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Effect of Balanced Nutrient Management on Niger (*Guizotia abyssinica*) in Red and Lateritic Soils of West Bengal

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A field experiment was conducted on rice during *rabi* season of 2015 to study the effect of balanced nutrient management in nutrient availability, yield, uptake, protein and oil content in niger. The experiment was conducted using five levels of potassium viz., 0, 20, 40, 60 and 80 kg ha^{-1}, four levels of sulphur viz., 0, 15, 30 and 45 kg ha^{-1}, four levels of zinc viz., 0, 2, 4 and 6 kg ha^{-1}, four levels of Boron viz., 0, 0.5, 1.0 and 1.5 kg ha^{-1} and nitrogen in a single dose @ 40 kg ha^{-1} using niger as the test crop. Stover and seed yield was increased with increasing application of sulphur. The highest seed yield (4.69 q ha^{-1}) was recorded with application of highest doses of sulphur. Oil content of niger varied from 31.7% to 38.8%. Sulphur application also increased oil content. Protein content ranged between 15.05 to 21.12%. Both micronutrients and sulphur application resulted in increase in protein content in niger seeds.

Introduction

Niger is a minor oilseed crop important under rainfed conditions, coarse textured, poor soils especially on hill slopes. Niger seeds contain a considerable quantity of edible oil (38 to 43%), protein (20%), sugar (12%), and minerals for human consumption and animal meals (Gentient and Teklewold, 1995). Cakes obtained after extraction of its oil are used as a nutritious cattle feed and the low grade oil-cake is also used as concentrated organic manure in the agricultural lands. India is the chief producer of niger seeds in the world by contributing second and fourth position in the acreage and annual production of the world, respectively. In the country, it is extensively grown in Madhya Pradesh, Chhattisgarh, Orissa, Maharashtra states and to a lesser extent in Karnataka, Bihar, Jharkhand and Andhra Pradesh.

Niger cultivation is confined in Chhindwara, Dindori, Mandla, Seoni, Jabalpur and Shahdol districts of the state mainly on marginal and eroded lands of forest areas. Niger can be grown successfully under varying agro-ecosystems even on poor soils with low agro inputs and wide range of sowing time from july to August months under rainfed conditions as well as during winter season with irrigation facilities. It has tolerance to streams of weather fluctuations with less susceptibility to damages caused by animals, birds, insects and diseases *etc*. (Sharma and Kewat, 1998). These features lure the farmers for its cultivation in different parts of the country. In spite of these peculiarities, the cultivation of this crop is still confined on marginal and sub-marginal lands with the use of negligible agro-inputs, which results in productivity. It is widely grown during *kharif* (rainy) season, but it performs well during winter season also due to its photo incentive nature. Its productivity is better with superior quality seeds during winter season than *kharif* season in Madhya Pradesh (Agrawal *et al.*, 1996).

The judicious combination of two or more nutrients depending on the site-specific nutrient status of soil and demand of crop varieties may have considerable role on growth and yields of crops. According to Patil and Balal (1964) individual nutrients (N:P:K) application did not give any increase in the yield of seed and straw of niger at Poona (Maharashtra), but combined application of N and P was found to be very effective in increasing the yields. This beneficial effect was still greater by balanced fertilization through N, P and K. The combined application of N and P was beneficial in increasing the oil output also. Application of secondary nutrients particularly S have been reported advantageous for niger. Mamatha *et al.*,(1994) underlined that the oil content in niger seeds decreased with increased nitrogen application, while it increased with phosphorus and sulphur application. Apart from major nutrients zinc and boron are very much responsive in case of niger. Zinc is required in a large number of enzymes and plays an essential role in DNA transcription. Adequate availability of zinc to young and developing plants is certain promise for sufficient growth and development. Zinc plays a greater role during reproductive phase especially during fertilization. Boron (B) is responsible for better pollination, pod setting in niger making it more important during the reproductive stage as compared to the vegetative stage of the crop. Balanced nutrition based on soil test value is the key to sustain niger productivity and to improve soil productivity. A suitable combination of secondary and micronutrients is the most important single factor that affects the productivity of the crops.

This crop has potential to produce yields upto 600 kg/ha on the research farms with the adoption of improved crop varieties and production technologies. Though it can be grown with the use of negligible quantity of manures and fertilizers, it responds well to considerably higher quantity in balanced manner. Since, the adequate quantity of fertilizer application is unaffordable by the most of the niger growers, hence, balanced nutrient management through various organic and inorganic sources appears to be an alternative for its proper nutrient management.

