India (Samant and Mohanty, 2017). By virtue of its early maturity, high production capabilities and excellent in having nutritive value as food, feed and forage; it is mostly cultivated in wider range of soils of semi-arid and arid regions of India (Singh *et al.*, 2016). Being a pulse crop, mungbean is an excellent source of protein (25%) with high lysine content (460 mg/g) and tryptophan (60 mg/g). Moreover, it also bears good amount of riboflavin (0.21 mg/100 g), minerals (3.84 g/100 g) and ascorbic acid, when used after sprouting (Choudhary *et al.*, 2017).

In India, mungbean occupied an acreage of 4.25 million hectares with a total production of 2.41 million tonnes and average productivity of 567 kg/ha. Majorly growing states of mungbean are Rajasthan, Madhya Pradesh, Uttar Pradesh, Punjab and Haryana. Among these states, Rajasthan has occupied first rank and shared 26 per cent in the total mungbean production of India, which produces 1.24 million tonnes from 1.92 million hectares with an average productivity of 650 kg/ha(Anonymous, 2019).

Abiotic stress is a major problem incurred in semi-arid and arid regions of Western Rajasthan basically governs by hot weather and erratic rainfall prevailing during *kharif* season that aggravate moisture deficit throughout crop period. Furthermore, the most of area is occupied by sandy-loam textured soil, which does not have capacity to store soil moisture for longer periods and simultaneously it heats up rapidly when temperature rises. During dry spell, plant suffers due to denaturation of protein ultimately cellular integrity of plant is damaged. During the crop growth beginning from germination to maturity, dry spell is frequently observed that have tremendous effect on initial growth and development. Some of the heat shocking proteins (HSPs) are released by plants to fight against moisture stress and high temperature prevailing during growth period (Das *et al.*, 2016). To overcome these abiotic stresses, exogenous application of stress mitigating chemicals, some time it is synonymously termed as antioxidants *viz.* salicylic acid, thiourea, brassinosteroids and indole-3-acetic acid (IAA) are useful. These chemicals are useful in guiding the signal molecules present in small quantities in the cells and mediates their responses to the stressed plants. It plays pivotal roles in promoting plant acclimatization to the changing climate by mediating growth and development, source/sink transitions and nutrient allocation in the plant systems (Shabir *et al.*, 2016).

Among the stress mitigating chemicals, thiourea is a sulphydral compound including of one -SH group and its function on plant thioredoxin system that may be play a key role in plant tolerance mechanism to abiotic stresses. In various field trials, application of thiourea as bioregulator is

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Table 1: Plant height, Dry matter accumulation and SPAD Chlorophyll Meter Reading of mungbean as influenced by stress mitigating chemicals and sulphur

Treatments	Plant height (cm)			Dry matter accumulation (g/plant)			SPAD Chlorophyll Meter Reading (SCMR)		
	25 DAS	50 DAS	At harvest	25 DAS	50 DAS	At harvest	25 DAS	50 DAS	At harvest
A. Stress mitigating chemicals									
Control	11.87	34.90	42.90	1.54	12.83	17.55	36.90	44.01	30.93
Salicylic acid @ 75 ppm (FI) + 7 DAFS	11.98	38.31	46.45	1.55	14.18	19.17	41. 54	48.73	31.25
Salicylic acid @ 75 ppm + 2% urea (FI)	12.53	42.26	52.20	158	15.50	20.54	41.75	51.14	33.44
Thiourea @ 500 ppm (FI)	12.66	44.88	57.35	1.61	16.79	21.89	41.89	53.90	36.31
SEm±	0.30	0.88	1.04	0.03	0.32	0.46	0.75	0.82	0.66
CD (P=0.05)	NS	2.55	2.99	NS	0.93	1.32	NS	2.37	1.90
B. Sulphur									
Control	10.95	35.78	44.48	1.34	12.65	17.35	36.62	45.15	29.40
20 kg/ha	11.90	39.02	47.72	1.56	14.47	19.35	39.03	48.53	32.21
30 kg/ha	12.78	42.21	52.23	1.68	15.79	20.76	42.22	51.32	34.39
40 kg/ha	13.01	43.44	54.48	1.70	16.38	21.69	44.21	52.77	35.02
SEm±	0.30	0.88	1.04	0.03	0.32	0.46	0.75	0.82	0.66
CD (P=0.05)	0.86	2.55	2.99	0.09	0.93	1.32	2.16	2.37	1.90
Interaction (C × S)									
SEm±	0.59	1.77	2.07	0.07	0.64	0.91	1.50	1.64	1.31
CD (P=0.05)	NS	NS	NS	NS	NS	2.63	NS	NS	NS

also found to mitigate heat, drought and salinity stresses through maintaining cellular integrity and ultimately enhances the crop yields. Thus, it is an important and effective bioregulator, which regulate cell metabolic activities and restoring cellular redox-homeostasis in crop plants under stressful environments. Hence, thiourea has marked capacity for achieving higher production of mungbean under the changing scenario of climate change (Sahu, 2017).

