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RESEARCH PAPER

Yield and nutrient uptake in niger (*Guizotia abyssinica*) as influenced by different levels of nitrogen, phosphorus, potassium and sulphur

P. Bora*, P. C. Bora, K. Kurmi **and** S. Kalita
Department of Agronomy, Assam Agricultural University, Jorhat (Assam) India
(Email: borapriyanka91@gmail.com)

Abstract : A field experiment was conducted during the *Rabi* seasons of 2016-17 and 2017-18 at Instructional-Cum-Research (ICR) Farm, Assam Agricultural University, Jorhat to study the effect of different levels of primary major nutrients (nitrogen, phosphorus and potassium) as well as secondary nutrient (sulphur) on the uptake of the same by niger and yield of the crop. The experiment was laid out in Factorial Randomized Block Design and replicated thrice. The treatments consisted of three NPK levels *viz*., F_1 (20-10-10 kg N-P_2O_5-K_2O ha^{-1}), F_2 (25-12.5-12.5 kg N-P_2O_5-K_2O ha^{-1}), F_3 (30-15-15 kg N-P_2O_5-K_2O ha^{-1}) and three sulphur levels *viz*., S_1 (no sulphur), S_2 (10 kg S ha^{-1}), S_3 (20 kg S ha^{-1}). Application of F_3 (30-15-15 kg N-P_2O_5-K_2O ha^{-1}) and S_3 (20 kg sulphur ha^{-1}) significantly increased the nitrogen, phosphorus, potassium and sulphur uptake by seed and stover as well as their total uptake by niger as compared to other treatments during both the years of study. Seed yield and protein content (%) of seed of niger were also increased significantly by application of F_3 (30-15-15 kg N-P_2O_5-K_2O ha^{-1}) and S_3 (20 kg sulphur ha^{-1}) as compared to other treatments during both the years. Interaction effects of NPK (F) and sulphur (S) were found to be significant in respect of seed yield, nitrogen, phosphorus, potassium and sulphur uptake by seed as well as total nitrogen uptake by niger during both the years and phosphorus uptake by niger was found to be significant only in the first year of study.

Key Words : Niger, Nitrogen, Phosphorus, Potassium, Sulphur

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INTRODUCTION

Niger (*Guizotia abyssinica*) is an important minor edible oilseed crop of tropical and sub-tropical ecosystems like India and Ethiopia. India is the chief producer of niger and ranks second and fourth in the world for its acerage and annual production, respectively (Dalei *et al*., 2014). In India, niger is grown in an area of 4.2 lakh ha with a production of 1.12 lakh tonnes (Surve *et al*., 2013). The productivity of niger in India is 320 kg/ha (Jagtap *et al*., 2015). The crop is known for its adaptability to *Rainfed* conditions, on poor soil such as marginal and sub-marginal lands in tribal belts, hill tops and slopes. The seeds contain a considerable quantity of edible oil (38 to 43%), protein (20%), sugar (12%) and minerals essential for human and animal meals. The oil

* **Author for correspondence :**

is used for culinary purposes, in paints, soft-soap, lighting, lubrication and cosmetics. Its cake obtained after extraction of oil is valuable cattle feed, particularly for milch cattle and the low grade oil-cakes are also used as concentrated organic manures in the agricultural lands.

Niger can be grown successfully under varying agro-ecosystems even on poor soils. It has tolerance to streams of weather fluctuations with less susceptibility to damage caused by animals, birds, insects and diseases etc. Requirement of low levels of management in crop production, cultivation in poor lands, resistance to drought are the important features favouring niger crop for its cultivation by the farming community. It gives sustained seed yield even under harsh situations (Sharma, 1993). In Assam, area occupied by this oilseed crop is 5.29 thousand hectares and productivity is 619 kg ha^{-1} which is more than the national average productivity (Anonymus, 2019). Niger is grown under *Rainfed* condition hence, its performance depends upon amount and distribution of rainfall in the state. Proper fertility management may be another factor for further improvement in productivity of the crop in Assam. Nitrogen, phosphorus and potassium are major nutrients required for crop growth and yield. Moreover, the fourth major nutrient sulphur helps in increasing seed yield as well as oil content. Keeping all the above points in view, the present experiment has been conducted with the objective to study the yield and nutrient uptake in niger (*Guizotia abyssinica*) as influenced by different levels of nitrogen, phosphorus, potassium and sulphur.

