

ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating (2026): 4.97
IJAFS 2026; 8(10): 1307-1310
www.agriculturaljournals.com
Received: 09-08-2026
Accepted: 21-09-2026
Published: 27-10-2026

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Effect of soil and foliar application of different silicon sources on yield and economics of rabi onion (*Allium cepa* L.) in saline-sodic soil

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DOI: https://www.doi.org/10.33545/2664844X.2026.v8.i10q.2159

Abstract

A field experiment entitled "Effect of soil and foliar application of different silicon sources on yield and economics of *rabi* onion in saline-sodic soil" was conducted during *rabi* 2025-26 at the Post Graduate Institute Research Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri. The experiment was laid out in a randomised block design with ten treatments and three replications, T_1- Absolute control, T_2- GRDF (100:50:50 N:P_2O_5:K_2O kg ha^{-1} + 10 t ha^{-1} FYM), T_3- GRDF + soil application of DE @ 250 kg ha^{-1}, T_4- GRDF + soil application of DE @ 300 kg ha^{-1}, T_5 - GRDF + two foliar sprays of silicic acid @ 2 ml L^{-1} at 30 and 60 DAT, T_6 - GRDF + two foliar sprays of potassium silicate @ 2 ml L^{-1} at 45 and 75 DAT, T_7 - GRDF + DE @ 250 kg ha^{-1} + two foliar sprays of silicic acid @ 2 ml L^{-1} at 30 and 60 DAT, T_8 - GRDF + DE @ 300 kg ha^{-1} + two foliar sprays of silicic acid @ 2 ml L^{-1} at 30 and 60 DAT, T_9 - GRDF + DE @ 250 kg ha^{-1} + two foliar sprays of potassium silicate @ 2 ml L^{-1} at 45 and 75 DAT, T_{10} - GRDF + DE @ 300 kg ha^{-1} + two foliar sprays of potassium silicate @ 2 ml L^{-1} at 45 and 75 DAT. The result revealed that the application of GRDF + DE @ 300 kg ha^{-1} + two foliar sprays of potassium silicate @ 2 ml L^{-1} at 45 and 75 DAT recorded the highest polar diameter (5.99 cm), equatorial diameter (6.29 cm) and fresh bulb yield (36.36 t ha^{-1}) and the thinnest neck (0.49 cm). The yield was statistically at par with T_9 (35.94 t ha^{-1}), T_8 (34.46 t ha^{-1}) and T_7 (33.92 t ha^{-1}). The treatment T_{10} also recorded the highest gross monetary returns (Rs. 4,36,280 ha^{-1}) and net monetary returns (Rs. 2,36,100 ha^{-1}) and it was at par with T_9, T_8 and T_7, and the highest B:C ratio (2.18) recorded under T_{10} treatment.

Keywords: Silicon, Diatomaceous earth, Potassium silicate, Silicic acid, Onion, Saline-sodic soil, Economics

Introduction

Silicon is beneficial element, it strengthens cell walls, helps plants tolerate abiotic stresses including salinity, and influences phosphorus nutrition (Epstein, 1994) [1]. Under salt stress, silicon improves growth, photosynthesis, nutrient balance and osmotic regulation while reducing Na^+ uptake and improving K^+ uptake (Ashraf *et al.*, 2010; Laane, 2018) [2, 3]. In onion grown under salinity, silicon supplied through diatomaceous earth reduced the salinity penalty on yield (Venancio *et al.*, 2022) [4], and silicon has been reported to improve the yield of onion and related alliums in several studies (Nazirkar *et al.*, 2017; Shinde, 2017; Bybordi *et al.*, 2018; Alves *et al.*, 2025) [6, 7, 8, 5].

Onion (*Allium cepa* L.) is an important bulb vegetable and salt-tolarant crop. Its threshold salinity is 1.4 dS m^{-1}, and each unit increase in EC above it reduces tuber yield by about 18.52% (Sanwal *et al.*, 2022) [9]. In saline-sodic soils, high exchangeable sodium disperses clay and degrades soil structure and the high pH and bicarbonate content further limit nutrient availability. Together these factors restrict root growth, nutrient uptake and bulb development. Silicon can be supplied to the soil as diatomaceous earth, which releases monosilicic acid slowly, or to the foliage as soluble silicic acid or potassium silicate. Most of the earlier onion work from this region was done in non-saline soil during *kharif*, and the response of *rabi* onion to combined soil and foliar silicon in saline-sodic soil, including the economic return from it, has received little attention. This study therefore evaluated the effect of soil and foliar silicon sources (diatomaceous earth, potassium silicate, silicic acid) on the yield and economics of *rabi* onion in saline-sodic soil.