Similarly, salicylic acid (SA) belongs to group of phenolic phytohormone and participated in signaling and pathogen resistance. Salicylic acid regulates the plant processes such as ion uptake and their transport, photosynthesis, opening and closing of stomata, membrane permeability. Exogenously application of salicylic acid is known to reduce the counter effect caused by sodium, chlorine and reactive oxygen species (ROS) in the plants, which increases due to moisture deficit, higher temperature and salinity. Being a stress hormone, it has tremendous role under arid conditions of Western Rajasthan, where uncertainty of monsoon is being observed. Under water deficit and elevated temperature, it imparts resistance in plants by modulating signal response to the stresses (Ramzan *et al*., 2018).

Table 2: Interaction effects of stress mitigating chemicals and sulphur on dry matter accumulation (g/plant) at harvest stage

C × S	Dry matter accumulation (g/plant)				
	C_0	C_1	C_2	C_3	Mean
S_0	15.31	18.21	18.84	17.04	17.35
S_1	18.66	17.80	20.71	20.24	19.35
S_2	17.70	20.35	21.03	23.93	20.76
S_3	18.53	20.33	21.62	26.30	21.69
Mean	17.55	19.17	20.54	21.89	19.78
SEm±	0.43	0.61	0.91	0.45	-
CD (P=0.05)	NS	NS	2.63	NS	-

FI-Flower initiation, DAFS-Days after first spray

Application of these stress mitigating chemicals in conjunction with fertilizer doses might provide a best management practice in order to understand the proven technology. After nitrogen, phosphorus and potassium, sulphur is the fourth important nutrient. Sulphur is a secondary plant nutrient and it is highly preferred by the crop particularly pulses and oil seeds. Sulphur also stimulates the synthesis of certain vitamins *viz.* thiamine and biotine and three essential amino acids in the pulses *viz.* cystine (27% S), cysteine (26% S) and methionine (21% S) that acted as building block of cells. Its deficiency symptoms start with the appearance of pale yellow or light greenish leaves. Unlike nitrogen, deficiency symptoms of sulphur are appearing first on younger leaves and persist even after nitrogen application. The younger leaves show cupped like appearance or V-shaped deficiency symptoms in the plants (Biswas *et al*., 2004).

MATERIALS AND METHODS

Description of study area: The experiment was carried out at Instructional Farm, College of Agriculture, Jodhpur

Table 3: Number of nodules, fresh weight of nodules(mg/plant), dry weight of nodules(mg/plant), number of primary and secondary (branches/plant), grain yield (kg/ha) CGR and RGR of mungbean at 50 DAS as influenced by stress mitigating chemicals and sulphur

Treatments	Number of nodules/ plant	Fresh weight of nodules	Dry weight of nodules	Number of seco-ndary	Number of seco-ndary	CGR		RGR		Grain yield (kg/ha)
						25 to 50 DAS	50 DAS to at harvest	25 to 50 DAS	50 DAS to at harvest	
A. Stress mitigating chemicals										
Control	22.12	223.68	33.05	4.55	2.17	3.08	1.31	0.155	0.0216	760
Salicylic acid @ 75 ppm (FI) + 7 DAFS	23.21	240.45	35.87	5.60	3.16	3.37	1.43	0.148	0.0216	902
Salicylic acid @ 75 ppm + 2% urea (FI)	23.64	254.54	38.88	6.58	.88	3.74	1.35	0.162	0.0187	1034
Thiourea @ 500 ppm (FI)	24.73	277.51	41.63	7.77	4.82	3.97	1.16	0.147	0.0153	1055
SEm±	0.28	4.61	0.74	0.33	0.31	0.090	0.154	0.006	0.0022	17.15
CD (P=0.05)	0.81	13.32	2.14	0.96	0.90	0.261	NS	NS	NS	49.54
B. Sulphur										
Contro	20.91	226.17	32.43	4.51	2.15	3.26	1.33	0.152	0.0207	726
20 kg/ha	23.02	244.58	36.85	5.90	3.06	3.71	1.30	0.156	0.0186	916
30 kg/ha	24.60	257.94	39.54	6.89	4.02	3.55	1.24	0.157	0.0182	1047
40 kg/ha	25.17	267.43	40.62	7.26	4.71	3.64	1.38	0.148	0.0196	1062
SEm±	0.28	4.61	0.74	0.33	0.31	0.090	0.154	0.006	0.0022	17.15
CD (P=0.05)	0.81	13.32	2.14	0.96	0.90	0.261	NS	NS	NS	4954
Interaction (C × S)										
SEm±	0.56	10	1.48	0.66	0.62	0.180	0.307	0.011	0.004	34.30
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	99.08