Materials and Methods

A field experiment was conducted on niger during *rabi* season of 2015 in red and lateritic soils of West Bengal at the Agricultural Farm of Palli Siksha Bhavana (Institute of

Agriculture), Visva-Bharati, Sriniketan. The experimental farm was situated at 23°39´ N latitude and 87°42´ E longitude with an average altitude of 58.9 m above the mean sea level under sub humid semi-arid region of West Bengal. The soil was acidic (pH 4.35), low in organic carbon (0.32%), available nitrogen (160 k g ha^{-1}), available phosphorus (15.92kg ha^{-1}), available potassium (72 kg ha^{-1}), available sulphur (11.23 kg ha^{-1}). The experiment was laid out in randomized block design with 17 treatments. As per the treatments specification, fertilizers were applied in the form of urea, diammonium phosphate (DAP), murate of potash (MOP) for the source of nitrogen, phosphorus and potassium respectively. Magnesium sulphate (26.63% S) was used for the source of sulphur. In the cases of micronutrients Boric acid (17% B), zinc sulphate heptahydrate (21% Zn) are used for the source of boron and zinc respectively. The available nutrient status of soil, total uptake of nutrients, grain yield, stover yield, protein and oil content was calculated. The soil samples were analyzed following standard procedures. The crop was harvested at full mature stage. Nitrogen in grain and straw were determined by modified micro-Kjeldhal method (Jackson, 1973). Available sulphur in the soil was extracted using 0.15% $CaCl_2$ solution. The total sulphur in the soil was extracted by perchloric acid ($HClO_4$) digestion. The sulfur content in the digest of plant and soil extract was determined using turbidimetric method. The amount of seed nitrogen content was estimated as per Jackson and expressed the concentration in percentage. Crude protein was determined by multiplying percentage of nitrogen content in grain of rice with a factor of 6.25. The nutrient uptake was calculated by multiplying the concentration values with respective grain and straw yield data. Statistical analysis was done by using multiple comparison test (Gomez and Gomez, 1984).

Results and Discussion

Effect of Nutrient Management on available nutrient status in soil

Available nitrogen content in soils after harvesting of niger ranged between 259.24 to 167.25 kg ha^{-1} (Table 1). The minimum value was recorded where no fertilizer was applied (control) and the maximum was recorded in plots receiving nitrogen @ 40 kg ha^{-1}, sulphur @ 30 kg ha^{-1} along with Phosphorus @ 40 kg ha^{-1} and potassium @ 20 kg ha^{-1}. There is no treatment effect was found to be significant in altering available nitrogen content in soil.

Data on the available phosphorus content in soils after harvesting are presented in table 1. The values varied from 49.97 kg ha^{-1} to 11.75 kg ha^{-1}. Maximum value recorded in plots receiving 40 kg ha^{-1} phosphorus, 20 kg ha^{-1} potassium and 30 kg ha^{-1} sulphur along with 4 kg ha^{-1} zinc and 1 kg ha^{-1} boron and the minimum value was observed in plots receiving no fertilizer (control). As observed in the earlier case, no treatment effect was found to be significant.

Available potassium content in soils (Table 1) ranged from 111.10 to 52.71 kg ha^{-1}. Increasing potassium levels to K @ 80, 60 and 40 kg ha^{-1} respectively resulted in increased potassium availability whereas minimum availability results in without application of fertilizers (control). So the other nutrients had no significant effect in potassium availability.

Data on the available sulphur content in soils after harvesting niger are presented in table 1. The values varied between 32.42 and 16.63 kg ha^{-1}. The minimum value was recorded in plots receiving no fertilizers (control). The maximum value of available sulphur was recorded with application of maximum sulphur @ 45 kg ha^{-1}. It also followed similar trend as that observed in case of available potassium contents.

Data on the available zinc content in soils after harvesting of niger are presented in table 1. The valued varied between 1.11and 3.02 mg kg^{-1}. The minimum value was recorded in plots receiving no fertilizers (control). The maximum value of available zinc was recorded in T_{11} with application of maximum dose of zinc @ 6 kg ha^{-1} along with NPK followed by $T_{10.}$ Treatment effect was found to be significant.

Data on the available boron content in soils after harvesting of niger are also presented in table 1. The valued varied between 0.57 and 1.34 mg kg^{-1}. The minimum value was recorded in plots receiving no fertilizers (control). The maximum value of available boron was recorded in T_{14} with application of maximum dose of boron @ 1.5 kg ha^{-1} along with NPK followed by $T_{16.}$ Treatment effect was found to be significant.

