Sulphur Fertilization Effects on Yield and Nutrient Uptake of Mung bean [Vigna radiata (L.) Wilczek]

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ABSTRACT

A field trial was conducted to study mungbean crop performance and production potential under sulphur fertilization with recommended dose of NPK whereby, seventeen treatments were replicated thrice. Results showed that treatment T15:100% RD of NPK+S was found significantly superior to other treatments and recorded maximum grain yield. This was significantly superior to all treatments except treatment T16:125% RD of NPK+S and recorded maximum stover yield. Seed yield of mung bean exhibited significant variation under different combinations of nutrients and declined significantly with successive decreasing sulphur application. Nitrogen, phosphorus and potassium uptake by seed and stover increased significantly to the higher value (40.20 to 36.20 kg ha⁻¹) with highest in treatment T15:100% RD of NPK+S and lowest in treatment T17: Control in both seed and stover. Nitrogen, phosphorus and potassium removal by seed and stover (total uptake) increased significantly with recommended dose of sulphur fertilization.

Key words: Mung bean, Nutrient uptake, Seed yield, Sulphur.

INTRODUCTION

With the growing population of the world in general and the developing countries in particular, demands are overwhelmed for enhanced food production. Besides emphasizing on main crops and vegetables, various pulses play an important role to satisfy the growing human food demands. Among many others pulses, green gram is an important short duration pulse crop. At present soil health has become a cause of concern for sustainable agricultural production in the new millennium. Use of high analysis fertilizers, heavy sulphur (S) removal by the crops under intensive cultivation and neglect of S replenishment contributed to widespread S deficiencies in India. Sulphur deficiencies have been reported from 72 countries in the world (Das, 2017). Over 27000 soil samples from twelve states of India were analysed, of which 40% were found deficient and another 35% were potentially deficient in available sulphur (Biswas et al., 2004). More than 70% soil samples taken from U.P., M.P, Maharashtra, Orissa, Jharkhand, West Bengal, Andhra Pradesh and Karnataka were found low to medium in available sulphur.

Sulphur has a great role in N-fixation by influencing active nodulation in legume. It is a part of nitrogenase enzyme, promotes nodulation in legumes, which enhances biological N-fixation (BNF) and the productivity of pulses may drastically be reduced by an inadequate supply of sulphur. It is also necessary for chlorophyll formation and helps in biosynthesis of oil and metabolism of carbohydrates, proteins and fats and thus now-a-days sulphur is being considered as the fourth major nutrient element after N, P, K.

Sulfur (S) deficiency is reported from different parts of the country mainly due to increased crop yield coupled with intensive farming and a drastic shift from low-analysis fertilizers to high analysis fertilizers containing little or no elemental S. Sulphur deficiency in Indian soils is widespread and the optimal gains from intensive investments in N, P and K will not be achieved until its correction. Sulphur requirements of mung bean plants is quite higher with high yielding varieties and by increasing cropping intensity, large amounts of nutrients are removing from the soil gradually. Pulse crops have been reported to deplete the soil S relatively to a greater extent. Western Uttar Pradesh soils are covered by sandy loam soils which are slightly alkaline in reaction and is having low organic matter content. Crops grown in such soil conditions would suffer multi nutrient deficiencies including sulphur and iron.

This study was planned on sulphur fertilization with recommended dose of NPK fertilizer to determine sulphur fertilization effect on yield, nutrient concentration and uptake of mungbean.

MATERIALS AND METHODS

Experimental details

This field trial was conducted during 2010 in “Sardar Vallabhbhai Patel University of Agriculture and Technology Meerut”, western Uttar Pradesh region which falls under subtropical climatic and semi-arid zone. The field experiment
Sulphur Fertilization Effects on Yield and Nutrient Uptake of Mung bean \(Vigna\) \textit{radiata}\ (L.) Wilczek was structured in Randomized Block Design (RBD) whereby 17 treatments (T1: 50% RD of NP+S), (T2: 75% RD of NP+S), (T3: 100% RD of NP+S), (T4: 125% RD of NP+S), (T5: 50% RD of NK+S), (T6: 75% RD of NK+S), (T7: 100% RD of NK+S), (T8: 125% RD of NK+S), (T9: 50% RD of NPK), (T10: 75% RD of NPK), (T11: 100% RD of NPK), (T12: 125% RD of NPK), (T13: 50% RD of NPK+S), (T14: 75% RD of NPK+S), (T15: 100% RD of NPK+S), (T16: 125% RD of NPK+S) and (T17: control) were replicated thrice. The recommended dose of fertilizers (RDF) for mung bean was 20, 30, 20 and 20 kg of N, P\(_2\)O\(_5\), K\(_2\)O and S ha\(^{-1}\), respectively.