MATERIAL AND METHODS

A field experiment was carried out at the Instructional-Cum-Research (ICR) Farm, Assam Agricultural University, Jorhat-13 during *Rabi* season of 2016-17 and 2017-18. The farm is situated at 26º45'N latitude, 94º12'E longitude and at an altitude of 87.0 meter from the mean sea level. The climatic condition of Jorhat is sub-tropical humid with hot summer and cold winter. During the crop season of 2016-17 and 2017-18 a total rainfall of 99.5 mm and 41.8 mm, respectively was received. The experiment was laid out in Factorial Randomized Block Design with three replications. The treatments consisted of three NPK levels *viz*., F_1 (20-10-10 kg N-P_2O_5-K_2O ha^{-1}), F_2 (25-12.5-12.5 kg N-P_2O_5-K_2O ha^{-1}), F_3 (30-15-15 kg N-P_2O_5-K_2O ha^{-1}) and three S levels *viz*., S_1 (no sulphur), S_2 (10 kg S ha^{-1}), S_3 (20 kg S ha^{-1}). The soils of the experimental site were sandy loam in texture, acidic in reaction, medium in organic carbon (0.68% and 0.70%, respectively), medium in available N (285.10 kg ha^{-1} and 274.42 kg ha^{-1}, respectively), available P_2O_5 (24.45 kg ha^{-1} and 25.40 kg ha^{-1}, respectively), available K_2O (158.32 kg ha^{-1} and 150.58 kg ha^{-1}, respectively) and low in available S (17.94 kg ha^{-1} and 16.40 kg ha^{-1}, respectively) for the year, 2016-17 and 2017-18.

The crop variety used in the experiment was 'NG-1'. The sowing was done in the furrows of 3-5 cm depth opened at 25 cm apart. The fertilizers were incorporated into the soil one day before sowing of the crop by light hoeing. The seeds were sown on 4th November and harvested on 25th February in both the years. In order to represent the plot, five plants of niger from each plot were selected randomly for various observations. Seed and stover yields were worked out based on yield per plot. Available nitrogen was estimated by alkaline potassium permanganate method (Subbiah and Asija, 1956), available phosphorus was estimated by Bray's I method (Jackson, 1973), available potassium was estimated by neutral normal ammonium acetate extractable K using flame photometer (Jackson, 1973) and available sulphur was estimated by turbidimetric method (Tabatabi and Bremner, 1970).

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads and Tables 1 to 5.

Yield :

Data regarding seed and stover yield (q ha^{-1}) of niger are presented in Table 4.

Among different levels of NPK the highest seed yield of 5.81q ha^{-1} in 2016-17 and 5.38 q ha^{-1} in 2017-18 and stover yield of 5.69 q ha^{-1} in 2016-17 and 5.37 q ha^{-1} in 2017-18 were recorded under F_3 (30-15-15 kg N-P_2O_5-K_2O ha^{-1}) which were significantly higher than those of F_2 and F_1 in both the years. The increase in seed yield may be attributed to the optimum availability of nutrients which favoured the growth and development of crops and helped in increased uptake of nutrients. Further, increase in levels of NPK increased leaf area might have resulted in higher photosynthesis which leads to dry matter accumulation and its translocation to reproductive parts as indicated by higher values of growth and yield components that resulted in increasing seed

Table 1 : Effect of levels of NPK (F) and sulphur (S) on nutrient content (%) in seed and stover of niger