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Material and methods

A field experiment was conducted during *rabi* 2025-26 on a saline-sodic soil classified as Inceptisol (fine, montmorillonitic, hyperthermic, Sodic Hapludepts) at the Department of Soil Science, Post Graduate Institute, MPKV, Rahuri. The experiment was laid out in a randomised block design with ten treatments and three replications. The gross plot size was 3.60 × 4.00 m (14.4 m^2) and the net plot size 3.30 × 3.60 m (11.88 m^2). The treatments were, *viz*; T_1- Absolute control, T_2- GRDF (100:50:50 N:P_2O_5:K_2O kg ha^{-1} + 10 t ha^{-1} FYM), T_3- GRDF + soil application of DE @ 250 kg ha^{-1}, T_4- GRDF + soil application of DE @ 300 kg ha^{-1}, T_5 - GRDF + two foliar sprays of silicic acid @ 2 ml L^{-1} at 30 and 60 DAT, T_6 - GRDF + two foliar sprays of potassium silicate @ 2 ml L^{-1} at 45 and 75 DAT, T_7 - GRDF + DE @ 250 kg ha^{-1} + two foliar sprays of silicic acid @ 2 ml L^{-1} at 30 and 60 DAT, T_8 - GRDF + DE @ 300 kg ha^{-1} + two foliar sprays of silicic acid @ 2 ml L^{-1} at 30 and 60 DAT, T_9 - GRDF + DE @ 250 kg ha^{-1} + two foliar sprays of potassium silicate @ 2 ml L^{-1} at 45 and 75 DAT, T_{10} - GRDF + DE @ 300 kg ha^{-1} + two foliar sprays of potassium silicate @ 2 ml L^{-1} at 45 and 75 DAT.

Onion seeds of variety *Phule Swami* (RHROR-12) about 120 days duration were used. *One-and-a-half-month-old seedlings* were transplanted with spacing 15 cm × 10 cm, one seedling per hill. FYM was applied at transplanting. A basal dose of 50:50:50 N:P_2O_5: K_2O kg ha^{-1} was given at transplanting through urea, single super phosphate and muriate of potash, and the remaining 50 kg N ha^{-1} was applied in two splits after transplanting. DE was applied to the soil at transplanting and foliar spray i.e. silicic acid, potassium silicate @ 2 ml L^{-1} at 30, 60 and 45, 75 days after transplanting respectively. Polar and equatorial diameter and neck thickness were measured with a vernier caliper on five randomly selected bulbs per net plot. Bulb yield was recorded from each net plot and expressed in t ha^{-1}. The cost of cultivation was worked out from the cost of inputs and operations. Gross monetary returns (GMR) were calculated as yield × market price, net monetary returns (NMR) as GMR − cost of cultivation, and the benefit:cost (B:C) ratio calculated as GMR ÷ cost of cultivation (Biswas *et al.,* 2024). The input and produce prices used in the economic analysis were as follows: urea at Rs. 5.77 kg^{-1}, SSP at Rs. 13.50 kg^{-1}, MOP at Rs. 34 kg^{-1}, FYM at Rs. 1,500 t^{-1}, DE at Rs. 18 kg^{-1}, silicic acid at Rs. 1.76 ml^{-1}, potassium silicate at Rs. 0.80 ml^{-1}, and onion at Rs. 12 kg^{-1}.

Results and discussion

Effect of soil and foliar application of different silicon sources on yield of onion: The fresh bulb yield of onion was significantly influenced by the silicon treatments (Table 1). The highest yield (36.36 t ha^{-1}) was recorded in treatment GRDF + DE @ 300 kg ha^{-1} + two foliar sprays of potassium silicate (T_{10}), it was statistically at par with T_9 (35.94 t ha^{-1}), T_8 (34.46 t ha^{-1}) and T_7 (33.92 t ha^{-1}). The lowest yield (12.07 t ha^{-1}) was recorded in the absolute control. T_{10} produced 201.24% more bulb yield than the control and 49.69% more than GRDF alone (24.29 t ha^{-1}). GRDF alone doubled the control yield (101.24% increase), which shows that the soil responded strongly to fertilizer, but silicon raised yield well beyond ferlizer application. The highest yield under T_{10} can be attributed to the continuous and complementary supply of silicon throughout the crop growth period. The combined application of soil and foliar silicon resulted in a higher yield than either method alone. Treatment T_9 (35.94 t ha^{-1}) recorded a yield 4.19 t ha^{-1} higher than T_3, while T_{10} recorded a yield 3.29 t ha^{-1} higher than T_4. DE is rich in amorphous silica and gradually releases monosilicic acid into the soil solution, ensuring silicon availability to the roots throughout the cropping period. Meanwhile, foliar sprays provide readily available silicon during the active vegetative growth and bulb development stages. Silicon deposited beneath the leaf cuticle keeps leaves erect, improves light interception, reduces transpirational water loss and protects chlorophyll from oxidative damage, which sustains photosynthesis and the translocation of assimilates to the bulb. The potassium in potassium silicate adds to this by activating enzymes of carbohydrate metabolism, regulating stomatal opening and promoting the movement of sugars to the storage organ. These results are in similar with Ashraf *et al.* (2010) [2], Nazirkar *et al.* (2017) [6], Shinde (2017) [7], Bybordi *et al.* (2018) [8], Durgude *et al.* (2010).

