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Effect of silicon and nitrogen levels on yield and quality of sorghum (*Sorghum bicolor* L. Moench) under Inceptisol

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Abstract
A field experiment entitled “Effect of silicon and nitrogen levels on soil nutrient dynamics, yield and quality of sorghum (*Sorghum bicolor* L. Moench) under Inceptisol” was conducted during the *rabi* season 2019-20, at Research Farm, Department of Soil Science and Agricultural Chemistry, College of Agriculture, Latur. The experiment was laid in factorial randomized block design with two factors *viz.*, four levels of Silicon (S_0-control, $S_{0.25}$-silicon @ 0.25% foliar spray, $S_{0.5}$-silicon @ 0.5% foliar spray and $S_{1.0}$-silicon @ 1% foliar spray) and four levels of nitrogen (N_0-control, N_{40}-nitrogen @ 40 kg ha^{-1}, N_{80}-nitrogen @ 80 kg ha^{-1} and N_{120}-nitrogen @ 120 kg ha^{-1}) with three replication and variety SPV-2407 (Parbhani super moti) was used as test crop. It was observed that the yield parameters *viz.* grain and straw yield as well as quality parameters *viz.* test weight, protein content and protein yield of sorghum were increased significantly with foliar application of silicon @ 1% in combination with soil application of nitrogen @ 120 kg ha^{-1} over rest of the treatments. The combined application of silicon and nitrogen was superior in increasing yield and quality of sorghum over separate application of silicon and nitrogen, under Inceptisol.

Keywords: Sorghum, silicon, Inceptisol and nitrogen

Introduction
Jowar (*Sorghum bicolor* (L.) Moench) is the fourth most important cereal following wheat, rice and maize in the world. Sorghum word is derived from Latin word ‘Sargo’ means ‘rising above’ *i.e.* growing taller than other crops in the field. Sorghum belongs to the family *Gramineae*. It is one of the most important cereal crop widely grown for food, feed, fodder, forage and fuel in the semi-arid tropics of Asia, Africa, America and Australia. In India, *Kharif* sorghum is grown in an area of 28.92 lakhs hectare and *rabi* sorghum in 46.39 lakhs hectare. In India, Maharashtra (54%), Karnataka (18%), Rajasthan (8%), Madhya Pradesh (6%) and Andhra Pradesh (4%) are the major sorghum growing states. In Maharashtra, it is truly the “poor man’s bread”. Marathwada and Western Maharashtra regions of the Maharashtra state are known as the ‘Sorghum Bowl of India’. Silicon is the second most abundant element in soil. In soil solution, Si^+ occurs mainly as monosilicic acid (H_4SiO_4) at concentrations ranging from 0.1 to 0.6 mm and is taken up by plants in this form (Epstein 1994; Ma and Takahashi 2002) [6, 12]. Silicon can play an important role in overcoming the effects of various environmental stresses. It reduces deficiency of various essential nutrients *viz.* Mn, Zn and P. It also increases the resistance to lodging, diseases and insects. Silicon can control and remove the negative effects of physical stresses (high temperature, freezing, drought, lodging, radiation, irradiation, UV) and chemical stresses (salt, nutrient imbalance, metal toxicity) (Shahnaz *et al.*, 2011) [15]. It has been reported that adding silicon to monocots, especially Gramineae plants, not only promotes growth and development but also promotes photosynthesis, reduces pest infection, maintains the shoot in an erect position and alleviates salt stress (Ahmad *et al.*, 1992, Epstein, 1999, Korndorfer and Ma, 2004) [2, 6, 10]. Nitrogen is a key element required for plant growth and is one of the most important yield-limiting nutrients in crop production in all agro-ecological regions of the world. N is commonly taken up from the soil in one of two inorganic forms: ammonium (NH_4^+) and nitrate (NO_3^-). Different N forms can affect the physiological and metabolic processes of plants, such as nutrient uptake, enzyme activity, photosynthesis rate, respiration rate, water balance, and signaling pathways, thus eventually influencing plant growth and crop yield.

Nitrogen is a crucial component of plant nutrition, and its deficiency limits productivity of crops more than any other element. In irrigated areas, N fertilizer is very important and is the main factor affecting the dry matter yield of sorghum cultivars; N fertilizers are easily soluble and leachable in most of the soils and increase the forage yield of sorghum varieties (Rahman *et al.*, 2001) [14].