Treatments	N content (%)				P content (%)				K content (%)				S content (%)			
	Seed		Stover		Seed		Stover		Seed		Stover		Seed		Stover	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Levels of NPK (F)																
F_1 = (20-10-10 kg N-P_2O_5-K_2O ha^{-1})	2.52	2.50	0.85	0.83	0.740	0.697	0.240	0.238	0.446	0.461	0.728	0.723	0.476	0.431	0.331	0.325
F_2 = (25-12.5-12.5 kg N-P_2O_5-K_2O ha^{-1})	2.60	2.56	0.89	0.87	0.764	0.719	0.260	0.252	0.461	0.479	0.753	0.748	0.489	0.442	0.340	0.334
F_3 = (30-15-15 kg N-P_2O_5-K_2O ha^{-1})	2.70	2.66	0.93	0.91	0.788	0.754	0.270	0.261	0.476	0.498	0.778	0.779	0.496	0.450	0.349	0.342
S.E.±	0.022	0.019	0.009	0.008	0.007	0.006	0.003	0.003	0.004	0.004	0.008	0.007	0.005	0.004	0.004	0.003
C.D. (P=0.05)	0.066	0.059	0.029	0.026	0.023	0.020	0.009	0.008	0.012	0.012	0.024	0.021	0.015	0.013	0.012	0.010
Levels of S (S)																
S_1 = (0 kg S ha^{-1})	2.53	2.49	0.85	0.83	0.739	0.702	0.230	0.234	0.443	0.459	0.731	0.724	0.463	0.417	0.318	0.312
S_2 = (10 kg S ha^{-1})	2.61	2.58	0.89	0.86	0.763	0.725	0.250	0.254	0.461	0.478	0.752	0.750	0.485	0.444	0.340	0.333
S_3 = (20 kg S ha^{-1})	2.68	2.64	0.92	0.89	0.787	0.740	0.260	0.264	0.479	0.500	0.780	0.775	0.511	0.461	0.361	0.354
S.E.±	0.022	0.019	0.009	0.008	0.007	0.006	0.003	0.003	0.004	0.004	0.008	0.007	0.005	0.004	0.004	0.003
C.D. (P= 0.05)	0.066	0.059	0.029	0.026	0.023	0.020	0.009	0.008	0.012	0.012	0.024	0.021	0.015	0.013	0.012	0.010
Interaction (F x S)																
S.E.±	0.038	0.034	0.017	0.015	0.013	0.011	0.005	0.004	0.008	0.008	0.015	0.013	0.009	0.007	0.006	0.006
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS= Non-significant

Table 2: Effect of levels of NPK (F) and sulphur (S) on nutrient uptake (kg ha^{-1}) by niger seed and stover

Treatments	N uptake (kg ha^{-1})				P uptake (kg ha^{-1})				K uptake (kg ha^{-1})				S uptake (kg ha^{-1})			
	Seed		Stover		Seed		Stover		Seed		Stover		Seed		Stover	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Levels of NPK (F)																
F_1 = (20-10-10 kg N-P_2O_5-K_2O ha^{-1})	9.87	9.16	11.19	10.30	2.95	2.54	3.16	2.90	1.79	1.71	9.39	9.11	1.90	1.59	4.40	4.14
F_2 = (25-12.5-12.5 kg N-P_2O_5-K_2O ha^{-1})	11.43	10.76	12.26	11.68	3.40	3.06	3.54	3.32	2.06	2.05	10.20	10.03	2.19	1.88	4.75	4.50
F_3 = (30-15-15 kg N-P_2O_5-K_2O ha^{-1})	14.17	12.96	13.64	13.05	4.17	3.70	3.92	3.71	2.55	2.47	11.14	11.08	2.66	2.21	5.11	4.93
S.E.±	0.37	0.33	0.25	0.24	0.09	0.09	0.08	0.07	0.06	0.06	0.23	0.22	0.06	0.04	0.11	0.10
C.D. (P=0.05)	1.11	1.01	0.75	0.74	0.27	0.27	0.25	0.21	0.18	0.18	0.69	0.68	0.18	0.14	0.34	0.32
Levels of S (S)																
S_1 = (0 kg S ha^{-1})	9.79	9.01	11.11	10.57	2.90	2.53	3.10	2.92	1.74	1.69	9.35	9.19	1.82	1.51	4.25	4.01
S_2 = (10 kg S ha^{-1})	11.89	10.98	12.33	11.72	3.52	3.11	3.55	3.36	2.16	2.05	10.16	10.09	2.24	1.90	4.68	4.52
S_3 = (20 kg S ha^{-1})	13.78	12.87	13.62	12.73	4.09	3.66	3.95	3.65	2.49	2.48	11.23	10.92	2.68	2.26	5.32	5.05
S.E.±	0.37	0.33	0.25	0.24	0.09	0.09	0.08	0.07	0.06	0.06	0.23	0.22	0.06	0.04	0.11	0.10
C.D. (P=0.05)	1.11	1.01	0.75	0.74	0.27	0.27	0.25	0.21	0.18	0.18	0.69	0.68	0.18	0.14	0.34	0.32
Interaction (F x S)																
S.E.±	0.64	0.58	0.43	0.42	0.16	0.15	0.15	0.12	0.10	0.10	0.40	0.39	0.10	0.08	0.20	0.18
C.D. (P=0.05)	S	S	NS	NS	S	NS	NS	NS	S	S	NS	NS	S	S	NS	NS

