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Response of Nitrogen and Sulfur on the Oil Content of Sesame and Nutrient Status of Soil

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Abstract

A study was conducted to see the influence of different levels of nitrogen and sulphur on oil content of sesame and nutrient status of soil during 2009 at the field of Sher-e-Bangla Agricultural University farm, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The experiment consisted of two factors. 4 levels of nitrogen N_0: 0 kg N/ha (control); N_1: 40 kg N ha^{-1}; N_2: 60 kg N ha^{-1} and N_3: 100 kg N ha^{-1}; and 4 levels of sulfur S_0: 0 kg S ha^{-1} (control); S_1: 20 kg S ha^{-1}; S_2: 40 kg S ha^{-1} and S_3: 60 kg S ha^{-1}. Oil content increased significantly with increasing N level upto 60 kg N ha^{-1} (N_2) whereas the concentration of N, P, K and S in plant increased upto 100 kg N ha^{-1}. On the other hand, oil content increased significantly with increasing S level upto 40 kg S ha^{-1} (S_2) whereas N, P, K and S concentration in plant increased upto 60 kg S ha^{-1}. The maximum oil content of sesame (46.98%) was recorded from the combined application of 60 kg N ha^{-1} and 60 kg S ha^{-1}.

1. Introduction

Sesame is an important edible oilseed crop. The seed contains all essential amino acids and fatty acids (Malik et al., 2003). Sesame (*Sesamum indicum L.*) is one of the important oil crops and widely grown in different parts of the world. In Bangladesh it is locally known as til and is the second important edible oil crop (Mondal et al., 1997). Sesame contains 42-45% oil, 20% protein and 14-20% carbohydrate (BARI, 2004). Among the oil crops, sesame (*Sesamum indicum* L.) has the highest oil content of 46-64% (Raja et al., 2007). Deficiency of soil nutrient is now considered as one of the major constraints to successful upland crop production in Bangladesh (Islam and Noor, 1982). Nitrogen plays a vital role as a constituent of protein, nucleic acid and chlorophyll. An adequate supply of nitrogen is essential for vegetative growth and desirable yield (Yoshizawa et al., 1981). On the other hand excessive application of nitrogen is not only uneconomical, but it can prolong the growing period and delay crop maturity. Excessive nitrogen application causes physiological disorder (Obreza and Vavrina, 1993). In oilseeds, sulphur plays a significant role in the quality and development of seeds. Therefore, crops of oilseeds require a higher quantity of sulphur for proper growth and development for higher yields (Salwa et al., 2010). It is reported that sulphur plays an important role in the primary and secondary plant metabolism as a component of proteins, glucosinolates and other compounds that related to several parameters determining the nutritive quality of crops (Ceccotti 1996, Jamal et al., 2010). The response of oilseeds to sulphur is increasing due to increasing of cropping intensity (Ghosh et al., 2002). It is required for the synthesis of proteins, vitamins and chlorophyl and also S containing amino acids such as cystine, cysteine and methionine which are essential components of proteins (Tisdale et al., 1999). However, nitrogen and sulphur metabolism are linked to each other. S-application significantly increased the uptake of N in straw and grain (Badruddin 1999, Fazli et al., 2008) thereby increased grain yield. Further, S-deficiency cause decrease in nitrate reductase activity and in the accumulation of chlorophyll, soluble protein, amino acid and sugar (Tandon 1986, Badruddin 1999; Jamal et al., 2006; Jamal et al., 2009; Shilpi et al., 2012). Thus the synergistic relationship of N and S in plant metabolism and the maximum yield response to these elements is achieved when the supply of them are balanced in oilseed crops (Jaggi et al., 1977, Badruddin 1999, Fazli et al., 2010). Optimum nutrition, among other agro-techniques is very important for realizing full yield potential and the role of sulfur is next only to nitrogen in the nutrition of this crop. Little effort is made to reclaim optimum S requirement for the growth and yield of sesame using tracer techniques. Lack of S causes retardation of terminal growth and root development. S deficiency induces chlorosis in young leaves and decrease seed yield by 45% (BARI, 2004). The objective of this experiment was to study the effect of Nitrogen and Sulphur on the oil content of sesame and nutrient status of soil.