Materials and Methods

Field experiment entitled "Effect of silicon and nitrogen levels on soil nutrient dynamics, yield and quality of sorghum (*Sorghum bicolor* L. Moench) under inceptisol" was conducted at Departmental Research Farm, College of Agriculture, Latur during *rabi* season 2019 on sorghum variety SPV-2407. The topography of experimental field was uniform and leveled. The experimental soil was slightly alkaline in nature. The total geographical area of Latur district is 7.37 mha. Geographically Latur district comes under Maharashtra state which is located between 18^0 05' to 18^0 75' North. The soils of Latur district belongs to order Vertisols, Inceptisol and Entisol derived from Deccan trap. RDF (80:40:40 kg NPK ha) was supplied through UREA, SSP and MOP.

The composite soil sample before sowing was taken for their initial values. The soil pH (7.9) and EC (0.32 dSm^{-1}) were analyzed using soil:water suspension (1:2.5) and determined by potentiometric method and Conductivity meter method (Jackson, 1973) [8], respectively, The soil was also carried for organic carbon (0.30%) by Walkley and Black (1934) method, available N (208.24 kg ha^{-1}) determined by alkaline $KMnO_4$ as described by Subbiah and Asija (1956) [17], available P (32.21 kg ha^{-1}) by Olsen's method as described by Jackson (1973) [8], and available K (294.36 kg ha^{-1}) by using Flame photometer as described by Piper (1966) [13]. The experiment was laid out in factorial randomized block design with two factors *viz.* four levels of Silicon (S_0-control, $S_{0.25}$-silicon @ 0.25%, $S_{0.5}$-silicon @ 0.5% and $S_{1.0}$-silicon @ 1% as foliar spray) and four levels of nitrogen (N_0-control, N_{40}-nitrogen @ 40 kg ha^{-1}, N_{80}-nitrogen @ 80 kg ha^{-1} and N_{120}-nitrogen @ 120 kg ha^{-1} as soil application) with three replications.

Results and Discussion

Effect on yield parameters (grain and fodder yield) of sorghum: The data regarding effect of silicon and nitrogen levels on grain yield and fodder yield of sorghum was presented in Table 1 and 2 respectively and depicted in Figure 1. The data showed that the application of various silicon and nitrogen levels significantly influenced grain and fodder yield of sorghum.

It was noticed from the data that the grain yield of sorghum ranged between 1568.41 to 1841.01 kg ha^{-1} and fodder yield ranges between 5766.10 to 6004.85 kg ha^{-1} due to various levels of silicon. The treatment $S_{1.0}$ recorded significantly higher grain (1841.01 kg ha^{-1}) and fodder yield (6004.85 kg ha^{-1}) than the other levels. However, the treatment S_0, $S_{0.25}$ and $S_{0.5}$ were at par with each other. Similar results were also reported by Ahmad *et al.*, (2013) [1] and Anand *et al.*, (2018) [4]. The increase in grain yield might be due to the application of silicon enhanced the sturdiness in plant and helped to grow erect without lodging. The erectness exposed the plant to sunlight and enhanced the photosynthetic activity and better assimilation of organic constituents (carbohydrates). This assimilation promoted the growth and development of crop, as well as reduced the incidence of pest and diseases. The crop grown vigorously and utilized the nutrients and moisture from soil which were turned into the economic yield of sorghum. In case of fodder yield similar results were reported by Shedeed (2018) [16]. The fodder yield of sorghum was increased with increasing of silicon levels. The yield increment attributed to the direct beneficial effects of Si such as vegetative growth, increase of chlorophyll content, photosynthetic activity of plant, more formation of carbohydrates, membrane lipid peroxidation, protective enzymes and water metabolism.