FI-Flower initiation, DAFS-Days after first spray

(Rajasthan) which is situated at a distance of about 10 km from Jodhpur railway station. Geographically, it is located between 26°15' N to 26°45' North latitude and 73°00' E to latitude 73°29' East longitude at an altitude of 231 meter above mean sea level (MSL).

Meteorological observation : The climate of Jodhpur falls under arid zone with hot dry summers. The average annual rainfall of Jodhpur is about 367 mm with wide variations in coefficient of variance (52%). The monsoon has arrived between the last weeks of June to first week of July, whereas the active phase of monsoon in Jodhpur region confined between 15th of July to 15th of August every year. However, weather aberrations are quite observed with respect to late onset and early withdrawal of monsoon that aggravated dry spells and high temperature during *kharif* season. The other peculiar climatic features of Jodhpur region are low relative humidity (15 to 30%) with high wind velocity (30 to 40 km/hour), solar incidence (520 cal/cm^{-2}), potential evapotranspiration (1843 mm/year) and wide deviations in maximum (24.6°C in January to 41.6°C in May) and minimum (9.6 in January to 27.7°C in June) temperatures.

Experimental treatments and design: Under the investigation, four stress mitigating chemicals *i.e.* Control (C_0), Salicylic acid @ 75 ppm (flower initiation) + 7 days after first spray (DAFS) (C_1), Salicylic acid @ 75 ppm + 2% Urea (C_2), Thiourea @ 500 ppm (C_3) and four levels of sulphur *i.e.* Control, 20 kg/ha (S_1), 30 kg/ha (S_2) and 40 kg/ha (S_3) were taken. The experiment having sixteen treatment combinations and three replications with forty-eight plots in total was laid out in Factorial Randomized Block Design (FRBD). The treatments were allocated randomly to different plots by using the random number table (Fisher and Yates, 1963).

Soil description: The analytical results showed that soil of the investigational field was sandy-loam in texture, slightly alkaline in reaction (pH 8.2), low in organic carbon (0.13%), available nitrogen (174 kg/ha) and available sulphur (8.68 ppm), while medium in available phosphorus (22.2 kg P_2O_5/ha) and high in potassium (325 kg K_2O/ha). However, soil having medium range of pH and EC that favored better crop management during the year of investigation.

Cultural practices: Among nutrient applications, nitrogen and phosphorus were applied as basal at the rate of 15 kg N/ha and 40 kg P_2O_5/ha through urea and diammonium phosphate (DAP), respectively. However, sulphur was applied as per treatments through elemental sulphur at the time of sowing. Before application in the field, elemental suphur was mixed

Table 4: Interaction effects of stress mitigating chemicals and sulphur on grain yield of mungbean

C × S	Grain yield (kg/ha)				
	C_0	C_1	C_2	C_3	Mean
S_0	604	634	832	835	726
S_1	746	910	998	1011	916
S_2	837	1072	1166	1112	1047
S_3	853	992	1140	1262	1062
Mean	760	902	1034	1055	1045
SEm±	23.65	25.65	34.30	28.46	-
CD (P=0.05)	NS	NS	99.08	NS	NS

C0-Control, C1-Salicylic acid @ 75 ppm (FI) + 7 DAFS, C2-Salicylic acid @ 75 ppm + 2% urea (FI) and C3-Thiourea @ 500 ppm (FI)

S0-Control, S1 -20 kg/ha sulphur S2-30 kg/ha sulphur and S3-40 kg/ha sulphur

with soil and applied uniformly over the soil surface and was mixed ~~it~~ well in soil before sowing. DAP was drilled uniformly before sowing in individual plot at a depth of 7 to 8 cm below the seed, whereas urea was applied at 20 days after sowing (20 DAS). One prophylactic measure was taken by spraying of monocrotophos @ 500 ml/ha at pod filling stage.