2. Materials and Methods

Study to determine the nitrogen and sulfur use efficiency of sesame (*Sesamum indicum* L.) on oil content and nutrient status of soil was carried out at the field of Sher-e-Bangla Agricultural University farm, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from February to May, 2009. The characteristics of initial surface soil (0-15) were: pH 6.47, textural class silty clay loam, organic carbon 0.98%, total N 780 ppm, Phosphorous 20.14 ppm and Sulfur 10.87 ppm. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The size of the plot was 2.5×2.0 m. The experiment consisted of 2 factors viz. 4 levels of Nitrogen N_0: 0 kg N ha^{-1} (control); N_1: 40 kg N ha^{-1}; N_2: 60 kg N ha^{-1}and N_3: 100 kg N ha^{-1}; and 4 levels of sulfur S_0: 0 kg S ha^{-1} (control); S_1: 20 kg S ha^{-1}; S_2: 40 kg S ha^{-1} and S_3: 60 kg S ha^{-1}. BARI Til-3 variety of sesame was used as a test crop in this experiment. Recommended doses of P, K, Zn and B (150 kg N ha^{-1} from TSP, 50 kg K ha^{-1} from MP, 5 kg Zn ha^{-1} from ZnO and 1 kg B ha^{-1} from Boric acid, respectively) were applied. Sesame seeds were sown on the 17th February 2009. Intercultural operations were applied when necessary. The crop was hervested on May, 2009. The harvested crop of each individual plots were recorded plot wise the yields were expressed in t ha^{-1}. Plant samples were collected from every individual plot for Nitrogen, Phosphorus, potassium and Sulphur analysis. Ten plants were randomly collected from each plot to record oil content. The oil content of sesame seed was determined by Folch method (Folch, et al., 1957). The plant samples were dried in an oven at 700C for 72 hours and then ground by a grinding machine to pass through a 20-mesh sieve and analyzed for determination of N, P, K and S. The data were analyzed statistically to find out the treatment difference and the mean differences were compared by DMRT (Gomez and Gomez 1984).

3. Results and Discussion

3.1. Oil content of sesame seed

Statistically significant difference in oil content in seed was recorded for nitrogen (ture 1). The maximum oil content in seed (41.32%) was observed from N_2 (60 kg N ha^{-1}) which was statistically identical (40.92%) with N_3 (100 kg N ha^{-1}), while the minimum (39.03%) from N_0 (control). Abdel et al. (2003) recorded highest oil yields (366.39 kg fed^{-1}) were obtained at 80 kg N fed^{-1}. But Fard and Bahrani (2005) earlier reported that seed oil percentage was a stable yield component and was not affected by either N rate. Seed oil contents were increased by N application except at the highest rate (90 kg N ha^{-1}) which slightly reduced oil content compared with the control (Ramakrishnan et al., 1994). Oil content in seed of sesame varied significantly for sulfur (Figure 1). The highest oil content (43.45%) was recorded from S_3 (60 kg S ha^{-1}) which was closely followed (41.78%) by and S_2 (40 kg S ha^{-1}) and the minimum oil content in seed (36.27%) was obtained from S_0 (control).