Effect of different levels and sources of silicon on economics of crop

Cost of cultivation: The cost of cultivation ranged from Rs. 1,70,120 ha^{-1} in T_1 to Rs. 2,02,108 ha^{-1} in T_8. Treatment GRDF + Soil application of DE @ 300 kg ha^{-1}+ Two foliar spray of Silicic acid @ 2 ml L^{-1}at 30 and 60 DAT recorded the highest cost of cultivation due to the higher dose of DE and the higher cost of silicic acid sprays, followed by T_7 (Rs. 2,01,175 ha^{-1}) and T_{10} (Rs. 2,00,180 ha^{-1}). The cost of cultivation under GRDF alone was Rs. 1,92,988 ha^{-1}. The differences in cultivation costs among treatments were mainly attributed to additional expenditure on DE, foliar silicon sources, and their application. The cost of cultivation under T_{10} was only Rs. 7,192 ha^{-1} higher than that under GRDF alone.

Gross monetary returns: The maximum gross monetary returns (GMR) of Rs. 4,36,280 ha^{-1} were obtained under T_{10}, which was statistically at par with T_9 (Rs. 4,31,280 ha^{-1}), T_8 (Rs. 4,13,480 ha^{-1}) and T_7 (Rs. 4,07,080 ha^{-1}). The minimum GMR of Rs. 1,44,840 ha^{-1} was recorded under the absolute control. Gross monetary returns followed the trend in bulb yield, with T_{10} recording the highest returns due to its superior bulb yield.

Net monetary returns: Treatment T_{10} recorded the maximum net monetary returns (NMR) of Rs. 2,36,100 ha^{-1}, which were statistically at par with those under T_9 (Rs. 2,32,033 ha^{-1}), T_8 (Rs. 2,11,372 ha^{-1}) and T_7 (Rs. 2,05,905 ha^{-1}). The absolute control incurred a loss of Rs. 25,280 ha^{-1}. Treatment T_{10} generated Rs. 1,37,648 ha^{-1} higher NMR than GRDF alone, indicating that the additional expenditure on DE and potassium silicate was economically worthwhile.

B:C ratio: The highest benefit–cost (B:C) ratio of 2.18 was recorded under T_{10}, followed by T_9 (2.16), T_8 (2.05), T_7 (2.02) and T_4 (2.00). GRDF recorded a B:C ratio of 1.51, whereas the absolute control recorded the lowest ratio of 0.85, indicating that the returns from the unfertilised crop were insufficient to cover its cultivation costs. Although T_{10} involved additional investment in silicon application, the resulting increase in yield more than compensated for the extra expenditure. Similar economic benefits of silicon nutrition have been reported by Patil *et al.* (2018) [10], Jawahar *et al.* (2022) [11], Mansoor *et al.* (2022) [12], Prajapat *et al.* (2022) [13] and Barat *et al.* (2025) [14].

Conclusion

The application of GRDF (100:50:50 N:P_2O_5: K_2O kg ha^{-1}+ 10 t ha^{-1}FYM) + soil application of Diatomaceous earth @ 250 kg ha^{-1}at the time of transplanting + two foliar spray of Potassium silicate @ 2 ml L^{-1}at 45 and 75 DAT or two foliar spray of Silicic acid @ 2 ml L^{-1}at 30 and 60 DAT to *rabi* onion was found beneficial for higher monetary returns and yield of onion.

Acknowledgements

The author expresses their sincere gratitude to Department of Soil Science, Mahatma Phule Krishi Vidyapeeth, Rahuri, Ahilyanagar, Maharashtra (413722), India for providing the necessary research facilities and support throughout the investigation.

Disclaimer

The results and conclusions of the present study are derived from a field experiment carried out during the *rabi* season of 2026 at the Post Graduate Institute Research Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra. The findings are applicable to the specific experimental conditions, soil characteristics, onion variety *Phule Swami*

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(RHROR-12) and treatments investigated in this study. As the experiment was conducted during a single cropping season, further research across multiple seasons and locations is necessary to validate the findings and establish their wider applicability.