Table 1: Effect of silicon and nitrogen levels on grain yield (kg ha^{-1}) of sorghum

	Silicon Level (%)				
Nitrogen Levels (kg ha^{-1})	**S_0**	**$S_{0.25}$**	**$S_{0.5}$**	**$S_{1.0}$**	**Mean**
N_0	1265.28	1349.38	1360.74	1430.41	1351.45
N_{40}	1480.52	1512.58	1567.07	1621.37	1545.38
N_{80}	1664.91	1711.76	1748.47	1823.77	1737.22
N_{120}	1862.94	1915.22	1954.16	2488.52	2055.21
Mean	1568.41	1622.23	1657.61	1841.01	
	Silicon	Nitrogen	S X N		
S.E.±	18.78	18.78	37.56		
C. D. at 5%	54.23	54.23	108.46		

It was further noticed from the data that the effect of different levels of nitrogen on grain yield and fodder yield of sorghum were ranged from 1351.45 to 2055.21 kg ha^{-1} and 5553.18 to 6214.01 kg ha^{-1}, respectively. The treatment N_{120} recorded significantly higher grain yield as well as fodder yield than the rest of the treatments. All the treatments were significantly superior over their lower levels. Significantly lower grain and fodder yield were recorded in treatment N_0. The finding of present investigation corroborates with the findings of Arshewar *et al.* (2018) [5]. Increasing grain yield with increasing N rates up to adequate level might be due to the role of N in increasing the leaf area and promote photosynthesis efficiency which promotes dry matter production and increased yield. Similar results were also reported by Kadam *et al.* (2019) [9]. The fodder yield of sorghum is increased with increased nitrogen was mainly associated with greater plant height, higher number of leaves $plant^{-1}$ and stem diameter.

Table 2: Effect of silicon and nitrogen levels on fodder yield (kg ha^{-1}) of sorghum

	Silicon Level (%)				
Nitrogen Levels (kg ha^{-1})	**S_0**	**$S_{0.25}$**	**$S_{0.5}$**	**$S_{1.0}$**	**Mean**
N_0	5457.49	5523.45	5598.55	5633.23	5553.18
N_{40}	5679.14	5709.75	5788.76	5837.16	5753.70
N_{80}	5874.43	5906.74	5954.58	5986.67	5930.60
N_{120}	6053.33	6087.28	6153.10	6562.35	6214.01
Mean	5766.10	5806.81	5873.75	6004.85	
	Silicon	Nitrogen	S X N		
S.E.±	23.77	23.77	47.54		
C. D. at 5%	68.63	68.63	137.26		

The interaction effect of silicon and nitrogen levels on grain and fodder yield of sorghum was also found significant. The interaction $S_{1.0}N_{120}$ was significantly superior over rest of the interaction and recorded significantly higher grain (2488.52 kg ha^{-1}) and fodder yield (6562.35 kg ha^{-1}) than rest of the interactions. The lowest grain and fodder yield was recorded due to N_0S_0 treatment.

