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Influence of Nitrogen and Sulphur Application on Yield and Quality of Soybean (*Glycine max* L.)

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A B S T R A C T

A field experiment was conducted to study the effect of different levels of nitrogen and sulphur on yield and quality of soybean with four levels of nitrogen (0, 40, 80, 120 kg N ha^{-1}) and four levels of sulphur (0, 20, 30 and 40 kg ha^{-1}). The highest mean grain yield of 1997 and 1874 kg ha^{-1} were recorded with the application of 120 kg N and 40 kg S ha^{-1}, respectively. The oil content and protein content also progressively increased with increasing levels of nitrogen and sulphur. The highest oil and protein content of 18.65 and 40.3 percent were observed with the application of 120 kg N ha^{-1}. Application of 40 kg S ha^{-1} recorded higher oil and protein contents of 18.38 and 38.74 percent, respectively.

Introduction

Soybean (*Glycine max* L. Merrill), is an introduced and commercially exploited crop in India. It has highest protein 40 %, oil 20 %, rich in lysine and vitamins A, B and D and also rich in mineral salts. Soybean is preferable for human nutrition due to its high protein content and it is a good source of isoflavones and therefore it helps in preventing heart diseases, cancer. Soybean oil is the leading vegetable oil in the world and is used in many industrial applications including biodiesel. The crop is called as "Golden Bean" or "Miracle crop" of the 21st century because of its high nutritional value and myriad form of uses. Soybean was grown in a small way for the past many decades in India, but since 1972 the area sown to the crop has increased substantially. Currently, in India area under soybeans is grown in 11.60 m ha with a production of 10.91 million tones and productivity of 738 kg ha^{-1} (Directorate of Economics and Statistics, 2015-16).

Nitrogen and sulphur plays an important physiological and biochemical role in plants, nitrogen is a major essential plant nutrient element. It has the quickest and most pronounced effect on plant growth and yield of crops. It tends primarily to encourage above ground vegetative growth and to impart deep

green colour to the leaves. In all plants, nitrogen governs a considerable degree of utilization of potassium, phosphorus and other nutrients. Plants receiving insufficient nitrogen are stunted in growth with restricted root systems. The leaves turn yellow or yellowish green and tend to drop off.

Sulphur is one of the essential nutrient required for the plant growth. It is now assuming importance next to the major nutrients *i.e.,* nitrogen, phosphorus and potassium. Intensive cultivation with high yielding varieties, use of high analysis NPK fertilizers and limited manuring have resulted in emergence of secondary and micronutrient deficiencies in soils. Among secondary nutrients, deficiency of sulphur (S) was reported (Tiwari). Sulphur deficiency in soils of Indian states varies from 5 to 83 per cent with overall mean of 33 to 41 per cent16.

Lack of sulphur in soil limits the efficiency of added nitrogen in the soils, therefore, sulphur addition become necessary to achieve the maximum efficiency of added nitrogenous fertilizers. The optimum ratio of available N to the available S to be 7:1, the ratio below 7 gives reduced seed yield. The larger dose of gypsum reduces the yield when nitrogen status in soil is unsatisfactory and shortage of sulphur to crops lowers the utilization of available nitrogen.

Materials and Methods

In order to study the effect of nitrogen and sulphur levels on yield, protein and oil content of soybean an experiment was conducted during *kharif*, 2017 at College Farm, Agricultural College, Polasa, Jagtial, Professor Jayashankar Telangnana State Agricultural University. The experiment was laid out in randomized block design with factorial concept (FRBD) with three replications. Four levels of nitrogen *viz.*, 0, 40, 80, 120 kg N ha^{-1} and four levels of sulphur *viz.*, 0, 20, 30 and 40 kg ha^{-1} were adopted, thus a total of 16 treatments were imposed. Soybean variety JS-335 was used for the study. The soil of the experiment site was sandy loam in texture, having neutral in reaction (pH 7.26), normal in salinity (EC 0.03 d Sm^{-1}), low in organic carbon content (0.34 %), available N (126 kg ha^{-1}), available phosphorus (20.6 kg ha^{-1}), medium in available potassium (180.2 kg ha^{-1}) and deficient in available sulphur (9.2 mg kg^{-1}). Recommended dose of P and K (60 kg P_2O_5 and 40 kg K_2O) were applied to all plots in the form of DAP and MOP. Nitrogen and elemental sulphur were applied to the respective plots as per treatment requirement.