Yield of niger

The data pertaining to yield of stover, seed and biological yield of niger during 2014 are presented in Table 2. Significant response of Niger is due to balanced nutrient management irrespective of different sources of nutrients as evidenced by stover, seed and total biological yield was recorded.

The seed yield of niger ranged from 2.74 q ha^{-1} to 4.69 q ha^{-1}. Seed yield of Niger was found to increase with increasing levels of sulphur application. The maximum seed yield was observed in plots receiving the highest dose of sulphur application @45 kg ha^{-1}. The response of sulphur was more pronounced in seed yield in plots treated with nitrogen @ 40 kg ha^{-1}. Increase in number of pods and dry matter yield could be as a result of nitrogen being involved in carbohydrate and protein metabolism that promotes cell division and enlargement resulting in more productive pods and dry matter yields.

Similar result obtained in case of a nitrogen dose of 40 kg/ha has been reported to be optimum as well as economical for obtaining higher seed yield at Bhavanisagar, Orissa (Patro *et al.,* 1996). Singh *et al.,* (1991) reported significant increase in seed yield of winter niger cv N-36 upto 60 kg N/ha under irrigated conditions in sandy loam soils at Jabalpur. Although application of 60 kg N/ha gave the highest seed yield at Navsari (Gujrat), the enhancement in seed and oil yield was significant only up to 40 kg N/ha (Trivedi and Ahlawat, 1991a, b and 1993).

More or less similar trend was observed in case of stover yield and total biological yield. Stover yield ranged from 9.42 q ha^{-1} to 17.28 q ha^{-1}. The maximum yield was recorded with highest dose of sulphur application @ 45 kg ha^{-1}. Minimum stover yield was obtained in plots receiving no fertilizers (control). The increase in yield due to application of sulphur may be due to better metabolism and increased efficiency of other nutrients.

Similarly the biological yield of Niger shows the same result as before observed in seed and stover. The maximum yield was recorded with highest dose of sulphur application @ 45 kg ha^{-1}. Minimum stover yield was obtained in plots receiving no fertilizers (control). The increase in yield due to application of sulphur may be due to better metabolism and increased efficiency of other nutrients.

The HI (harvest index) of Niger ranged from 15.16% to 23.18%. Minimum HI was obtained in plots receiving nitrogen, phosphorus and potassium fertilizers @ 40, 40 and 20 kg ha^{-1} along with zinc @ 6 q ha^{-1}. HI of blackgram was found to increase with application of boron and sulphur. The maximum HI was observed in plots receiving the dose of nitrogen, phosphorus and potassium fertilizers @ 40, 40 and 20 kg ha^{-1} along with boron application @ 0.5 kg ha^{-1}.

Nutrient uptake

Uptake of nitrogen

The effect of nutrients on uptake of N by seed, stover as well as total uptake by niger is tabulated in figure 1. Grain nitrogen uptake ranged between 6.63 and 13.52 kg ha^{-1}. Uptake of nitrogen increases with the increase in doses of S up to S @ 45 kg ha^{-1}. Nitrogen uptake by stover varied from 1.61 to 8.97 kg ha^{-1}. Application of Zinc and Boron @ 2 and 0.5 kg ha^{-1} respectively along with Sulphur application @ 15 kg ha^{-1} increased nitrogen uptake by stover of Niger. Nitrogen uptake by total plant varied from 8.25 to 20.34 kg ha^{-1} Application of sulphur @ 45 kg ha^{-1} increased total nitrogen uptake by niger.

Uptake of phosphorus

Phosphorus uptake by niger seed varied from 1.66 to 4.79 kg ha^{-1}. Minimum result was obtained in plots receiving no fertilizers (control) and the maximum in plots receiving sulpher @ 45 kg ha^{-1}. Phosphorus uptake by stover varied from 2.14 to 5.41 kg ha^{-1}. Similar trend was observed in case phosphorus uptake by stover as nitrogen uptake. Application of Zinc and Boron @ 2 and 0.5 kg ha^{-1} respectively along with Sulphur application @ 15 kg ha^{-1} registered highest nitrogen uptake by Niger stover. Phosphorus uptake by total plant varied from 4.41 to 9.71 kg ha^{-1}. Similar trend was noticed in figure 2 with regards to total phosphorus uptake as that of nitrogen uptake by grain. The maximum uptake was recorded with the sulphur application @ 45 kg ha^{-1}.