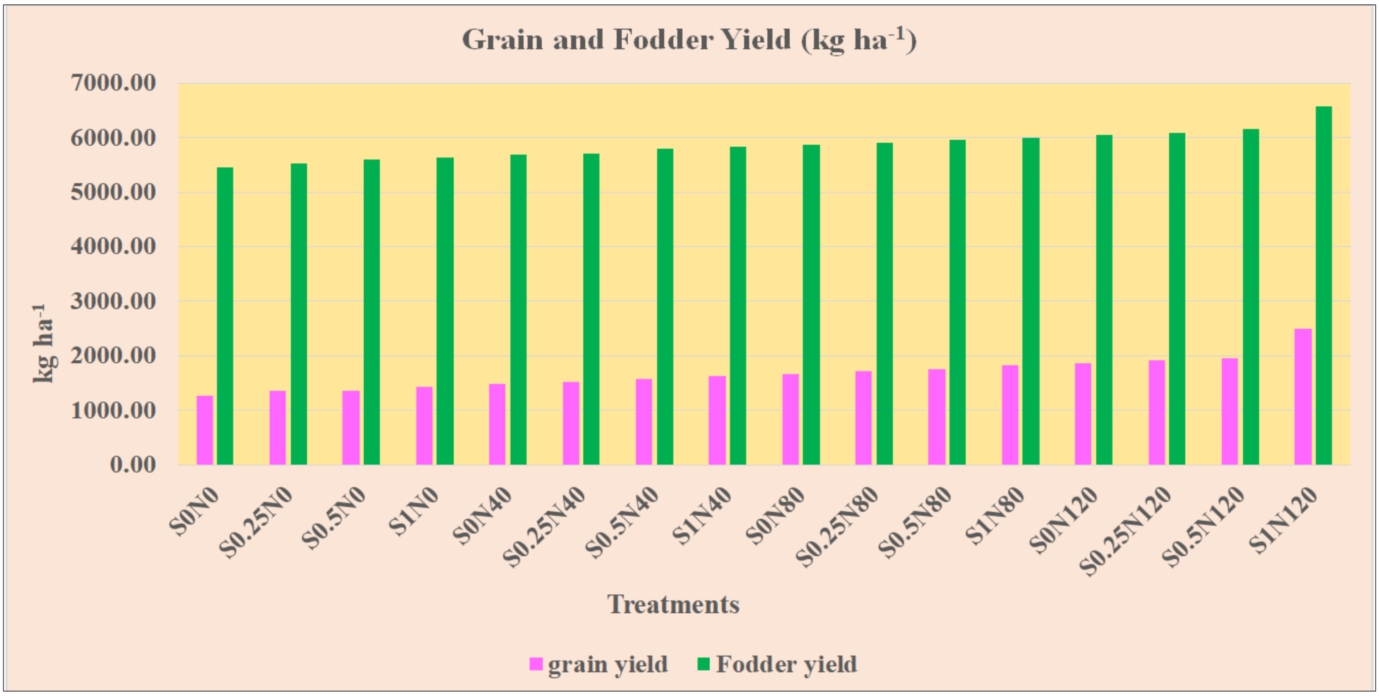

Fig 1: Effect of silicon and nitrogen levels on grain and fodder yield (kg ha^{-1})

Effect on quality parameters of sorghum

Test weight (g)

The data regarding effect of silicon and nitrogen levels on test weight of sorghum grain are summarized in Table 3 and depicted in Figure 2 respectively. The data showed that the application of various silicon and nitrogen levels significantly influenced test weight of sorghum grain.

It was noticed from the data that the effect of different levels of silicon on test weight of grain was influenced significantly and ranged between 26.91g to 27.68 g. The treatment $S_{1.0}$ recorded significantly higher test weight of sorghum grain (27.68 g) than the rest of the treatments. The treatment S_0, $S_{0.25}$ and $S_{0.5}$ were at par with each other. The treatment S_0 recorded lower test weight (26.91 g) of sorghum grain than the other treatments. Similar results were also reported by Anand *et al*. (2018) [4]. The enhancement in 1000 grain weight due to the silicon treatment was attributed to improve and enhance the photosynthetic activity, density of grain by improving the translocation and accumulation of carbohydrates and other macro and micro molecules.

Table 3: Effect of silicon and nitrogen levels on test weight (g) of sorghum grain

	Silicon Level (%)				
Nitrogen Levels (kg ha^{-1})	**S_0**	**$S_{0.25}$**	**$S_{0.5}$**	**$S_{1.0}$**	**Mean**
N_0	25.87	26.07	26.25	26.41	26.15
N_{40}	26.56	26.74	26.90	27.08	26.82
N_{80}	27.26	27.43	27.56	27.75	27.50
N_{120}	27.93	28.11	28.19	29.49	28.43
Mean	26.91	27.09	27.23	27.68	
	Silicon	Nitrogen	S X N		
S.E.±	0.06	0.06	0.12		
C. D. at 5%	0.18	0.18	0.36		

It was noticed that the effect of different levels of nitrogen on test weight of sorghum were influence significantly and ranged between 26.15 g to 28.43 g. The treatment N_{120} was recorded significantly higher test weight of sorghum (28.43 g) over rest of the treatments. All the treatments were significantly superior over their lower treatment. The nitrogen level N_0 recorded significantly lower (26.15 g) 1000 grain weight than other nitrogen levels. Similar results were also reported by Gebremarium and Assefa (2015) [7]. Increase in grain weight at higher nitrogen rate might be due to increase in photosynthetic rate which ultimately produced sufficient photosynthates available during grain development.

The interaction effect of silicon and nitrogen levels on test weight of sorghum was also found significant. The treatment $S_{1.0}N_{120}$ was significantly superior over rest of the interactions and recorded significantly higher 1000 grain weight than the other interaction treatments. The lower test weight was noticed in treatment S_0N_0.