**Site descriptions**

The trial site had good drainage and textured sandy loam (64.2 per cent sand, 18.5 per cent silt and 17.3 per cent clay (Bouyoucos, 1962). All physicochemical characteristics were evaluated according to the standard processes (Jackson, 1973). Soil sampling was conducted from top in permanent beds at 0-15 cm soil layer and in flats in row. The experimental site recorded bulk density 1.40 mg m\(^{-3}\) (medium), weighted mean soil aggregate diameter 0.58 mm, infiltration rate 23 mm hr\(^{-1}\), porosity 46.50%, organic carbon 0.47 %, soil pH 7.60, available nitrogen 151.20 kg ha\(^{-1}\), available phosphorus 13.30 kg ha\(^{-1}\), available potassium 139.82 kg ha\(^{-1}\), and available sulphur 8.3 kg ha\(^{-1}\).

**Crop management**

SML-668, a short duration variety maturing in only 55-60 days was selected for the study. The recommended dose of fertilizers (RDF) for mung bean was 20, 30, 20 and 20 kg of N, P\(_2\)O\(_5\), K\(_2\)O and S ha\(^{-1}\), respectively. The whole quantity of NPK fertilizer was applied at final ploughing.

**Data collection**

Each plot contained 10 rows out of which one row on either side of the plot was kept as border row followed by one sampling row. Five continuous plants from the sampling row excluding 0.5m on either ends were selected at random on all sampling dates for the following studies. Five tagged plants were identified from every plot sampling. Yield attributes were recorded by selecting 10 plants in each plot and yield was estimated based on produce harvested from net plot for each treatment, and expressed at 14 % moisture whereas seed yield (Kg ha\(^{-1}\)) was reported as seed weight from the net plot. Net plot seed yield was recorded and converted to kg ha\(^{-1}\). Stover yield was calculated by subtracting seed yield from biological yield and eventually converting into kg ha\(^{-1}\). Biological yield was calculated by adding seed yield and stover yield of mungbean.

**Nutrient content and uptake**

Seed and stover were analyzed for nitrogen, phosphorus and potassium using modified Micro-Kjeldahl method, Vanadomolybdate phosphoric yellow colour method and Flame Emission Spectrophotometer method, respectively (Jackson, 1973). Uptake of particular nutrient in seed and stover was worked out by multiplying the nutrient content with corresponding dry matter yield ha\(^{-1}\). Total nutrient uptake of nutrients in seed and stover was calculated by adding seed and stover uptake.

**Statistical analysis**

Recorded data was statistically analyzed using computer package ‘IRRISTAT’ applying the analysis of variance technique (Gomez and Gomez, 1984). The critical difference (5 % level of probability) was computed for comparing treatment means in cases where effect was significant by F-test.

**RESULTS AND DISCUSSION**

**Yields**

Treatment T15: 100% RD of NPK+S recorded highest seed yield (1524 kg ha\(^{-1}\)), significantly higher than other treatments. Treatment T16: 125% RD of NPK+S was significantly superior to remaining treatments. Treatments T3: 100% RD of NP+S, T4: 125% RD of NP+S and T13: 50% RD of NPK+S were at par, however, they recorded significantly higher seed yield over treatments T1: 50% RD of NP+S, T5: 50% RD of NK+S, T6: 75% RD of NK+S, T7: 100% RD of NK+S, T8: 125% RD of NK+S, T9: 50% RD of NPK and T10: 75% RD of NPK, respectively. Treatment

![Fig 1: Yield of mung bean as affected by N, P, K and S fertilization combinations NPK content (%) in mungbean seed and stover.](image-url)
T17: Control recorded minimum seed yield of 386 kg ha$^{-1}$. This has also been reported by Singh et al., (1992) (Fig 1).