NS= Non-significant

Table 3: Effect of levels of NPK (F) and sulphur (S) on total nutrient uptake (kg ha^{-1}) by niger seed and stover

Treatments	Total N uptake (kg ha^{-1})		Total P uptake (kg ha^{-1})		Total K uptake (kg ha^{-1})		Total S uptake (kg ha^{-1})	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Levels of NPK (F)								
F_1 = (20-10-10 kg N-P_2O_5-K_2O ha^{-1})	21.05	19.39	6.12	5.50	11.19	10.82	6.33	5.73
F_2 = (25-12.5-12.5 kg N-P_2O_5-K_2O ha^{-1})	23.69	22.44	6.95	6.39	12.20	12.07	6.90	6.27
F_3 = (30-15-15 kg N-P_2O_5-K_2O ha^{-1})	27.81	26.01	7.95	7.42	13.67	13.56	7.75	7.15
S.E.±	0.50	0.45	0.14	0.11	0.24	0.24	0.16	0.13
C.D. (P=0.05)	1.50	1.36	0.42	0.35	0.74	0.73	0.49	0.39
Levels of S (S)								
S_1 = (0 kg S ha^{-1})	20.90	19.59	5.96	5.51	11.11	10.89	6.07	5.53
S_2 = (10 kg S ha^{-1})	24.22	22.64	7.09	6.47	12.26	12.15	6.93	6.31
S_3 = (20 kg S ha^{-1})	27.41	25.60	7.95	7.31	13.72	13.42	7.98	7.31
S.E.±	0.50	0.45	0.14	0.11	0.24	0.24	0.16	0.13
C.D. (P=0.05)	1.50	1.36	0.42	0.35	0.74	0.73	0.49	0.39
Interaction (F x S)								
S.E.±	0.87	0.79	0.24	0.22	0.43	0.42	0.28	0.22
C.D. (P=0.05)	S	S	S	S	NS	NS	NS	NS

NS= Non-significant

Table 4 : Effect of levels of NPK (F) and sulphur (S) on seed and stover yield, protein content of niger seed and available nutrient in soil after harvest of niger

Treatments	Available N (kg ha^{-1})		Available P_2O_5 (kg ha^{-1})		Available K_2O (kg ha^{-1})		Available SO_4 (kg ha^{-1})		Seed yield (q ha^{-1})		Stover yield (q ha^{-1})		Protein content (%)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Levels of NPK (F)														
F_1 = (20-10-10 kg N-P_2O_5-K_2O ha^{-1})	268.13	271.00	26.88	27.83	146.31	148.61	15.92	17.43	4.38	4.07	27.83	26.78	15.73	15.61
F_2 = (25-12.5-12.5 kg N-P_2O_5-K_2O ha^{-1})	269.28	270.22	28.02	29.15	147.04	150.50	16.01	17.91	4.89	4.64	29.38	28.49	16.26	16.02
F_3 = (30-15-15 kg N-P_2O_5-K_2O ha^{-1})	270.67	271.33	28.56	29.30	147.32	51.42	16.02	18.68	5.81	5.38	31.17	30.70	16.90	16.65
S.E. ±	3.79	3.99	0.54	0.61	2.01	2.40	0.30	0.37	0.13	0.12	0.50	0.47	0.13	0.12
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	0.41	0.37	1.50	1.43	0.41	0.37
Levels of S (S)														
S_1 = (0 kg S ha^{-1})	271.81	272.78	28.25	29.57	147.91	150.94	15.53	17.36	4.32	4.01	27.76	26.97	15.83	15.58
S_2 = (10 kg S ha^{-1})	269.11	272.11	27.86	28.70	146.78	150.27	15.92	18.06	5.06	4.70	29.33	28.60	16.31	16.15
S_3 = (20 kg S ha^{-1})	267.15	267.67	27.33	28.01	145.98	149.98	16.51	18.60	5.69	5.37	31.28	30.38	16.73	16.54
S.E.±	3.79	3.99	0.54	0.61	2.01	2.40	0.30	0.37	0.13	0.12	0.50	0.47	0.13	0.12
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	0.41	0.37	1.50	1.43	0.41	0.37
Interaction (F x S)														
S.E.±	6.57	0.75	0.94	1.06	3.49	4.16	0.52	0.65	0.24	0.22	0.87	0.82	0.24	0.21
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	S	S	NS	NS	NS	NS