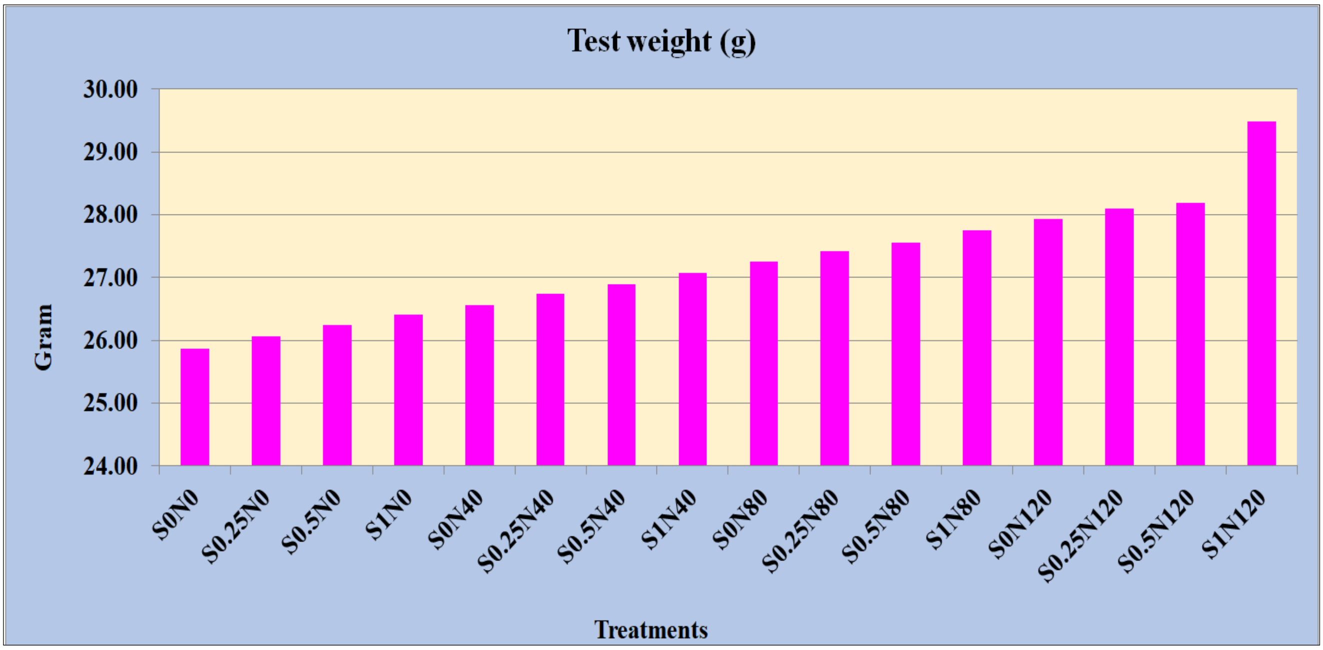

Fig 2: Effect of silicon and nitrogen levels on test weight (g) of sorghum

Protein content and protein yield

The data regarding protein content and protein yield of sorghum was affected significantly due to silicon and nitrogen levels and are presented in Table 4 and depicted in Figure 3 respectively.

The values of protein content and protein yield of sorghum revealed that the silicon levels had marked effect on protein content and protein yield of sorghum. Higher protein content (12.48%) and protein yield (232.39 kg ha^{-1}) was observed due to $S_{1.0}$ treatment. The treatment $S_{1.0}$ recorded significantly higher value of protein content as compared to rest of treatments except $S_{0.5}$. However, the treatment $S_{0.25}$, $S_{0.5}$ and $S_{1.0}$ were at par with each other in case of protein content. In case of protein yield the treatment $S_{1.0}$ recorded significantly higher protein yield (232.39 kg ha^{-1}) than the rest of the treatments. The treatment $S_{0.25}$ and $S_{0.5}$ were at par with each other in case of protein yield. Significantly lowest protein content (12.05%) and protein yield (190.35 kg ha^{-1}) were recorded by the treatment S_0. Similar results were also reported by Anand *et al.*, (2018) [4]. Protein content and protein yield of sorghum were increased by increased silicon levels. This might be due to application of silicon which directly improved the synthesis of various amino acids and the activity of enzymes in plants.

