

Original Research Article

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Effect of Fertility Levels and Stress Mitigating Chemicals on Nutrient Uptake, Yield and Quality of Mungbean [*Vigna radiata* (L.) Wilczek] under Loamy Sand Soil of Rajasthan

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ABSTRACT

A field experiment was conducted during *kharif* season of 2017 on loamy sand soil to study the Effect of Fertility Levels and Stress Mitigating Chemicals on productivity of Mungbean [*Vigna radiata* (L.) Wilczek]. The experiment consisted of four fertility levels [control (F₀), 50% RDF (F₁), 75% RDF (F₂), 100% RDF (F₃)] and four stress mitigating chemicals [control (S₀), SA @ 75 ppm at flower initiation and 7 days after first spray (S₁), SA@75 ppm + 2% Urea at flower initiation (S₂) and Thiourea @ 500 ppm (S₃)]. Results indicated that the application of 75% RDF being at par with 100% RDF, significantly increased the phosphorus concentration and total P- uptake, total K- uptake. However, in respect of N concentration in seed and straw and its uptake and protein content in seed, seed (1077 kg ha⁻¹), straw (2279 kg ha⁻¹) and biological yield (3356 kg ha⁻¹), 100% RDF excelled over all other treatments. Results further revealed that among stress mitigating chemicals 500 ppm thiourea remaining at par with SA + 2% Urea significantly higher seed (1048 kg ha⁻¹), straw (2276 kg ha⁻¹) and biological yield (3324 kg ha⁻¹), protein content, nitrogen and phosphorus concentration and their uptake K- uptake of mungbean over SA and control.

Keywords

Thiourea, Stress mitigating chemicals, Flower initiation, SA (Salicylic acid)

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Introduction

Mungbean [*Vigna radiata* (L.) Wilczek] is a self pollinated leguminous crop which is grown during *kharif* as well as summer season in arid and semi arid regions. It is tolerant to drought and can be grown successfully on well drained loamy to sandy loam soils even in the areas of erratic rainfall.

Mungbean is a legume, it has the capacity to fix atmospheric nitrogen by its effective root nodules. The major part of nitrogen is met through *Rhizobium* present in the root nodules. Hence, crop requires starter dose of additional nitrogen for its initial growth and development.

In terms of significance, phosphorus is the most indispensable mineral nutrient for legume crops as it helps in better root growth and development and thereby making them more efficient in biological nitrogen fixation (BNF). Nitrogen, phosphorus, potassium uptake by crop was also relatively higher with RDF. This was mainly due to higher biological production under these fertility levels.

The application of stress mitigating chemicals might prove beneficial in crop tolerance to adverse conditions. Thiourea is an important sulphhydryl compound which contains one –SH group and is known to bring marked biological activity in plants. Foliar spray of thiourea has been reported not only to improve growth and development of plants but also the dry matter partitioning for increased grain yield (Arora, 2004).

Salicylic acid (SA) is a naturally occurring plant hormone acting as an important signalling molecule which adds to tolerance against abiotic stresses. It plays a vital role in plant growth, ion uptake and transport. This positive effect of SA could be attributed to an increased CO₂ assimilation, photosynthetic rate and increased mineral uptake by the stressed plant under SA treatment.

These signaling molecules activate a range of signal transduction pathways, some of which relieve the plant to overcome stress. However, the physiological and biochemical basis of plants to unfavorable conditions induced by SA are yet to be clearly understood. Application of these stress mitigating chemicals in conjunction with fertilizer doses might provide a best management practice in order to understand the proven technology. Since, under such situation, the crop response to fertilizer application varies due to deficit moisture or uncertain weather conditions.

Materials and Methods

Experimental site and climate

An experiment was conducted at Agronomy farm, S.K.N. College of Agriculture, Jobner in Jaipur district of Rajasthan during *kharif* season of 2017 on loamy sand soil. Geographically, Jobner is situated 45 km west of Jaipur at 26° 05' North latitude, 75° 28' East longitude and at an altitude of 427 meters above mean sea level.

The area falls in agro-climatic zone-III a (Semi-arid Eastern Plain Zone) of Rajasthan. The climate of this region is a typically semi-arid, characterized by extremes of temperature during both summer and winter. The average annual rainfall of this tract varies from 250 mm to 300 mm and is mostly received during the months of July to September.