Uptake of potassium

Data on the effect of nutrients on potassium uptake by grains are presented in figure 3. The values ranged from 0.95 to 2.91 kg ha^{-1}. The maximum potassium content was recorded with highest dose of sulphur application @ 15 kg ha^{-1}. Potassium uptake by stover varied between 4.80 and 12.46 kg ha^{-1}. Potassium application @ 80 kg ha^{-1} resulted in increased potassium content in stover which is maximum. Application of highest dose of boron @ 1.5 kg ha^{-1} give the minimum result in potassium content in stover. It is also found that application of sulphur also increasing the potassium uptake. Potassium uptake by plant varied between 6.43 to 14.92 kg ha^{-1}. Highest dose of potassium application @ 80 kg ha^{-1} resulted highest uptake of potassium.

Uptake of sulphur

Sulphur uptake by grains ranged between 0.70 and 2.49 kg ha^{-1} (Fig. 4). Application of sulphur @ 45 kg ha^{-1} give the most valuable result in sulphur uptake by grain. Minimum result was obtained in plots receiving no fertilizers (control). Sulphur uptake by stover ranged between 1.38 and 8.99 kg ha^{-1}. The maximum value was recorded in plots receiving maximum sulphur @ 45 kg ha^{-1} and the minimum value got in plots receiving where there no fertilizer were applied (control). Sulphur uptake by plant ranged between 2.09 and 11.48 45 kg ha^{-1}. The maximum value was recorded in plots receiving maximum sulphur @ 45 kg ha^{-1} and the minimum value got in plots receiving where there no fertilizer were applied (control). The results come similar as compared to total sulphur uptake by seed and stover.

Uptake of zinc

Zinc uptake by grains ranged between 0.48 and 2.21 kg ha^{-1} (Fig. 5). Application of zinc @ 6 kg ha^{-1}give the most valuable result in zinc uptake by grain. Minimum result was obtained in plots receiving no fertilizers (control). Zinc uptake by stover ranged between 1.92 and 4.76 kg ha^{-1}. The maximum value was recorded in plots receiving maximum zinc @ 6 kg ha^{-1} and the minimum value got in plots receiving where there no fertilizer were applied (control).

Uptake of boron

Boron uptake by grains ranged between 0.96 and 2.56 kg ha^{-1} (Fig. 6). Application of boron @ 1.5 kg ha^{-1}give the most valuable result in boron uptake by grain. Minimum result was obtained in plots receiving no fertilizers (control). Boron uptake by stover ranged between 1.11 and4.78 kg ha^{-1}. The maximum value was recorded in plots receiving maximum boron @ 1.5 kg ha^{-1} and the minimum value got in plots receiving where there no fertilizer were applied (control).

Oil content and oil yield

Oil content of niger varied from 31.73% to 38.80% (Table 3). The increase in oil content with increasing sulphur application observed up to45 kg S ha^{-1}.

Table.1 Available nutrient status after harvesting of niger

Treatments	2014-2015					
	Availab leN	Availab leP	Availabl eK	Available S	Available Zn	Availabl eB
	(kg ha^{-1})				(mg kg^{-1})	
T_1- $N_{40}+P_{40}+K_{20}$	259.24	29.47	58.24	21.34	1.47	**0.63**
T_2- $N_{40}+P_{40}+K_{20}+S_{15}$	167.25	23.49	77.84	30.07	1.29	**0.72**
T_3- $N_{40}+P_{40}+K_{20}+S_{30}$	259.24	41.86	83.22	31.58	1.48	**0.78**
T_4- $N_{40}+P_{40}+K_{20}+S_{45}$	192.34	39.51	78.51	32.42	1.62	**0.83**
T_5- $N_{40}+P_0+K_0$	209.07	36.73	85.68	27.38	1.18	**0.78**
T_6- $N_{40}+P_{40}+K_{40}$	200.70	43.14	90.83	27.89	1.41	**0.81**
T_7 -$N_{40}+P_{40}+K_{60}$	250.88	41.64	95.42	24.19	1.82	**0.85**
T_8- $N_{40}+P_{40}+K_{80}$	192.34	38.65	111.10	25.54	1.34	**0.68**
T_9- $N_{40}+P_{40}+K_{20}+Zn_2$	209.07	26.05	69.44	26.38	1.83	**0.72**
T_{10}-$N_{40}+P_{40}+K_{20}+Zn_4$	192.34	43.14	83.14	23.52	2.42	**0.81**
T_{11}-$N_{40}+P_{40}+K_{20}+Zn_6$	200.70	41.00	79.48	28.39	3.02	**0.84**
T_{12}-$N_{40}+P_{40}+K_{20}+B_{0.5}$	192.34	40.15	86.17	22.01	1.78	**0.94**
T_{13}-$N_{40}+P_{40}+K_{20}+B_1$	217.43	38.01	82.25	29.23	1.53	**1.17**
T_{14}-$N_{40}+P_{40}+K_{20}+B_{1.5}$	209.07	25.41	50.14	23.35	1.31	**1.34**
T_{15}-$N_{40}+P_{40}+K_{20}+S_{15}+Zn_2+B_{0.5}$	234.15	37.16	84.37	28.85	1.82	**1.04**
T_{16}-$N_{40}+P_{40}+K_{20}+S_{30}+Zn_4+B_1$	242.52	49.97	84.71	30.41	2.11	**1.27**
T_{17}-Control	167.25	11.75	52.71	16.63	1.11	**0.57**
SE(m)	22.783	10.953	9.113	3.078	0.07	**0.06**
CD(P=0.05)	70.199	33.747	28.079	9.484	1.364	**1.85**
CV	**18.65**	**53.12**	**19.82**	**20.17**	**1.48**	**0.63**