NS= Non-significant

yield of niger. The increase in stover yield might be due to better vegetative growth of crop in terms of more branching and taller plants as influenced by increased nutrients uptaker. Baishya and Thakur (1997) also reported that application of 30-15-15 kg N-P_2O_5-K_2O ha^{-1} recorded maximum and significantly increased seed yield of niger and was economically viable under *Rainfed* condition of north bank plains agro-climatic zone of Assam.

The seed and stover yield increased significantly with the increase in levels of sulphur in both the years. The highest seed yield of 5.69 q ha^{-1} in 2016-17 and 5.37 q ha^{-1} in 2017-18 and stover yield of 31.28 q ha^{-1} in 2016-17 and 30.38 q ha^{-1} in 2017-18 were recorded under S_3 (20 kg S ha^{-1}) which were significantly higher than the values of S_2 and S_1 in both the years. It might be due to the balanced nutritional environment, efficient and greater partitioning of metabolites and adequate translocation of nutrients towards reproductive site. Thirdly, more accumulation of amino acids, amide substances and their translocation to the reproductive organs influenced growth and yield of crop. The increase in stover yield might be due to the increase in vegetative growth which resulted in increased photosynthesis and assimilation rates, cell division, cell elongation and activation of enzymes. Debanath and Basu (2013) also found that the application of 20 kg S ha^{-1} proved to be optimum dose for yield maximization of safflower in Nadia (West Bengal).

Protein content (%):

Data on protein content (%) of niger seed are presented in Table 4.

Among different levels of NPK the highest protein content in niger seed was recorded by F_3 (30-15-15 kg N-P_2O_5-K_2O ha^{-1}). The increase in protein content with increased levels of NPK might be due to availability of nitrogen which is essential for plants to synthesize amino acids, as a building block for protein synthesis. Similar results were reported by Surve *et al*. (2013).

Among the levels of sulphur the highest protein content in niger seed was recorded by S_3 (20 kg S ha^{-1}). The increase in protein content with increase in levels of sulphur might be because of sulphur, which is a constituent of essential amino acids like methionine, cystine and cystine which helps in conversion of these amino acids in to protein (Chopra and Kanwar, 1996). Secondly, for amino acid formation appropriate structure is needed and sulphur provides di-sulphide (S-S) bonds for cross linkage of two polypeptide chains and thus help in the formation of protein (Allaway and Thompson, 1966). These findings are in conformity with the findings of Babu (2014) in safflower.

Nutrient content (%) and their uptake by plants (kg ha^{-1}) :

Data regarding nutrient content (%) in seed and stover, their uptake by plants (kg ha^{-1}) and interaction effects on nutrient uptake by niger are presented in Table 1, 2, 3 and 5.

The nutrient content as well as their uptake by seed and stover increased significantly with increase in levels of NPK. The highest nutrient content as well as their

Table 5: Interaction effects of levels of NPK (F) sulphur (S) on nutrient uptake by seed (kg ha^{-1}) and their total uptake by niger (kg ha^{-1})