Treatment T15:100% RD of NPK+S recorded significantly superior stover yield (2696 kg ha$^{-1}$) to all other treatments except T16:125% RD of NPK+S. The stover yield recorded significant increase with successive increasing balanced fertilizer supply. Treatments T2:75% RD of NP+S, T3:100% RD of NP+S, T4:125% RD of NP+S, T13:50% RD of NPK+S and T14:75% RD of NPK+S recorded at par stover yields; however, these treatments recorded significantly higher stover yield over treatment T17: Control (835kg ha$^{-1}$), respectively (Fig 1). NPK were responsible for increased plant height, growth and yield parameters or ultimately yields of mungbean. These findings support work done on legume crops by several workers (Meena and Yadav, 2013 and Sarita, et al. 2019). Stover yield showed significant response to different treatments and treatment T15:100% RD of NPK+S recorded significantly higher stover yields than other treatments. Similarly, all the treatments recorded higher stover yield than treatment T17: Control. Higher stover yield could be accredited to the significant effect of fertilizers on the vegetative growth of the crop plant. Vegetative growth was vigorous with higher trifoliate in fertilized plots. Thus the stover yield increased because of enhancement of vegetative growth under improved fertilizer application. In the current study of seed and stover yield a significant aspect was observed in treatment T15:100% RD of NPK+S treatment. Seed yield obtained under this treatment was more as compared to control T17: Control treatment, whereas the corresponding stover yield was less. This could be attributed to fertilizer application, leading to more pods plant$^{-1}$ and more number of seeds per pod under this treatment. Similar kind of reports on yields have also been given by Khairnar et al., (2009) (Fig 1). The treatment T15:100% RD of NPK+S was found to be significantly superior followed by treatment T14:75%RD of NPK+S and treatment T16:125%RD of NPK+S during the crop year and treatment T15:100% RD of NPK+S recorded maximum biological yield (4220 kg ha$^{-1}$). Treatments T2:75% RD of NP+S, T3:100% RD of NP+S, T4:125% RD of NP+S, T13:50% RD of NPK+S and T14:75% RD of NPK+S were at par, however, these recorded significantly higher biological yield over treatment T17: Control recording minimum biological yield (1021 kg ha$^{-1}$). Same has also been reported by Singh et al., (1992) (Fig 1).

The highest nitrogen content in mung bean seed among the treatments of sulphur (4.02%) was observed in T16:125% RD of NPK+S. The lowest nitrogen content (3.35 %) was observed in T17: Control treatment. The highest nitrogen content in stover among the treatments of sulphur (1.65 %) was observed in T15:100% RD of NPK+S. The highest phosphorus content in mungbean seed among the treatments of sulphur (0.613%) was observed in T15:100% RD of NPK+S. The lowest phosphorus content (0.068 %) was observed in T17: Control treatment. The highest phosphorus content in mungbean stover among the treatments of sulphur (0.275%) was observed in T16:125% RD of NPK+S. The highest potassium content in mungbean seed among the treatments of sulphur (0.516%) was observed in T16:125% RD of NPK+S. The lowest phosphorus content (0.463%) was observed in T17: Control treatment. The highest potassium content in mungbean stover among the treatments of sulphur (4.02%) was observed in T15:100% RD of NPK+S. The lowest potassium content (2.24%) was observed in T13:50% RD of NPK+S. The highest biological yield (1021 kg ha$^{-1}$) was observed in T17: Control treatment. Similar kind of reports on biological yield have also been given by Singh et al., (1992) (Fig 1).

Effect of sulphur fertilization on NPK content (%) in mungbean seed and stover.