Protein content in seed was estimated by Lowry method (Sadasivam and Manickam, 1996) and protein yield was calculated by multiplying the protein content in each treatment with corresponding seed yield. Oil content was determined by Nuclear Magnetic Resonance (NMR) spectrophotometer and expressed as percentage (Sambunatham *et al.*, 1985). Oil yield was calculated by multiplying the oil content (%) in each treatment with corresponding seed yield as given as

$$\text{Oil yield (kg ha}^{-1}\text{)} = \frac{\text{Oil content (\%) X Seed yield (kg ha}^{-1}\text{)}}{100}$$

Results and Discussion

Yield

Significant variation on haulm and seed yield of soybean was observed from different nitrogen and sulphur levels. Among the nitrogen levels, the highest haulm and seed yields (3069 and 1977 kg ha^{-1}) were recorded with the application of 120 kg N ha^{-1}(N_3), whereas, lowest haulm and seed yields (2031and 1399 kg ha^{-1}) were recorded in control (N_0). The mean seed yield was

increased by 21.0, 40.0 and 42.7 per cent by the application of 40 (N_1), 80 (N_2) and 120 (N_3) kg N ha^{-1}, respectively as against control (N_0) which recorded the lowest mean seed yield. The increase in haulm and seed yield might be due to continuous supply of nitrogen during crop growth and important role played by nitrogen in energy transformations, activation of enzymes in carbohydrate metabolism and consequently greater transformation of photosynthates into reproductive parts. These results are in line with the findings of Sikka *et al.,* (2013) and Mohanyadravi and Angadi, (2016) who reported that application of higher doses of nitrogen to soybean recorded significantly higher seed yield compared to control plot (Table 1).

Similarly, application of graded levels of sulphur significantly increased the haulm and seed yield of soybean. Increasing the sulphur levels increased the haulm yield up to application of 20 kg S ha^{-1} (S_1). Application of sulphur at the rate of 20 kg ha^{-1} recorded maximum haulm yield of 2675 kg ha^{-1}, it was comparable with the treatments receiving 30 (S_2) and 40 (S_2) kg S ha^{-1} and lowest was recorded in control (2397 kg ha^{-1}). The mean seed yield of 1977 kg ha^{-1} was recorded with the application of 120 kg N ha^{-1} and it was significantly superior over control (N_0) and 40 kg N ha^{-1} (N_1), and statistically on par with the application of 80 kg N ha^{-1} (N_2). The mean seed yield was increased by 21.0, 40.0 and 42.7 per cent by the application of 40 (N_1), 80 (N_2) and 120 (N_3) kg N ha^{-1}, respectively over control (N_0). The increase in haulm and seed yield of soybean might be due to continuous supply of nitrogen during crop growth and important role played by nitrogen in energy transformations, activation of enzymes in carbohydrate metabolism and consequently greater transformation of photosynthates into reproductive parts. These results are in line with the findings of Sikka *et al.,* (2013) and Mohanyadravi and Angadi, (2016) who reported that application of higher doses of nitrogen to soybean recorded significantly higher seed yield compared to control plot.

The interaction effect of nitrogen and sulphur levels had no influence on haulm yield of soybean and it was significant in increase the seed yield of soybean from 1374 kg ha^{-1} in control to 2160 kg ha^{-1} obtained due to the combined application of 120 kg N and 40 kg S ha^{-1} (N_3S_3). This is because of synergistic effect of N and S in producing the higher yield. These findings are in conformity with those of Jamal *et al.,* (2005), Sharma *et al.,* (2014), Anil *et al.,* (2017).