Table 4: Effect of silicon and nitrogen levels on protein content and protein yield of sorghum

Silicon levels %	**Protein content (%)**	**Protein Yield (kg ha^{-1})**
S_0	12.05	190.35
$S_{0.25}$	12.27	200.45
$S_{0.5}$	12.32	205.77
$S_{1.0}$	12.48	232.39
S.E.	0.05	2.12
C.D. at 5%	0.16	6.12
Nitrogen levels (kg ha^{-1})		
N_0	11.53	156.27
N_{40}	11.92	184.50
N_{80}	12.52	217.82
N_{120}	13.12	270.36
S.E.	0.05	2.12
C.D. at 5%	0.16	6.12
Interaction (S X N)		
S.E.	0.11	4.23
C.D. at 5%	NS	12.24

The protein content and protein yield of sorghum were also affected significantly due to N levels. The protein content (13.12%) and protein yield (270.36 kg ha^{-1}) of sorghum was significantly higher due to treatment N_{120} over rest of the treatments. Significantly lower protein content (11.53%) and protein yield (156.27 kg ha^{-1}) was recorded with N_0 than other higher levels of N. Present investigation findings were similar to Afzal *et al.*, (2012) [3]. The increase in protein content of sorghum grain due to increased nitrogen content in grain which resulted into improvement in metabolic activities in the plant. Protein yield was increased due to higher grain yield and higher protein content in grain.

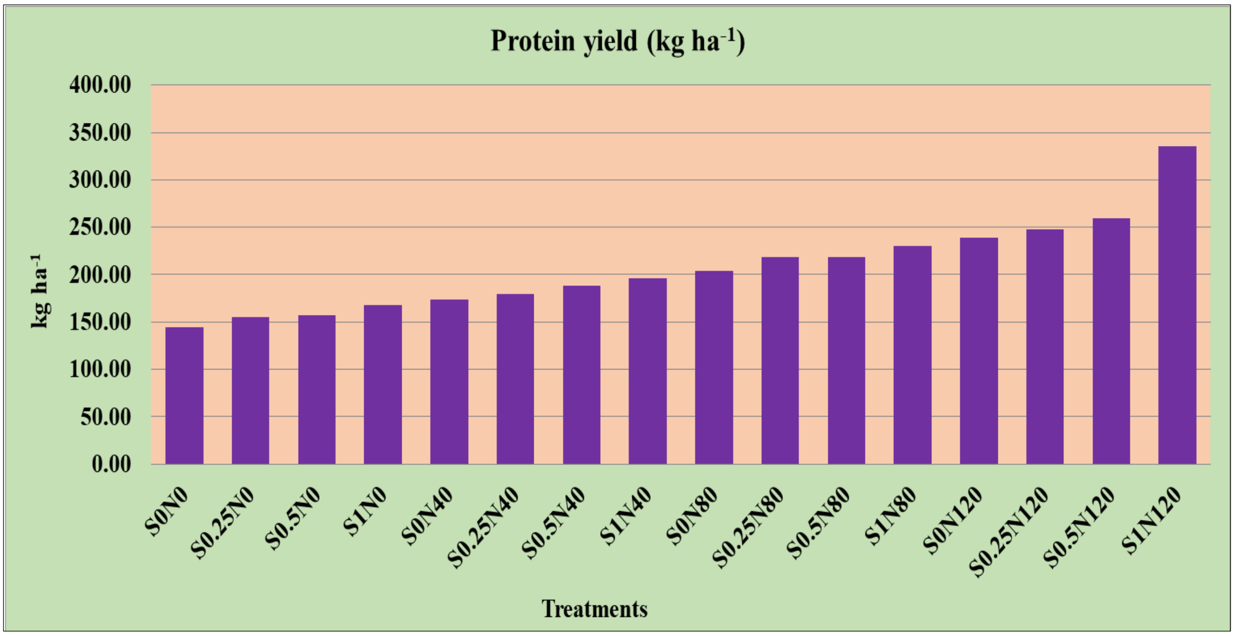

Fig 3: Effect of silicon and nitrogen levels on protein yield (kg ha^{-1}) of sorghum

Table 5: Interaction effect of silicon and nitrogen levels on protein yield (kg ha^{-1}) of sorghum

Nitrogen Levels (kg ha^{-1})	Silicon levels (%)			
	S_0	$S_{0.25}$	$S_{0.5}$	$S_{1.0}$
N_0	144.45	155.51	157.48	167.66
N_{40}	174.10	179.77	187.84	196.29
N_{80}	204.02	218.38	218.54	230.37
N_{120}	238.81	248.15	259.23	335.25
Interaction (S X N)				
S.E.±	4.23			
C. D. at 5%	12.24			

Interaction effect of silicon and nitrogen on protein content of sorghum was non-significant but in case of protein yield the interaction effect was significant (Table 5). Interaction effect of $S_{1.0}N_{120}$ was significantly higher incase of protein yield (335.25 kg ha^{-1}) of sorghum and proved that it was superior over rest of treatments. Treatment S_0N_0 recorded lowest protein yield (144.45 kg ha^{-1}) than the other interactions.