Table.2 Effect of nutrient management on Stover, grain and total biological yield and harvest index of Niger

Treatments	2014-2015			
	Seed Yield	Stover Yield	Biological Yield	Harvest Index
	q ha^{-1}			(%)
T_1- N_{40}+P_{40}+K_{20}	3.8	13.7	17.90	**21.0**
T_2- N_{40}+P_{40}+K_{20}+S_{15}	3.8	12.6	16.40	**20.0**
T_3- N_{40}+P_{40}+K_{20}+S_{30}	4.4	16.3	21.20	**22.9**
T_4- N_{40}+P_{40}+K_{20}+S_{45}	4.6	17.2	22.47	**23.0**
T_5- N_{40}+P_0+K_0	3.8	11.6	15.07	**20.0**
T_6- N_{40}+P_{40}+K_{40}	3.0	15.0	19.57	**23.0**
T_7 -N_{40}+P_{40}+K_{60}	3.4	11.8	15.47	**18.3**
T_8- N_{40}+P_{40}+K_{80}	3.3	14.8	19.30	**23.0**
T_9- N_{40}+P_{40}+K_{20}+Zn_2	3.0	10.7	13.93	**19.2**
T_{10}-N_{40}+P_{40}+K_{20}+Zn_4	3.7	11.2	14.60	**19.1**
T_{11}-N_{40}+P_{40}+K_{20}+Zn_6	3.1	10.1	13.13	**15.1**
T_{12}-N_{40}+P_{40}+K_{20}+$B_{0.5}$	3.9	16.5	21.47	**23.1**
T_{13}-N_{40}+P_{40}+K_{20}+B_1	3.0	11.5	15.03	**18.7**
T_{14}-N_{40}+P_{40}+K_{20}+$B_{1.5}$	3.0	11.6	15.13	**18.6**
T_{15}-N_{40}+P_{40}+K_{20}+S_{15}+Zn_2+$B_{0.5}$	3.5	13.7	17.90	**23.0**
T_{16}-N_{40}+P_{40}+K_{20}+S_{30}+ Zn_4+B_1	3.9	15.6	20.30	**18.7**
T_{17}-Control	2.7	9.42	12.23	**23.0**
SE(m)	0.6	3.22	4.192	**3.79**
CD(P=0.05)	0.2	0.99	1.291	**11.7**
CV	**33.**	**42.3**	**42.40**	**31.8**