Levels of S (S)	Levels of NPK (F)																													
	N-uptake by seed (kg ha^{-1})						Total N-uptake by niger (kg ha^{-1})						P-uptake by seed (kg ha^{-1})						Total P-uptake by niger (kg ha^{-1})			K-uptake by seed (kg ha^{-1})						S-uptake by seed (kg ha^{-1})					
	2016-17			2017-18			2016-17			2017-18			2016-17			2016-17			2017-18			2016-17			2017-18			2016-17			2017-18		
Treatments	F_1	F_2	F_3	F_1	F_1	F_1	F_2	F_3	F_1	F_2	F_3	F_3	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
S_1	8.94	9.65	10.78	8.33	1.57	1.68	1.84	1.96	1.37	1.53	1.65	1.9	2.68	2.89	3.16	5.54	5.97	6.93	5.05	5.40	6.09	1.57	1.75	1.92	1.52	1.66	1.9	1.68	1.84	1.96	1.37	1.53	1.65
S_2	9.85	11.23	14.60	8.98	1.82	1.91	2.12	2.71	1.59	1.88	2.24	2.45	2.94	3.33	4.29	6.12	6.86	8.26	5.46	6.44	7.53	1.82	2.01	2.65	1.65	2.05	2.45	1.91	2.12	2.71	1.59	1.88	2.24
S_3	10.81	13.41	17.13	10.16	1.99	2.12	2.60	2.66	1.80	2.24	2.75	3.07	3.24	4.00	5.05	6.70	8.01	9.16	6.00	7.32	8.64	1.99	2.41	3.08	1.97	2.43	3.07	2.12	2.60	2.66	1.80	2.24	2.75
S.E. ±		0.64			0.58			0.87			0.79			0.10			0.10			0.08			0.10			0.10			0.10			0.08	
C.D. (P=0.05)		1.92			1.74			2.61			2.37			0.30			0.30			0.24			0.30			0.30			0.30			0.24	

uptake by crop were recorded by F_3 (30-15-15 kg N-P_2O_5-K_2O ha^{-1}) in both the years. Total N uptake increased by 17.39 and 32.11 per cent (2016-17) and 17.39 and 34.14 per cent (2017-18) under F_3 over F_2 and F_1, respectively. Total P uptake increased by 14.38 and 30.00 per cent (2016-17) and 16.11 and 34.90 per cent (2017-18) under F_3 over F_2 and F_1, respectively. Total K uptake increased by 12.04 and 22.16 per cent (2016-17), 12.34 and 25.32 per cent (2017-18) under F_3 over F_2 and F_1, respectively. Total S uptake increased by 12.31 and 22.43 per cent (2016-17), 14.00 and 24.78 per cent (2017-18) under F_3, over F_2 and F_1, respectively. Increase in nutrient uptake might be due to increase in total biomass yield and higher nutrient concentration in seed and stover. Secondly, nitrogen plays an important role in development of extensive root system which increases absorption and utilization of other nutrients as well (Garnayak *et al*., 2000). Again, phosphorus promotes early root proliferation favouring the development of lateral and fibrous roots which in turn increases uptake of other nutrients. Moreover, potassium improves higher biomass production and thereby increased the uptake of other nutrients.

The nutrient content as well as their uptake by seed and stover increased significantly with increase in levels of sulphur. The highest content as well as uptake of these nutrients were recorded by S_3 (20 kg S ha^{-1}). Total N uptake increased by 13.17 and 31.14 per cent (2016-17), 10.68 and 30.67 per cent (2017-18), under S_3 over S_2 and S_1, respectively. Total P uptake increased by 12.12 and 33.38 per cent (2016-17), 12.98 and 32.66 (2017-18) per cent under S_3 over S_2 and S_1, respectively. Total K uptake increased by 12.00 and 23.50 per cent (2016-17), 10.45 and 23.23 per cent (2017-18) under S_3 over S_2 and S_1, respectively. Total S uptake increased by 15.15 and 31.46 per cent (2016-17), 15.84 and 32.18 per cent (2017-18) under S_3 over S_2 and S_1, respectively. Increase in nitrogen uptake might be due to higher level of sulphur application which resulted in profuse vegetative and root growth and thus, increased the absorption of nitrogen from the soil (Patel *et al*., 1992). The increase in phosphorus uptake might be due to synergistic effect of sulphur on phosphorus and also sulphur accelerates metabolic activities of plants resulting in increased nutrient absorbing power of root system (Agarwal and Verma, 1998). Increase in potassium uptake might be due to the role of sulphur in improving the vegetative growth of the crop which increases uptake of potassium (Sharma and Gupta, 1992). Higher sulphur uptake with higher dose of sulphur might be due to its effect on profuse vegetative and root growth and that increased the absorption of sulphur from soil (Patel *et al*., 1992).

Available N, P_2O_5, K_2O and SO_4 in soil after harvest:

Available N, P_2O_5, K_2O and SO_4 in soil after harvest of niger were not significantly affected by various levels of NPK and S (Table 4).

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