**Table 1**: Effect of sulphur fertilization on NPK content (%) in mungbean seed and stover.

| Treatment          | Content in Seed and Stover (%) |
|--------------------|--------------------------------|
|                    | N (%) | P (%) | K (%) |
|                    | Seed  | Stover| Seed | Stover | Seed | Stover |
| T1:50% RD of NP+S | 3.70  | 1.55  | 0.327  | 0.224  | 0.487  | 1.23  |
| T2:75% RD of NP+S | 3.82  | 1.59  | 0.493  | 0.228  | 0.502  | 1.25  |
| T3:100% RD of NP+S| 3.90  | 1.62  | 0.562  | 0.231  | 0.511  | 1.26  |
| T4:125% RD of NP+S| 3.88  | 1.61  | 0.550  | 0.230  | 0.508  | 1.30  |
| T5:50% RD of NK+S | 3.58  | 1.52  | 0.219  | 0.221  | 0.476  | 1.22  |
| T6:75% RD of NK+S | 3.51  | 1.51  | 0.190  | 0.220  | 0.469  | 1.21  |
| T7:100% RD of NK+S| 3.67  | 1.54  | 0.286  | 0.230  | 0.484  | 1.23  |
| T8:125% RD of NK+S| 3.50  | 1.50  | 0.147  | 0.219  | 0.465  | 1.20  |
| T9:50% RD of NPK  | 3.62  | 1.53  | 0.243  | 0.222  | 0.480  | 1.22  |
| T10:75% RD of NPK | 3.74  | 1.56  | 0.373  | 0.225  | 0.490  | 1.24  |
| T11:100% RD of NPK| 3.80  | 1.58  | 0.474  | 0.226  | 0.498  | 1.25  |
| T12:125% RD of NPK| 3.77  | 1.57  | 0.432  | 0.227  | 0.495  | 1.25  |
| T13:50% RD of NPK+S| 3.85  | 1.60  | 0.532  | 0.229  | 0.505  | 1.26  |
| T14:75% RD of NPK+S| 3.93  | 1.63  | 0.578  | 0.232  | 0.514  | 1.25  |
| T15:100% RD of NPK+S| 3.98  | 1.65  | 0.613  | 0.234  | 0.520  | 1.27  |
| T16:125% RD of NPK+S| 4.02  | 1.64  | 0.596  | 0.275  | 0.516  | 1.26  |
| T17:Control       | 3.35  | 1.48  | 0.068  | 0.217  | 0.463  | 1.08  |
| SEm±               | 0.057 | 0.016 | 0.008  | 0.028  | 0.014  | 0.012 |
| CD(P=0.05)         | 0.166 | 0.047 | 0.022  | 0.010  | 0.014  | 0.024 |
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Table 2: NPK uptake in seed and stover of mungbean as affected by sulphur fertilization.

| Treatment                  | NPK Uptake in Seed and Stover (kg ha⁻¹) |
|----------------------------|----------------------------------------|
|                            | Nitrogen | Phosphorus | Potassium |
|                            | Seed     | Stover     | Total     | Seed | Stover | Total     | Seed | Stover | Total     |
| T1:50% RD of NP+S         | 33.80    | 31.80      | 65.60     | 7.30 | 4.70   | 12.00     | 4.20 | 26.10 | 30.30     |
| T2:75% RD of NP+S         | 36.70    | 33.80      | 70.50     | 8.10 | 5.10   | 13.20     | 4.60 | 26.60 | 31.20     |
| T3:100% RD of NP+S        | 38.10    | 35.10      | 73.20     | 8.70 | 5.40   | 14.10     | 5.00 | 27.30 | 32.30     |
| T4:125% RD of NP+S        | 37.80    | 34.70      | 72.50     | 8.50 | 5.30   | 13.80     | 4.90 | 27.00 | 31.90     |
| T5:50% RD of NK+S         | 31.40    | 34.20      | 65.60     | 7.00 | 4.40   | 11.40     | 3.90 | 25.40 | 29.30     |
| T6:75% RD of NK+S         | 30.60    | 29.80      | 60.40     | 6.90 | 4.30   | 11.20     | 3.80 | 25.20 | 29.00     |
| T7:100% RD of NK+S        | 33.10    | 31.20      | 64.30     | 7.20 | 4.60   | 11.80     | 4.10 | 25.90 | 30.00     |
| T8:125% RD of NK+S        | 29.20    | 29.60      | 58.80     | 6.80 | 4.13   | 10.93     | 3.70 | 25.00 | 28.70     |
| T9:50% RD of NPK          | 32.30    | 30.60      | 62.90     | 7.10 | 4.50   | 11.60     | 4.00 | 25.70 | 29.70     |
| T10:75% RD of NPK         | 34.60    | 32.30      | 66.90     | 7.50 | 4.80   | 12.30     | 4.30 | 26.30 | 30.60     |
| T11:100% RD of NPK        | 36.10    | 33.40      | 69.50     | 7.90 | 5.00   | 12.90     | 4.50 | 26.50 | 31.00     |
| T12:125% RD of NPK        | 35.30    | 32.86      | 68.16     | 7.70 | 4.90   | 12.60     | 4.40 | 26.40 | 30.80     |
| T13:50% RD of NP+K+S      | 37.20    | 34.20      | 71.40     | 8.30 | 5.20   | 13.50     | 4.70 | 26.80 | 31.50     |
| T14:75% RD of NP+K+S      | 38.70    | 35.40      | 74.10     | 8.90 | 5.50   | 14.40     | 5.20 | 27.50 | 32.70     |
| T15:100% RD of NP+K+S     | 40.20    | 36.20      | 76.40     | 9.40 | 5.70   | 15.1      | 5.50 | 27.90 | 33.40     |
| T16:125% RD of NP+K+S     | 39.40    | 35.80      | 75.20     | 9.20 | 5.60   | 14.8      | 5.40 | 27.70 | 33.10     |
| T17:Control               | 27.90    | 29.40      | 57.30     | 6.70 | 4.10   | 10.8      | 3.60 | 24.80 | 28.40     |
| SEm±                      | 0.16     | 0.82       | 0.94      | 0.16 | 0.19   | 0.35      | 0.04 | 0.08  | 0.11      |
| CD(P=0.05)                | 0.33     | 2.38       | 2.72      | 0.46 | 0.55   | 1.01      | 0.10 | 0.22  | 0.32      |