Fig.1 Nitrogen uptake

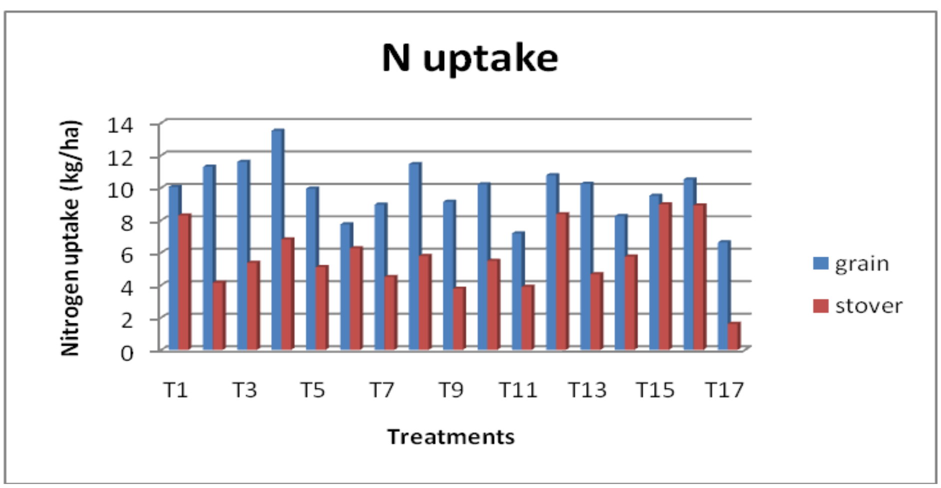


Table.3 Oil content, oil yield, crude protein content and protein yield of niger

	2014-2015			
Treatments	**Oil Content**	**Oil Yield**	**Protein Content**	**Protein yield**
	(%)	**$kgha^{-1}$**	**(%)**	**$kgha^{-1}$**
T_1- $N_{40}+P_{40}+K_{20}$	33.03	127.73	16.22	**73.23**
T_2- $N_{40}+P_{40}+K_{20}+S_{15}$	35.47	134.73	18.08	**80.14**
T_3- $N_{40}+P_{40}+K_{20}+S_{30}$	37.93	170.45	16.80	**77.30**
T_4- $N_{40}+P_{40}+K_{20}+S_{45}$	38.80	181.39	18.08	**94.28**
T_5- $N_{40}+P_0+K_0$	35.13	134.16	16.10	**63.32**
T_6- $N_{40}+P_{40}+K_{40}$	35.57	107.61	15.98	**72.08**
T_7 -$N_{40}+P_{40}+K_{60}$	35.10	119.84	16.80	**76.94**
T_8- $N_{40}+P_{40}+K_{80}$	33.90	113.97	21.12	**95.09**
T_9- $N_{40}+P_{40}+K_{20}+Zn_2$	34.30	105.19	18.55	**74.37**
T_{10}-$N_{40}+P_{40}+K_{20}+Zn_4$	34.20	127.28	17.27	**68.34**
T_{11}-$N_{40}+P_{40}+K_{20}+Zn_6$	34.67	109.94	14.23	**66.51**
T_{12}-$N_{40}+P_{40}+K_{20}+B_{0.5}$	35.87	143.53	17.15	**84.54**
T_{13}-$N_{40}+P_{40}+K_{20}+B_1$	34.70	105.63	22.05	**101.66**
T_{14}-$N_{40}+P_{40}+K_{20}+B_{1.5}$	36.43	111.77	17.03	**78.39**
T_{15}-$N_{40}+P_{40}+K_{20}+S_{15}+Zn_2+B_{0.5}$	36.47	127.37	16.92	**70.02**
T_{16}-$N_{40}+P_{40}+K_{20}+S_{30}+Zn_4+B_1$	37.83	149.78	16.33	**93.33**
T_{17}-Control	31.73	87.11	15.05	**42.25**
SE(m)	0.633	25.250	1.590	**13.304**
CD(P=0.05)	1.951	77.799	4.900	**40.992**
CV	**3.10**	**34.46**	**15.94**	**29.86**