Significant difference was recorded for the interaction effect

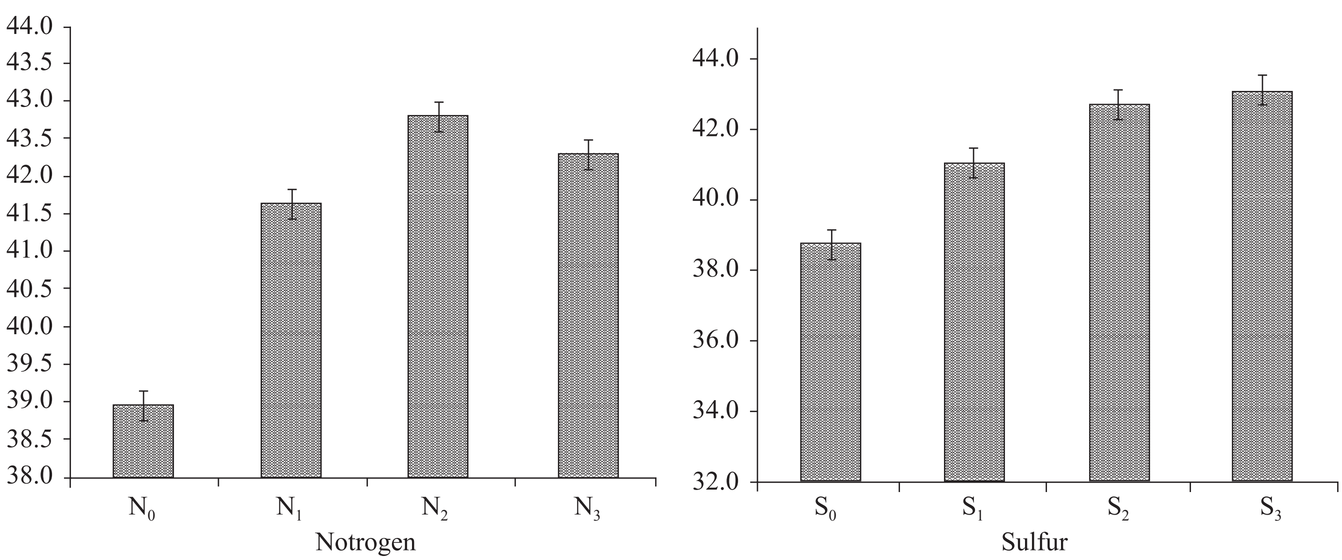

Figure 1: Single effect of nitrogen and sulfur on oil content of sesame.

of nitrogen and sulfur in terms of oil content in seed of sesame (Figure 2). The maximum oil content of sesame (46.80%) was recorded from N_2S_3 (60 kg N ha^{-1}and 60 kg S ha^{-1}), while the minimum oil content (36.07%) was recorded from N_3S_1. Relationship between level of nitrogen and sulfur on oil content of sesame were presented in Figure 3. When the data on % oil content and level of nitrogen were regressed a positive relationship was obtained between these two characters. Here the equation y=0.0345x+39.695 gave a good fit to the data, and the value of the co-efficient of determination (R^2=0.698) showed that the fitted regression line had a significant regression coefficient (Figure 3).

3.2. NPKS uptake by plant

Significant variations were recorded for NPKS uptake in plant of sesame due to different level of nitrogen (Table 3). The highest uptake of N (34.70 kg), P (41.36 kg), K (48.46 kg) and S (27.31 kg) by plant was recorded with N_3 (100 kg N ha^{-1}) and S (7.69 kg) from N_3. On the other hand, the lowest uptake of N (24.54 kg), P (25.39 kg), K (28.09 kg) and S (16.92 kg) by plant were observed from N_0. Different level of sulfur caused significant variation for NPKS uptake by plant of sesame (Table 3). The highest uptake of N (33.99 kg), P (43.44 kg), K (52.95 kg) and S (26.40 kg) by plant was recorded with S_3 (60 kg N ha^{-1}). Again, the lowest uptake of N (27.38 kg), P (30.57 kg), K (28.98 kg) and S (18.39 kg) by plant were observed from S_0.

Interaction effect of nitrogen and sulfur showed significant variations for NPKS uptake by plant of sesame (Table 4). The highest uptake of N (39.77 kg), P (55.93 kg), K (56.05 kg) and S (34.40 kg) by plant was recorded with N_3S_3 (100 kg N and 60 kg N ha^{-1}), while the lowest uptake of N (20.09 kg), P (20.80 kg), K (22.86 kg) and S (11.52 kg) by plant were recorded from N_0S_0.

3.3. Nutrient status of post-harvest soil

Significant variations was recorded for organic matter, total N, available P, exchangeable K and available S in post-harvest soil for the application of different levels of nitrogen (Table 4). The highest organic matter (1.10%), total N (9000 ppm), available P (30.56 ppm), exchangeable K (3500 ppm), available