During summer, temperature may go as high as 46°C while in winter, it may fall as low as -1.5°C. There is hardly any rain during winter and summer. The climate affects the growth, yield and quality of agricultural product. During crop season witnessed a rainfall of 147 mm. The mean daily maximum and minimum temperatures during the growing season of mungbean fluctuated between 29.4 to 36.6°C and 18.4 to 26.6°C, respectively. Similarly, mean daily relative humidity ranged between 37 to 81 per cent.

Properties of soil of the experimental field

The soil of the experimental field was loamy sand in texture, alkaline in reaction (P^H-8.2), poor in organic carbon (0.18 %), low in available nitrogen (128.3 kg ha⁻¹) and medium in phosphorus (16.23 kg ha⁻¹) and potassium (154.26 kg ha⁻¹).

Experimental detail and treatment

The experiment consisted of four fertility levels control (F₀), 50% RDF (F₁), 75% RDF (F₂), 100% RDF (F₃) and stress mitigating chemicals control (S₀), SA @ 75 ppm at flower initiation and 7 days after first spray (S₁), 75 ppm SA + 2% Urea at flower initiation (S₂) and 500 ppm Thiourea (S₃). The total 16 treatment combinations were tested in factorial randomized block design with three replications; plot size was 4 m x 3.6 m for crop; seed rate is 15-20 kg ha⁻¹. mungbean was sown on 6th July 2017. Fertilizers were applied as per treatment through diammonium phosphate (DAP) containing 46% P₂O₅ and 18% N and urea containing 46% N at the time of sowing as per treatment. Thiourea and salicylic acid treatments were administered as foliar spray with 500 lit water per hectare. Foliar spray of

thiourea @ 500 ppm applied as 500 mg/liter and salicylic acid 75 ppm as 75mg /liter was done at flower initiation and salicylic acid + 2% urea at flower initiation and salicylic acid 75 ppm 7 days after first spray.

Analysis of nutrient content, uptake and quality parameters

Nitrogen concentration and its uptake

Nitrogen was estimated by digesting plant samples with 2 ml concentrated sulphuric acid using hydrogen peroxide for removing black colour. Estimation of nitrogen was done by colorimetric method using Nessler’s reagent to develop colour (Snell and Snell, 1949). Nitrogen concentration was calculated and expressed in percentage. The uptake of nitrogen by crop was calculated using following formula:

$$N \text{ uptake (kg ha}^{-1}\text{)} = \frac{\text{Per cent N in seed} \times \text{seed yield (kg ha}^{-1}\text{)} + \text{percent N in Straw} \times \text{Straw yield (kg ha}^{-1}\text{)}}{100}$$

Phosphorus concentration and its uptake

The seed and straw samples were analyzed for phosphorus concentration by Vanadomolybdo

phosphoric yellow colour method in sulphuric acid system (Richards, 1954). The uptake of phosphorus by crop was calculated using following formula:

P uptake (kg ha⁻¹) =

$$\frac{\text{P conc. in seed (\%)} \times \text{Seed yield (kg ha}^{-1}\text{)} + \text{P conc. in straw (\%)} \times \text{Straw yield (kg ha}^{-1}\text{)}}{100}$$

Potassium concentration and its uptake

Potassium concentration in seed and straw

was estimated by flame photometer method (Jackson, 1973). The uptake of potassium by crop was calculated using following formula:

K uptake (kg ha⁻¹)=

$$\frac{\text{K conc. in seed (\%)} \times \text{Seed yield (kg ha}^{-1}\text{)} + \text{K conc. in straw (\%)} \times \text{Straw yield (kg ha}^{-1}\text{)}}{100}$$

Total nutrient uptake

The total uptake of nitrogen, phosphorus and

potassium was computed from N, P and K concentration in seed and straw at harvest using following relationship:

Total uptake (kg ha^{-1}) =

Nutrient conc. in seed (%) x yield (kg ha^{-1}) + Nutrient conc. in straw (%) x Straw yield (kg ha^{-1})

100

Protein content in seed

Protein content in seed was calculated by multiplying nitrogen concentration (%) in seed by the factor 6.25 (A.O.A.C., 1960).