Fig.2 Phosphorus uptake

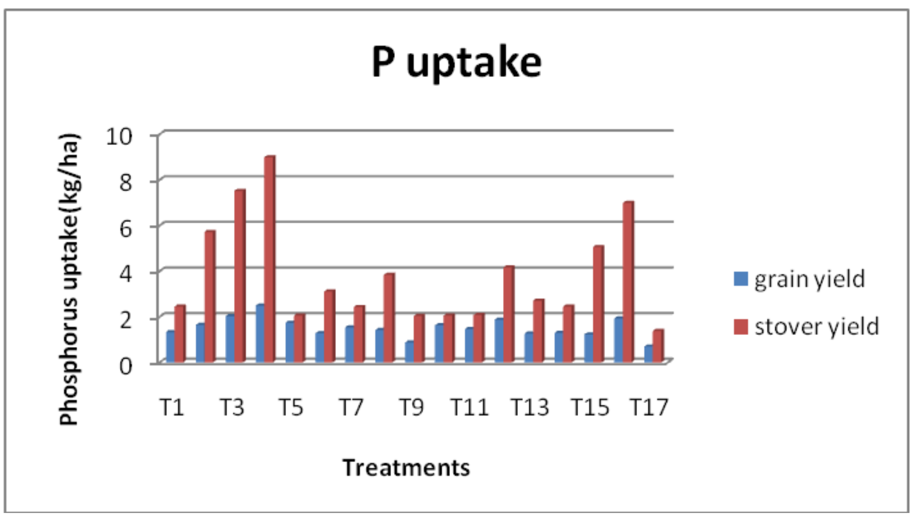


Fig.3 Potassium uptake

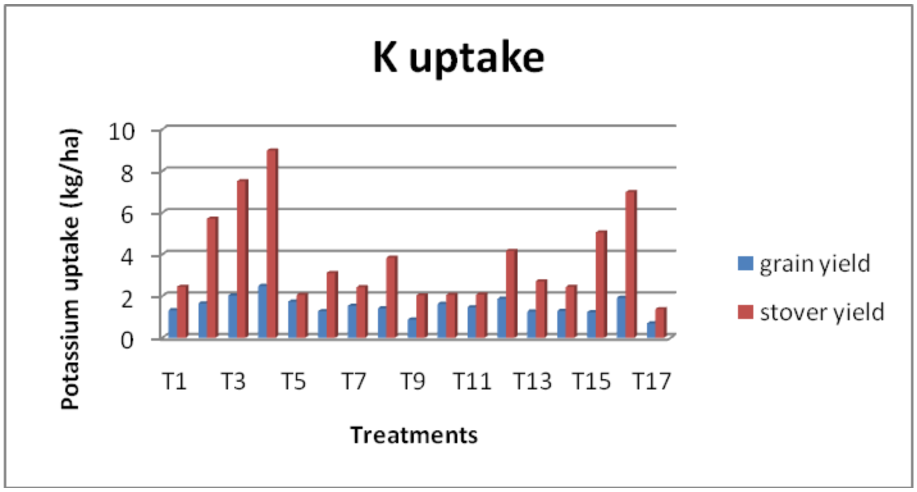


Fig.4 Sulphur uptake

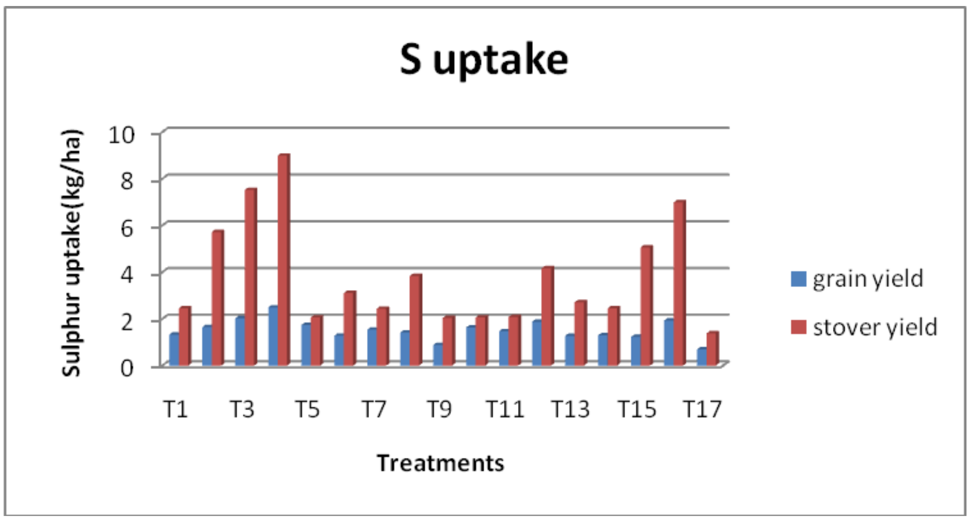


Fig.5 Zinc uptake

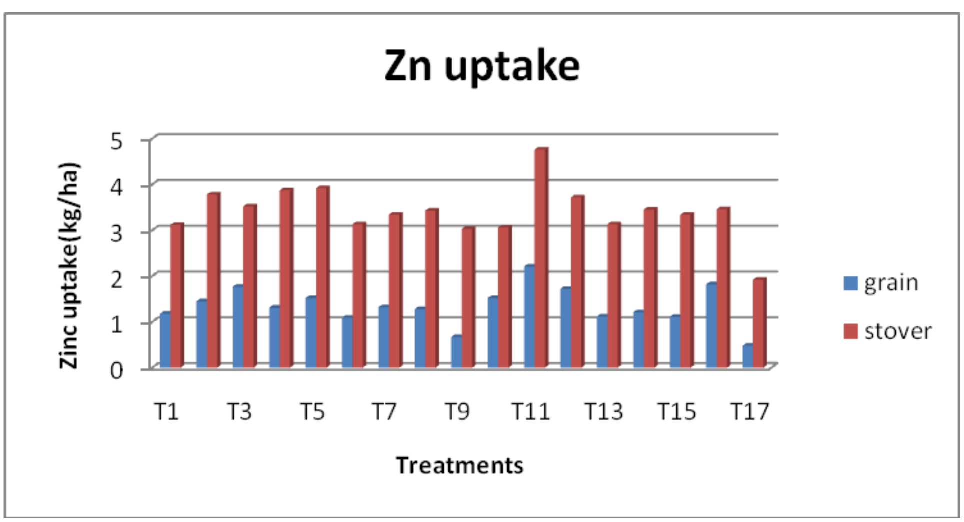
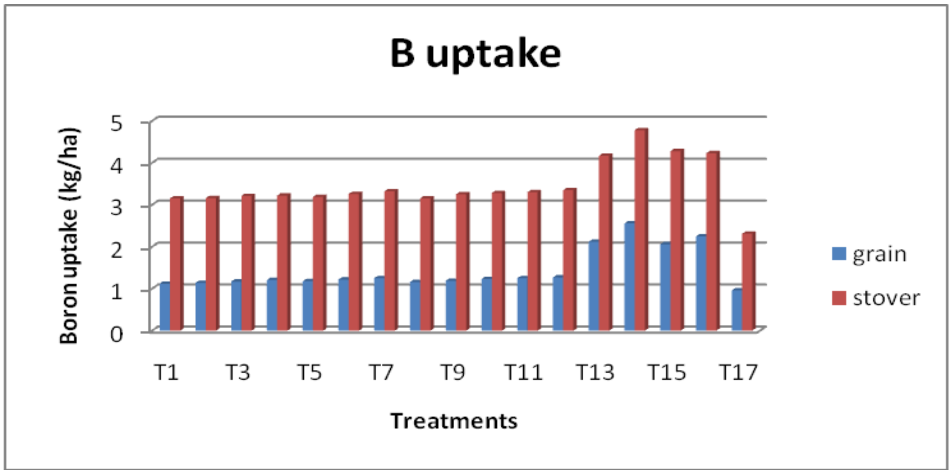


Fig.6 Boron uptake



Application of zinc and boron along with sulphur significantly increased oil content of niger. The maximum value was recorded in plots receiving maximum sulphur @ 45kg ha^{-1} and the minimum value got in plots receiving where there no fertilizer were applied (control). Oil yield (Table 3) varied from 87.11 kg ha^{-1} to 181.39 kg ha^{-1}. The maximum value was recorded in plots receiving maximum sulphur @ 45kg ha^{-1} and the minimum value got in plots receiving where there no fertilizer were applied (control). Increased oil content and oil yield due to application of nitrogen and sulphur was also reported by Das and Das (1995) and Indira *et al.*, (2008). The acetic thiolinase, a sulphur based enzyme in the presence of S convert acetyl Co-A to melonyl Co-A, rapidly resulting in higher oil content in seed crops. Sulfur plays a role in the formation of glucosides, which on hydrolysis produce higher amount of oil as allylisothiocyanate, which are responsible for pungency, a determinative factor of oil quality. The allylisothiocyanate value is affected by the application of sulfur (Sharma *et al.*, 1991).

Crude protein content and protein yield