The highest potassium content in mungbean stover among the treatments of sulphur (1.27%) was observed in T15:100% RD of NPK+S (Table 1). The lowest nitrogen content of NPK were observed in treatment T17: Control treatment. The correlation coefficient between NPK content in seed and seed yield was found positively correlated with NPK content in mungbean seed (r=0.9968, r=0.9915, r=0.9981). Similar positive trends were recorded between NPK content in stover and stover yield of mungbean (r=0.9923, r=0.6909, r=0.7321).

NPK uptake (kg ha⁻¹) by mungbean seed and stover

The highest nitrogen and phosphorus uptake (40.20 kg ha⁻¹ and 9.4 kg ha⁻¹) in mungbean seed among the treatments of sulphur was observed in T15:100% RD of NPK+S whereas treatments T15:100% RD of NPK+S (36.20 kg ha⁻¹) and T16:125% RD of NPK+S (5.7 kg ha⁻¹) recorded highest nitrogen and phosphorus uptake respectively. The highest potassium uptake in mungbean seed among the treatments of sulphur (5.5 kg ha⁻¹) was observed in T16:125% RD of NPK+S whereas highest potassium concentration in mungbean stover among the treatments of sulphur (5.5 kg ha⁻¹) was observed in T15:100% RD of NPK+S. The lowest NPK uptake were observed in treatment T17: Control (Table 2). The correlation coefficient between NPK uptake in seed and seed yield were also recorded and seed yield was found positively correlated with NPK uptake in mungbean seed (r=0.969, r=0.9619, r=0.9733). Similar positive trends were recorded between NPK uptake in stover and stover yield of mungbean (r=0.9104, r=0.9931, r=0.9993).

NPK uptake by seed and stover was significantly influenced in treatment T15:100% RD of NPK+S over all the treatments, however, treatment T16:125% RD of NPK+S was also significantly superior over other treatments. Treatment T4:125% RD of NP+S and Treatment T14:75% RD of NP+K+S recorded at par NPK uptake with each other (Table 2).

These results indicate the existence of significant synergistic interaction between phosphorus and sulphur which might have resulted in increased dry matter production. It is well established fact that with increase in dry matter production, N uptake increases. The N uptake due to P and S application increased due to N-fixation as a result of increased number of nodules. Similar results have been reported in soybean by Paliwal et al., (2009) that 60 kg P₂O₅ along with 40 kg S ha⁻¹ significantly increased the N (6.72, 1.02 %), P (0.37, 0.097 %) and K (1.76, 1.82 %) concentration in soybean seed and stover compared to control. Nilambari et al., (2003) reported that use of 60 kg S ha⁻¹ resulted in significantly higher N, P, K and S uptake in chickpea (203.4, 15.6, 215.2 and 20.9 kg ha⁻¹) and increased due to N-fixation as a result of increased number of nodules. Similar results have been reported in soybean by Paliwal et al., (2009) that 60 kg P₂O₅ along with 40 kg S ha⁻¹ significantly increased the N (6.72, 1.02 %), P (0.37, 0.097 %) and K (1.76, 1.82 %) concentration in soybean seed and stover compared to control. Nilambari et al., (2003) reported that use of 60 kg S ha⁻¹ resulted in significantly higher N, P, K and S uptake in chickpea (203.4, 15.6, 215.2 and 20.9 kg ha⁻¹).
CONCLUSION
Seed yield of mung bean exhibited significant variation under different combinations of nutrients and declined significantly with successive decreasing sulphur application. In present study nitrogen, phosphorus and potassium uptake by seed and stover increased significantly to the higher value (40.20 to 36.20 kg ha$^{-1}$) with highest in treatment T15:100% RD of NPK+S and lowest in treatment T17: Control in both seed and stover. Nitrogen, phosphorus and potassium removal by seed and stover (total uptake) increased significantly with recommended dose of sulphur fertilization.

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