Conclusion

Foliar application of silicon @1% and soil application of N @120 kg/ha in combination significantly increased the yield of sorghum over separate application of silicon and nitrogen. The interaction effect of silicon (1%) and nitrogen (120 kg/ha) was also found significant in improvement of quality of sorghum *viz.* test weight and protein yield.

References

1. Ahmad A, Afzal M, Ahmad AUH, Tahir M. Effect of foliar application of silicon on yield and quality of rice (*Oryza sativa* L). Cercetari. Agron. Moldava. 2013;3(155):21-28.
2. Ahmad R, Zaheer S, Ismail S. Role of silicon in salt tolerance of wheat (*Triticum aestivum* L.). Plant Sci. 1992;85:43-50.
3. Afzal M, Ahmad A, Ahmad AH. Effect of nitrogen on growth and yield of sorghum forage (*Sorghum bicolor* (L.) Moench cv.) under three cuttings system. Researchgate. 2012;4(152):57-64.
4. Anand L, Sreekanth B, Jyothula DPB. Effect of foliar application of sodium silicate on yield and grain quality of rice. Inter. J Chem. Studies. 2018;6(6):1711-1715.
5. Arshewar SP, Karanjikar PN, Takankhar VG, Waghmare YM. Effect of nitrogen and zinc on growth, yield and economics of pearl millet (*Pennisetum glaucum* L.). Int. J Curr. Microbiol. App. Sci. 2018;6:2246-2253.
6. Epstein E. Silicon Annual Review of Plant Physiology and Molecular Biology. 1999;50:641-664.
7. Gebremariam G, Assefa D. Nitrogen fertilization effect of grain sorghum (*Sorghum bicolor* L. Moench) yield, yield components and witch weed (*Striga hermonthica* (Del.) Benth) infestation in Northern Ethopia. Inter. J Agri. Res. 2015;10(1):14-23.
8. Jackson ML. Soil chemical analysis-advanced course, 2nd Edn.Publ.by the author, Univ. of Wisconsin, Madison, USA. Int. J Res. Analyt. Reviews. 1973;6(1):579-590.
9. Kadam SB, Pawar SB, Jakkawad SR. Response of pearl millet (*Pennisetum glaucum* L.) to levels and scheduling of nitrogen under Maharashtra condition. J Pharmacognosy Phytochem. 2019;8(3):2922-2925.
10. Korndorfer GH, Lepsch I. Effect of silicon on plant growth and crop yield. Silicon in Agriculture. Studies. Plant. Sci. 2001;8:115-131.
11. Ma JF. Role of silicon in enhancing the resistance of plants to biotic and abiotic stresses. Soil Sci. Plant Nutr. 2004;50(1):11-18.
12. Ma JF, Takahashi. Soil, fertilizer and plant silicon research in Japan. Elsevier. Science, Amsterdam; c2002. P. 11-18.
13. Piper CS. Soil and Plant Analysis, Hans Publishers, Bombay; c1966.
14. Rahman MS, Fukai FPC, Blamey. Forage production and nitrogen uptake of forage sorghum, grain sorghum and maize as affected by cutting under different nitrogen levels. In: Proceedings of the 10th Australian Agronomy Conference, Hobart, Australia, 2001.
15. Shahnaz G, Shekoofeh E, Kourosh D, Moohamadbagher B. Interactive effects of silicon and aluminum on the

malondialdehyde (MDA), proline, protein and phenolic compounds in *Borago officinalis* L. J Medicinal Plant Res. 2011;5(24):5818-5827.
16. Shedeed SI. Assessing effect of potassium silicate consecutive application on forage maize plants (*Zea mays* L.). J Innovations Pharma. Bio. Sci. 2018;5(2):119-127.
17. Subbiah BV, Asija GL. Rapid procedure for the estimation of available nitrogen in soil. Curr. Sci. 1956;25:259-260.
18. Walkely A, Black CA. An estimation of the digestion method of determining soil organic matter and proposed modification of the chromic acid titration method of soil science. 1934;37:29-38.