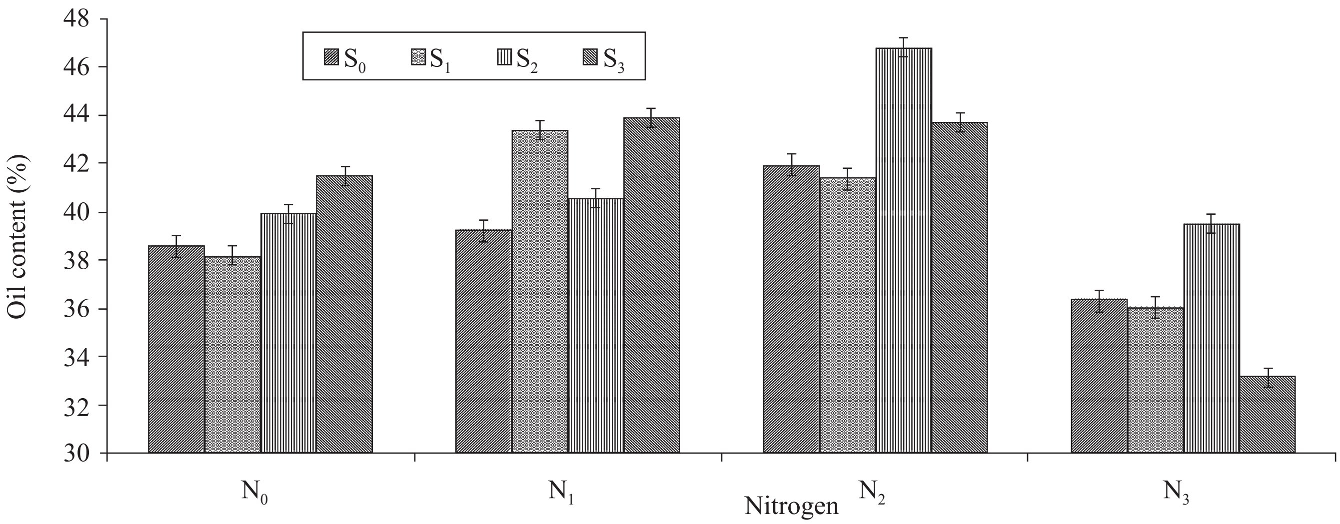

Figure 2: Interaction effect of nitrogen and sulfur on oil content of sesame.

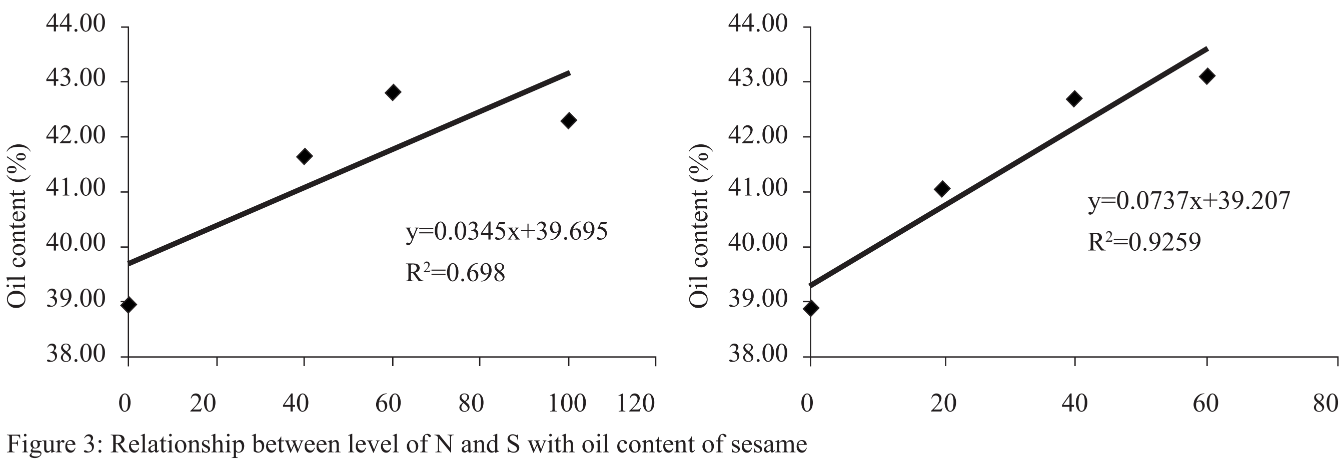

Figure 3: Relationship between level of N and S with oil content of sesame

S (33.49 ppm) were recorded from N_2 (60 kg N ha^{-1}). while the lowest pH (5.68), organic matter (0.98%), total N (710 ppm), available P (27.21 ppm), exchangeable K (1900 ppm), available S (31.53 ppm) were observed from N_0. Significant variations were recorded for pH, organic matter, total N, available P, exchangeable K and available S in post-harvest soil due to the application of different levels of sulfur (Table 12).