30.32 and 9.36 %, respectively. These results are in cognizance with the findings of Sasode (2008) and Rathore *et al.*, (2010).

Results and Discussion

Effect on nitrogen content and uptake

Improved nutritional environment in the rhizosphere as well as in the plant system leading to enhanced translocation of N, P and K in plant parts. Since the nutrient uptake is a function of its content in crop plant and seed and straw yield of the crop. The increase in these parameters due to N and P fertilization led to an increased uptake of nutrients in the present study. The data showed that increasing fertility levels increased the nitrogen concentration in seed and straw up to maximum dose. Application of 100% RDF improved the N concentration in seed (4.01%) by over control, 50% and 75% RDF. Data further revealed that N concentration in straw (1.50 %) also showed the similar pattern with increasing level of fertilizer up to 100% RDF. A perusal of data indicated that total nitrogen uptake significantly increased due to different fertility levels as compared to control and the significantly highest N uptake was registered at 100% RDF. Enhancement in total nitrogen uptake due to 100% RDF (81.02 kg ha^{-1}) as compared to control (F_0), 50% RDF (F_1) and 75% RDF (F_2) was to the tune of 39.92, 18.85 and 6.94 kg ha^{-1} which corresponded to 97.12,

Thiourea application might have helped in improvement of metabolic processes of plants and better growth and development, leading to greater absorption of nutrients from rhizosphere, it might be due to metabolic role of SH-group in root physiology and biochemistry. Data (Table 1) revealed that nitrogen concentration in seed and straw of mungbean was influenced significantly by stress mitigating chemicals over control. Foliar application of 500 ppm thiourea at flower initiation (S_3) estimated the maximum nitrogen concentration in seed (22.22 %) and proved superior over rest of the treatments except SA+ 2% Urea. The similar trend was also observed with nitrogen concentration in straw. The corresponding enhancement due to thiourea over control and SA alone was to the extent of 38.83 and 5.92 %. Data further revealed that the spray of different chemicals brought about significant improvement in nitrogen uptake by mungbean over control. The maximum total nitrogen uptake was recorded with thiourea (73.98 kg ha^{-1}) which proved significantly superior to control and 75 ppm SA by 53.80 and 11.85 %, respectively and remained at par with SA+ 2% Urea. The per cent increase in total N uptake due to application of SA + 2% Urea and SA over control was 45.82 and 37.50 %, respectively. Thiourea creates better microbial population in soil which is responsible to

mobilize essential nutrients. These results are in close conformity with the findings of Lakhana *et al.*, (2005) and Yadav (2005).

Effect on phosphorus content and uptake

Phosphorus is the most indispensable mineral nutrient for legume crops as it helps in better root growth and development and thereby making them more efficient in biological nitrogen fixation (BNF). Phosphorus is an essential constituent of nucleic acid (RNA and DNA), ADP and ATP, nucleoproteins, amino acid, protein, several co-enzymes (NADP), *viz.*, thiamine and pyrodoxyl phosphate. The data (Table 1) showed that increasing fertility levels significantly increased the phosphorus concentration in seed and straw. Application of 75% RDF being at par with 100% RDF recorded significantly higher phosphorus concentration in seed and straw, indicating an increase of 74.81 and 9.66 % in seed and 98.13 and 10.41 % in straw over control and 50% RDF, respectively. A perusal of data (Table1) indicated that total phosphorus uptake was found to be significantly higher under 75% RDF (9.87 kg ha⁻¹ over 50% RDF (8.09 kg ha⁻¹) and control (3.99 kg ha⁻¹). The increase in P uptake due to 75% RDF in terms of kg ha⁻¹ was 5.88 and 1.78 over control and 50% RDF, respectively and it also remained at par with 100% RDF. The present results are also in agreement with the findings on legume crops work has been done by several workers (Singh and Pareek, 2003, Yakadri *et al.*, 2004).