Conflict of interest

The authors declare no conflicts of interest, and no external funding or sponsorship influenced the study design, data collection, analysis, publication decision, or manuscript preparation.

Table 1. Effect of soil and foliar application of different silicon sources on yield of onion

Tr. No.	Treatment details	Bulb fresh yield (t ha^{-1})
T_1	Absolute control	12.07
T_2	GRDF (100:50:50 N:P_2O_5: K_2O kg ha^{-1}+ 10 t ha^{-1}FYM)	24.29
T_3	GRDF +Soil application of DE @ 250 kg ha^{-1}	31.75
T_4	GRDF +Soil application of DE @ 300 kg ha^{-1}	33.07
T_5	GRDF + Two foliar spray of Silicic acid @ 2 ml L^{-1}at 30 and 60 DAT	26.54
T_6	GRDF + Two foliar spray of Potassium silicate @ 2 ml L^{-1}at 45 and 75 DAT	29.12
T_7	GRDF + Soil application of DE @ 250 kg ha^{-1}+ Two foliar spray of Silicic acid @ 2 ml L^{-1}at 30 and 60 DAT	33.92
T_8	GRDF + Soil application of DE @ 300 kg ha^{-1}+Two foliar spray of Silicic acid @ 2 ml L^{-1}at 30 and 60 DAT	34.46
T_9	GRDF + Soil application of DE @ 250 kg ha^{-1}+ Two foliar spray of Potassium silicate @ 2 ml L^{-1}at 45 and 75 DAT	35.94
T_{10}	GRDF +Soil application of DE @ 300 kg ha^{-1}+ Two foliar spray of Potassium silicate @ 2 ml L^{-1}at 45 and 75 DAT	36.36
	SE ±	1.03
	CD at 5%	3.08

Cost of inpiuts and produce : Urea : 5.77 Rs. kg^{-1} Farm Yard Manure : 1500 Rs. t^{-1}

Table 2. Effect of soil and foliar application of different silicon sources on economics of onion

Tr. No.	Treatment details	Cost of cultivation (Rs ha^{-1})	Gross monetary returns	Net monetary returns	B:C Ratio
T_1	Absolute control	1,70,120	144840	-25280	0.85
T_2	GRDF (100:50:50 N:P_2O_5:K_2Okg ha^{-1}+ 10 t ha^{-1}FYM)	1,92,988	291440	98452	1.51
T_3	GRDF +Soil application of DE @ 250 kg ha^{-1}	1,97,655	380960	183305	1.93
T_4	GRDF +Soil application of DE @ 300 kg ha^{-1}	1,98,588	396800	198212	2.00
T_5	GRDF + Two foliar spray of Silicic acid @ 2 ml L^{-1}at 30 and 60 DAT	1,96,508	318440	121932	1.62
T_6	GRDF + Two foliar spray of Potassium silicate @ 2 ml L^{-1}at 45 and 75 DAT	1,94,580	349480	154900	1.80
T_7	GRDF + Soil application of DE @ 250 kg ha^{-1}+ Two foliar spray of Silicic acid @ 2 ml L^{-1}at 30 and 60 DAT	2,01,175	407080	205905	2.02
T_8	GRDF + Soil application of DE @ 300 kg ha^{-1}+Two foliar spray of Silicic acid @ 2 ml L^{-1}at 30 and 60 DAT	2,02,108	413480	211372	2.05
T_9	GRDF + Soil application of DE @ 250 kg ha^{-1}+ Two foliar spray of Potassium silicate @ 2 ml L^{-1}at 45 and 75 DAT	1,99,247	431280	232033	2.16
T_{10}	GRDF +Soil application of DE @ 300 kg ha^{-1}+ Two foliar spray of Potassium silicate @ 2 ml L^{-1}at 45 and 75 DAT	2,00,180	436280	236100	2.18
	SE ±		12464.37	12464.37	
	CD at 5%		37033.54	37033.54	

Single Super Phosphate : 13.5 Rs. kg^{-1} Diatomaceous Earth : 18 Rs. kg^{-1}
Murate of Potash : 34 Rs. kg^{-1} Silicic acid : 1.76 Rs. ml^{-1}
Selling price of Onion : 12 Rs. kg^{-1} Potassium silicate : 0.8 Rs. ml^{-1}

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How to cite this article: Sanas SR, Kamble B, Thakare RS, Shelke S, Aghav S, Tatpurkar SR, et al. Effect of soil and foliar application of different silicon sources on yield and economics of rabi onion (*Allium cepa* L.) in saline-sodic soil. *International Journal of Agriculture and Food Science*. 2026;8(10):1307-1310. doi: https://www.doi.org/10.33545/2664844X.2026.v8.i10q.2159

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