Table 1: Main effect of nitrogen and sulfur on NPKS uptake by plant of sesame

Treatment(s)	Uptake by plant (kg ha^{-1})			
	N	P	K	S
Nitrogen				
N_0	24.54^{c}	16.45^{c}	28.09^{c}	16.92^{d}
N_1	28.74^{b}	26.72^{b}	37.89^{b}	20.49^{c}
N_2	34.15^{a}	28.59^{a}	45.63^{a}	22.97^{b}
N_3	34.69^{a}	28.81^{a}	48.46^{a}	27.31^{a}
Level of significance	0.01	0.01	0.01	0.01
Sulfur				
S_0	27.38^{c}	20.88^{c}	28.98^{c}	18.39^{d}
S_1	30.06^{b}	24.79^{b}	38.31^{b}	20.53^{c}
S_2	30.69^{b}	25.17^{b}	39.84^{b}	22.37^{b}
S_3	33.99^{a}	29.72^{a}	52.95^{a}	26.40^{a}
Level of significance	0.01	0.01	0.01	0.01

Table 2: Interaction effect of effect of nitrogen and sulfur on NPKS uptake by plant of sesame

Treatment	Uptake by plant (kg/ha)			
	N	P	K	S
N_0S_0	20.09^{i}	20.80^{h}	22.86^{e}	11.52^{g}
N_0S_1	23.83^{h}	26.57^{g}	28.63^{cde}	16.29^{f}
N_0S_2	25.74^{gh}	27.48^{g}	29.57^{cde}	18.95^{ef}
N_0S_3	28.48^{fg}	26.70^{g}	31.30^{cde}	20.91^{cde}
N_1S_0	25.91^{gh}	30.27^{fg}	28.08^{de}	15.66^{f}
N_1S_1	29.42^{ef}	39.62^{cd}	35.59^{cd}	21.66^{cde}
N_1S_2	28.64^{fg}	39.65^{cd}	35.59^{cd}	20.47^{de}
N_1S_3	31.00^{def}	42.89^{c}	52.31^{b}	24.17^{bc}
N_2S_0	34.14^{bcd}	37.54^{de}	32.84^{cde}	22.75^{bcd}
N_2S_1	33.02^{cd}	39.00^{cd}	38.50^{c}	18.88^{ef}
N_2S_2	32.74^{cde}	37.46^{de}	55.94^{a}	24.11^{bc}
N_2S_3	36.72^{ab}	48.23^{b}	55.25^{a}	26.13^{b}
N_3S_0	29.39^{ef}	33.68^{ef}	32.12^{cde}	23.62^{bcd}
N_3S_1	33.98^{bcd}	36.23^{de}	50.54^{b}	25.28^{b}
N_3S_2	35.64^{bc}	39.60^{cd}	38.28^{cd}	25.96^{b}
N_3S_3	39.77^{a}	55.73^{a}	56.05^{a}	34.40^{a}
Level of significance	0.05	0.01	0.01	0.01

Table 3: Main effect of nitrogen and sulfur on nutrient status of post-harvest soil of sesame

Treat-ment(s)	pH	Or-ganic matter (%)	Total N (ppm)	Avail-able P (ppm)	Ex-change-able K (ppm)	Avail-able S (ppm)
Nitrogen						
N_0	5.68	0.98^{c}	710^{c}	27.21^{c}	1900^{c}	31.53^{b}
N_1	5.80	1.04^{b}	790^{b}	28.61^{b}	2700^{b}	31.91^{b}
N_2	5.81	1.10^{a}	900^{a}	30.56^{a}	3500^{a}	33.49^{a}
N_3	5.69	1.04^{b}	750^{b}	29.38^{ab}	2700^{b}	32.12^{ab}
$LSD_{(0.05)}$	--	0.046	80	1.339	264	1.440
Level of significance	NS	0.01	100	0.01	100	0.01
Sulfur						
S_0	5.58^{b}	1.02	750	27.55^{b}	2500^{b}	26.11^{c}
S_1	5.67^{b}	1.03	800	28.56^{ab}	2700^{ab}	32.83^{b}
S_2	5.70^{b}	1.05	800	29.70^{a}	2600^{b}	34.61^{a}
S_3	6.02^{a}	1.07	820	29.95^{a}	2900^{a}	35.52^{a}
Level of significance	0.01	NS	NS	0.01	0.01	0.01