Data (Table 1) also revealed that phosphorus concentration in seed and straw was influenced significantly by stress mitigating chemicals over control. Foliar application of thiourea and SA+ 2% Urea increased the phosphorus concentration in seed and straw. Further, foliar spray of SA increased phosphorus concentration by 13.76% in seed

and 8.38% in straw over control. However, it remained statistically at par with SA+ 2% Urea. The application of chemicals brought about significant improvement in total phosphorus uptake in seed and straw over control. Highest total phosphorus uptake was recorded with 500 ppm thiourea over SA and control and remained at par with SA + 2% Urea treatment (S₂). Similar observation also found by Lakhana *et al.*, (2005) and Yadav (2005).

Effect on potassium content and uptake

The data (Table 1) indicated that varying fertility levels from 0 to 100% RDF failed to cause any significant variation in potassium concentration in seed and straw. However, the maximum concentration of potassium in both seed and straw was recorded under 100% RDF. The potassium uptake by mungbean was found significantly higher with increasing fertility levels up to 75% RDF. The extent of increase in K uptake due to 75% RDF over control and 50% RDF was 65.10 and 16.19 per cent, respectively. The fertility levels, 75% and 100% RDF remained equally effective with regard to the above parameter. This results obtained are in close conformity with Mondal *et al.*, (2005), Srinivasarao and Ali (2006).

Data further showed that different stress mitigating chemicals could not bring any perceptible variation in potassium content in both seed and straw (Table 1). The data revealed that the foliar spray of agrochemicals brought about significant improvement in potassium uptake by mungbean. The maximum potassium uptake was recorded with 500 ppm thiourea spray. Being at par with 75 ppm SA+ 2% urea, both these treatments increased the K uptake by 39.45 and 31.40 % over control, respectively. These similar results also found by Kuttimani and Velayutham (2011).

Effect on protein content

Higher nitrogen in seed is directly responsible for higher protein because it is a primary component of amino acids which constitute the basis of protein. Data presented in table 1 showed that protein content in seed was affected significantly due to different levels of fertility, wherein, application of 100% RDF (34.51 %) increased the protein content in seed by, over control, 50% RDF and 75% RDF. Higher nitrogen in seed is directly responsible for higher protein because it is a primary component of amino acids which constitute the basis of protein. These results are in cognizance with the findings of Sasode (2008) and Rathore *et al.*, (2010).

A critical examination of data (Table 1) further indicated that the protein content in seed of mungbean was improved significantly by stress mitigating chemicals over control. Foliar application of thiourea (22.19 %) and SA + 2% (20.31 %) Urea increased the protein content in seed over control. Further, foliar spray of 75 ppm SA increased the protein content in seed by 16.81 per cent over control but it was found at par with SA + 2% Urea. Further, foliar spray of 500 ppm thiourea significantly increased the protein content in seed of mungbean (Table 1). This might be due to increased concentration of N

in seed of mungbean by foliar spray of thiourea. These results are in close conformity with the findings of Lakhana *et al.*, (2005) and Yadav (2005).

Effect on yield

The results indicated that application of fertility levels up to 75% RDF recorded significantly higher seed, stover and biological yield of mungbean over preceding fertility levels but remained at par with 100% RDF (Table 2). Application of varying fertility levels at 50, 75 and 100% RDF enhanced the harvest index over control by 7.73, 12.76 and 14.55 %, respectively and remained at par amongst them.

Both nutrients are plays key role in mungbean seed formation and are responsible for keeping the system operating smoothly of mungbean plants, overall an increase in seed, straw, biological yield of mungbean (Meena and Yadav, 2015). In general, NPK were responsible for increased plant height, nodulation pattern, growth and yield parameters or ultimately yields and quality of mungbean. The present results are also in agreement with the findings on legume crops work has been done by several workers (Awomi *et al.*, 2012).

Table.1 Properties of soil

Particulars	Values obtained	Method adopted and references
(i) Available N (kg ha ⁻¹)	128.3	Alkaline permanganate method (Subbiah and Asija, 1956)
(ii) Available P ₂ O ₅ (kg ha ⁻¹)	16.23	Olsen's method (Olsen <i>et al.</i> , 1954)
(iii) Available K ₂ O (kg ha ⁻¹)	154.26	Flame photometric method (Metson, 1956)
(iv) Organic carbon (%)	0.18	Rapid titration method (Walkley and Black, 1947)
(v) EC of saturation extract at 25 ⁰ C (dS/m)	1.33	Method No. 4, USDA Hand Book No. 60 (Richards, 1954)
(vi) pH (1: 2 soil water suspension)	8.2	Method No. 21 (b) USDA, Hand Book No. 60 (Richards, 1954)