RESULTS AND DISCUSSION

Effect of stress mitigating chemicals on growth and growth attributes

Data presenting in Table 1 to 3 application of thiourea @ 500 ppm at flower initiation stage of mungbean recorded higher growth attributes *viz.* taller plants (12.66, 44.88 and 57.35 cm), higher dry matter accumulation/plant (1.61, 16.79 and 21.89 g), chlorophyll meter reading (41.89, 53.90 and 36.31) at 25, 50 DAS and at harvest, which showed its superiority over rest of the treatments except at 25 DAS, as well as higher numbers of primary branches/plant (7.77), secondary branches/plant (4.82), number of nodules/plant (24.73), fresh weight of nodules/plant (277.51 mg), dry weight of nodules/plant (41.63 mg) and grain yield (1055 kg/ha) were recorded followed by the treatment sprayed with salicylic acid @ 75 ppm + 2% urea at flower initiation stage. CGR (crop growth rate) and RGR (Relative growth rate) were non-significant at both the stages. Improvements in growth attributing characters might be due to application of thiourea under adverse as well as under normal conditions. The presence of thiourea in the plant systems has initiated signal transduction during dry spell under adverse conditions and synthesized various biochemical compounds including amino acids that provide building block of plant to continue their growth under stress conditions and these things are in conformity with the findings of Sharma *et al.* (2020), Devi *et al.* (2015) and Nezhad *et al.* (2014).

Effect of sulphur on growth and growth attributes

Sulphur data showed in Table 1 to 3 application of 40 kg sulphur/ha significantly recorded taller plants (13.01, 43.44 and 54.48 cm), SPAD chlorophyll meter reading (42.41, 52.27 and 34.52) and dry matter accumulation/plant (1.70, 16.38 and 21.69 g) at 25, 50 DAS and at harvest, as well as higher number of primary branches/plant (7.26), secondary branches/plant (4.71), number of nodules/plant (25.17), fresh weight of nodules/plant (267.43 mg), dry weight of nodules/plant (40.62 mg) and grain yield (1062 kg/ha) of mungbean, respectively over application of S @ 20 kg /ha and control whereas, it was statistically at par with application of S@ 30 kg /ha. CGR (crop growth rate) and RGR (Relative growth rate) were non-significant at both the stages. Growth and development are the continuous process and attained maximum at certain stage after that there are no gains in the growth and development. As the crop approaches grand growth phase, the differentiations of tissue into organs are started. Consequently, it is affected by fertility and productivity of soils on which crop nourishes. It was examined from the data that every increased in dose of sulphur had marked improvements in growth attributes and attained maximum at 40 kg sulphur/ha, however growth attributes which were obtained under 30 kg sulphur/ha were also at par to it, and also in conformity with the findings of Singh *et al.* (2016), Patel *et al.* (2017) and Das (2017).

Interaction effects of stress mitigating chemicals and sulphur on dry matter accumulation and grain yield

It is evident from the data in Table 2 and 4 that foliar application of thiourea @ 500 ppm at flower initiation stage of mungbean and soil application of 40 kg sulphur/ha in a combination produced significantly higher dry matter accumulation (26.30 g/plant) and grain yield (1262 kg/ha) over other combinations of treatments (stress mitigating chemicals and sulphur)

CONCLUSION

The experimental findings suggest that when thiourea is applied via foliar application at a concentration of @ 500 ppm during the flower initiation stage of mungbean cultivation, it leads to significantly enhanced growth, improved growth attributes, and a notably higher grain yield, specifically achieving a yield of 1055 kg per hectare. In the context of sulfur fertilization, it was observed that the application of 40 kg of sulfur per hectare in mungbean cultivation resulted in the most favorable outcomes in terms of growth, growth-related characteristics, and grain yield. This treatment yielded an impressive 1062 kg of mungbean grains per hectare throughout the duration of the investigation.

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Citation:

Bijarnia K K, Shukla U N, Kumari K, Khippal A K, Dhayal B C and Choudhary M S.2023. Influence of stress mitigating chemicals and sulphur on growth and yield of green gram. *Journal of AgriSearch* **10**(3):163-167