Table 4: Interaction effect of nitrogen and sulfur on nutrient status of post-harvest soil of sesame

Treat-ment	pH	Or-ganic matter (%)	Total N (ppm)	Avail-able P (ppm)	Ex-change-able K (ppm)	Avail-able S (ppm)
N_0S_0	5.43	0.91	680^{d}	24.19^{e}	1700^{j}	23.38^{h}
N_0S_1	5.63	0.99	900^{ab}	28.26^{bcd}	3800^{ab}	33.33^{cd}
N_0S_2	5.63	0.98	890^{abc}	30.04^{bc}	3500^{abc}	34.97^{bc}
N_0S_3	6.00	1.05	850^{abcd}	26.36^{de}	2900^{def}	25.48^{gh}
N_1S_0	5.97	1.03	750^{bcd}	27.55^{cd}	3300^{bcd}	30.63^{de}
N_1S_1	5.47	1.05	830^{abcd}	31.03^{ab}	2500^{efg}	34.10^{bc}
N_1S_2	5.87	1.03	800^{abcd}	29.71^{bc}	2300^{fghi}	33.96^{bc}
N_1S_3	5.90	1.06	770^{abcd}	26.15^{de}	2600^{efg}	28.96^{ef}
N_2S_0	5.67	1.09	770^{abcd}	28.72^{bcd}	2100^{ghij}	33.46^{cd}
N_2S_1	5.67	1.08	750^{bcd}	29.16^{bcd}	1800^{ij}	34.00^{bc}
N_2S_2	5.63	1.07	790^{abcd}	31.23^{ab}	3000^{cde}	34.42^{bc}
N_2S_3	5.80	1.09	700^{cd}	28.42^{bcd}	1900^{hij}	26.61^{fg}
N_3S_0	6.00	1.04	720^{bcd}	29.75^{bc}	2400^{efgh}	34.89^{bc}
N_3S_1	5.57	1.02	730^{bcd}	31.36^{ab}	2700^{efg}	37.00^{ab}
N_3S_2	5.53	1.03	700^{cd}	27.81^{cd}	2600^{efg}	32.35^{cd}
N_3S_3	6.10	1.14	950^{a}	33.30^{a}	4000^{a}	38.71^{a}
Level of signifi-cance	NS	NS	0.05	0.01	0.01	0.01

The highest pH (6.02), organic matter (1.07%), total N (8200 ppm), available P (29.95 ppm), exchangeable K (2900 ppm) and available S (35.52 ppm) were recorded from S_3 and the lowest pH (5.58), organic matter (1.02%), total N (752 ppm), available P (27.55 ppm), exchangeable K (2500 ppm) and available S (26.11 ppm) from S_0. Significant variations were recorded for total N, available P, exchangeable K and available S in post-harvest soil due to the interaction effect of nitrogen and sulfur (Table 5). The highest total N (950 ppm), available P (33.30 ppm), exchangeable K (4000 ppm) and available S (38.71 ppm) were recorded from N_3S_3 and the lowest pH (5.43), organic matter (0.91%), total N (680 ppm), available P (24.19 ppm), exchangeable K (1700 ppm) and available S (23.38 ppm) were observed from N_0S_0.

4. Conclusion

Different combination of Nitrogen and Sulphur fertilizer exhibited significant variation in respect of oil content of sesame plant and nutrient status. The maximum oil content of sesame (46.80%) was recorded from N_2S_3 (60 kg N ha^{-1} and 60 kg S ha^{-1}). The maximum concentration of N, P, K and S in plant was recorded with N_3S_3 (100 kg N $ha^{-1}$and 60 kg N ha^{-1}). The highest uptake of N, P, K and S by plant was recorded with N_3S_3 (100 kg N ha^{-1} and 60 kg N ha^{-1}). The highest total N, available P, exchangeable K and available S were recorded from N_3S_3 (100 kg N $ha^{-1}$and 60 kg N ha^{-1}).

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