Data on the protein content of niger seeds are presented in table 3. Protein content ranged between 15.05% and 22.05%. Nitrogen and sulphur application has significant effect on protein content. The maximum value was recorded in plots receiving boron @ 1kg ha^{-1} along with nitrogen @ 40kg ha^{-1} and the minimum value recorded in plots receiving where there no fertilizer were applied (control). Protein yield ranged between 42.25 to 101.66 kg ha^{-1}. Nitrogen and sulphur application has significant effect on protein yield. The maximum value was recorded in plots receiving boron @ 1kg ha^{-1} along with nitrogen @ 40kg ha^{-1}.

In conclusion, the result of the study revealed that combined application of NPK with S, B and Zn in case of niger resulted in higher yield, nutrient accumulation as well as uptake and maintaining soil fertility. Balanced nutrient management is one of the important issues for increasing crop production sustainably. The balanced application of NPK with sulphur, boron and zinc recorded higher seed yield, total biological yield, oil content, crude protein content, nutrient accumulation as well as uptake and maintained soil fertility. Combined application of sulphur, boron, and zinc increased the use efficiency of N, P and K. Balanced nutrient applications were more beneficial when the rate of the nutrient application was below the normal rate. It also improved the crop yields quality of the produce as well as improved the soil fertility, thus increased overall profit of the farmers.

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