Protein content and protein yield

Seed protein content and protein yield was significantly influenced by different nitrogen levels (Table 2). Application of nitrogen at 120 kg ha^{-1} (N_3) recorded the highest protein content and protein yield against control (N_0). These results are conformity with the findings of Kushwaha and Chandel (1997) who reported that application of 150 kg N ha^{-1} increased the protein content in case of soybean. Increase in protein content of soybean with increasing levels of N was also reported by Morshed *et al.,* (2008), Kumawat *et al.,* (2000).

Similar to nitrogen, sulphur levels also had a significant effect on protein content and protein yield of soybean. The protein content of the seed increased significantly from a mean value of 37.77 per cent at control (S_0) level to 38.48 per cent at S_{30} level which was on par with S_{40}. It may be because sulphur is the key constituent of essential amino acids like methionine, cysteine and cystine which are the precursors for protein synthesis. The above results are in conformity with reports of Hari ram *et al.,* (2014), Singh *et al.,* (2013).

Table.1 Effect of nitrogen and sulphur on haulm and seed

Treatment	Haulm yield (kg ha^{-1})	Seed yield (kg ha^{-1})
N_0	2031	1400
N_1	2565	1693
N_2	2945	1961
N_3	3069	1997
CD	**269**	**177**
S_0	2397	1623
S_1	2675	1756
S_2	2680	1799
S_3	2858	1874
CD	**269**	**177**
Interaction NXS		
CD	**NS**	**353**
CV	**12.2**	**12**

Table.2 Effect of nitrogen and sulphur on quality of soybean

Treatment	Protein Content (%)	Oil content (%)	Protein yield (kg ha^{-1})	Oil yield (kg ha^{-1})
N_0	35.6	17.24	498	241
N_1	37.4	18.13	634	307
N_2	39.5	18.62	777	367
N_3	40.3	18.65	805	372
CD	**0.61**	**0.71**	**69.12**	**38.5**
S_0	37.7	17.84	616	290
S_1	37.89	18.18	670	320
S_2	38.48	18.24	697	330
S_3	38.74	18.38	731	346
CD	**0.61**	**NS**	**69.12**	**38.5**
Interaction NXS				
CD	**NS**	**NS**	**NS**	**NS**
CV	**1.90**	**4.67**	**12.2**	**14.37**

The increase in seed protein content of soybean with the application of N and S might be due to the fact that N is the integral part of protein and protein of oil seeds contain relatively higher quantity of S containing amino acids (methionine and cystine and cystene). The increase protein content with increase in N and S rates confirmed with the findings of Aulakh (1995) who found that application of $N_{100}S_{20}$ recoded highest protein content. Interaction effect of nitrogen and sulphur was found to be non-significant in increasing the protein content of soybean.

Oil content and oil yield

The mean oil content and oil yield of soybean was significantly increased from 17.24

percent and 241 kg ha^{-1} at N_0 level (control) to 18.65 percent and 372 kg ha^{-1} due to the application of 120 kg N ha^{-1} (N_3). Nitrogen can increase oil content in seed via increasing vegetative growth and higher production of carbohydrate in plant and transferring to seeds (Hasanzade, 2002). The results are in agreement with those of reported by Jahangir *et al.*, 2009 who observed that there was an increased trend of oil percentage in soybean by nitrogen fertilizer application.

Increasing levels of sulphur application did not influenced the oil content of soybean. But the oil content was progressively increased with increasing levels of sulphur application. Application of sulphur from 0 to 40 kg ha^{-1} tends to increase the mean oil yield of soybean from 290 to 346 kg ha^{-1}. The increase in oil content with addition of sulphur might be associated with direct involvement of sulphur in the synthesis of lipids, in fatty acid synthesis acetyl-CoA enzyme activity (Ahmad *et al.*, 2000). In this conversion an enzyme thiokinase is involved in sulphur supply, moreover, acetyl Co- enzyme itself contain sulphur and sulpho-hydryl groups. These results are in accordance with Venugopal *et al.*, (2017), Hariram *et al.*, (2014), Choudhary *et al.*, (2014). Interaction effect of nitrogen and sulphur found to absent in oil content and oil yield of soybean.

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