Table.1 Effect of fertility levels and stress mitigating chemicals on nutrient concentration in seed and straw, total uptake and protein content

Treatments	Nitrogen content (%)		Total nitrogen uptake (kg ha ⁻¹)	Phosphorus content (%)		Total Phosphorus uptake (kg/ha)	Potassium content (%)		Total Potassium uptake (kg/ha)	Protein content (%)
	Seed	Straw		Seed	straw		Seed	straw		
Fertility levels										
F₀ - Control	2.98	1.00	41.10	0.266	0.107	3.99	0.79	1.61	35.97	18.63
F₁ - 50% RDF	3.63	1.30	62.17	0.424	0.192	8.09	0.80	1.63	42.20	22.69
F₂ - 75% RDF	3.85	1.41	74.08	0.465	0.212	9.87	0.82	1.65	46.47	24.06
F₃ - 100% RDF	4.01	1.50	81.02	0.470	0.219	10.49	0.83	1.68	48.79	25.06
SEm₊	0.05	0.03	1.49	0.008	0.003	0.23	0.02	0.04	1.45	0.44
CD (P = 0.05)	0.15	0.08	4.29	0.023	0.010	0.66	NS	NS	4.20	1.27
Stress mitigating chemicals										
S₀ - Control	3.15	1.03	48.10	0.356	0.167	6.50	0.79	1.60	38.37	19.69
S₁- SA @ 75 ppm at flower initiation and 7 days after first spray	3.68	1.35	66.14	0.405	0.181	8.08	0.80	1.63	43.14	23.00
S₂ - SA @ 75 ppm + 2% Urea at flower initiation	3.79	1.40	70.14	0.425	0.188	8.64	0.82	1.66	44.91	23.69
S₃ - Thiourea @ 500 ppm at flowering initiation	3.85	1.43	73.98	0.439	0.193	9.22	0.83	1.68	47.01	24.06
SEm₊	0.05	0.03	1.49	0.008	0.003	0.23	0.02	0.04	1.45	0.44
CD (P = 0.05)	0.15	0.08	4.29	0.023	0.010	0.66	NS	NS	4.20	1.27
CV (%)	7.22	7.15	7.97	6.72	6.58	9.74	7.50	7.52	11.61	7.19

Table.2 Effect of fertility levels and stress mitigating chemicals on seed, stover and biological yield

Treatments	Yield (kg/ha)			Harvest index (%)
	Seed	Straw	Biological	
Fertility levels				
F₀ - Control	743	1867	2610	28.44
F₁ - 50% RDF	940	2125	3065	30.64
F₂ - 75% RDF	1077	2279	3356	32.07
F₃ - 100% RDF	1133	2341	3474	32.58
SEm₊	23	40	63	0.74
CD (P = 0.05)	68	114	183	2.14
Stress mitigating chemicals				
S₀ - Control	858	1971	2829	30.16
S₁- SA @ 75 ppm at flower initiation and 7 days after first spray	979	2162	3141	31.00
S₂ - SA @ 75 ppm + 2% Urea at flower initiation	1008	2203	3211	31.22
S₃ - Thiourea @ 500 ppm at flowering initiation	1048	2276	3324	31.36
SEm₊	23	40	63	0.74
CD (P = 0.05)	68	114	183	NS
CV (%)	8.01	7.02	7.01	8.29

The results further indicated that the foliar application of thiourea @ 500 significantly recorded the grain, stover and biological yield and remained at par with SA @ 75 ppm + 2% Urea at over rest of the treatments (Table 2). However, above treatment significantly highest was recorded with respect to seed yield of mungbean. The beneficial role of thiols (Thiourea and SA+ 2% Urea), sulphhydryl compounds in improving the translocation of photosynthates for yield formation. Thiourea as bio-regulator has potential for increasing crop productivity under environmental stresses, which are mainly high temperature and drought due of changing climate and global warming. These beneficial effect of thiourea and SA +2 % Urea on the seed yield and yield attributes in crops has also been reported by several research workers (Ali and Mahmoud, 2013, Kumawat *et al.*, 2014).

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