E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; 7(10): 570-576
Received: 22-07-2024
Accepted: 28-08-2024

Seema Pooniyan
Department of Soil Science and Agricultural Chemistry, Rajasthan College of Agriculture (MPUAT), Udaipur, Rajasthan, India

KK Yadav
Department of Soil Science and Agricultural Chemistry, Rajasthan College of Agriculture (MPUAT), Udaipur, Rajasthan, India

Tushar Kumar
Department of Soil Science and Agricultural Chemistry, Rajasthan College of Agriculture (MPUAT), Udaipur, Rajasthan, India

Monika Choudhary
Department of Agronomy, Rajasthan College of Agriculture (MPUAT), Udaipur, Rajasthan, India

Neha Meena
Department of Soil Science and Agricultural Chemistry, Agriculture University Kota, Rajasthan, India

Mali Ram Nehra
Agriculture Botany, Government Agriculture College, Nawa Didwana Kuchaman, Rajasthan, India

Corresponding Author:
Mali Ram Nehra
Agriculture Botany, Government Agriculture College, Nawa Didwana Kuchaman, Rajasthan, India

Agronomic performance of maize (*Zea maize* L.) under varying fertility and silicon levels in typic haplustepts

Seema Pooniyan, KK Yadav, Tushar Kumar, Monika Choudhary, Neha Meena and Mali Ram Nehra

DOI: https://doi.org/10.33545/2618060X.2024.v7.i10h.1843

Abstract
This investigation was conducted to assess the impacts of altering fertility and silicon levels on agronomic performance of maize at the Instructional Farm of Rajasthan College of Agriculture, (MPUAT), Udaipur in a *kharif* season of 2022 and 2023. The experiment was conducted in split-plot design with three replications. Treatments consists of four fertility levels i.e. control, 50, 75, and 100% RDF in main plots and four silicon levels i.e. control, 100, 200, and 300 kg diatomaceous earth ha^{-1} in subplots. The experimental results revealed that the application of 100% recommended dose of fertilizer significantly increased plant height, dry matter accumulation, grains cob^{-1}, cob weight, seed index and shelling percentage as compared to the control. However, the application of 300 kg Diatomaceous Earth ha^{-1} showed a significant increase in plant height, dry matter accumulation, grains cob^{-1}, cob weight, seed index and peel percentage compared to the control.

Keywords: Maize, silicon, diatomaceous earth, plant, cob

Introduction
Maize (*Zea mays* L.) cultivation occupies an important place in the food grains of our country and is the third most important cereal crop in India and seventh in the world due to its contribution to food and fodder, specialty maize, starch, etc. Maize is sometimes referred to as the miracle crop or "queen of cereals" because of its high yield potential. It contributes directly to about 10 per cent of the Indian food basket and 5 per cent of the global food energy supply. After the agricultural revolution of the 1960s, dramatic changes occurred in maize production and productivity. The adoption of single and double maize hybrids has revolutionized maize production (Kumar *et al.,* 2013) [12]. Its cultivation has outpaced other major traditional cereals because it is high-yielding, easy to process, easy to digest and low-cost compared to other cereals (Olaniyi and Adewale, 2012) [18].
Although Si does not appear on the list of essential elements, it is considered one of the most important beneficial nutrients for plant growth (Laing *et al*., 2006) [14]. The Si content of soils can vary greatly from 1% to 45% (Amin *et al*., 2018) [1]. The potential of Si to increase grain yield has been demonstrated in many studies, especially under biotic (Pathogen attack) and abiotic stress conditions (eg, salinity, drought, high temperature, and heavy metal toxicity) (Galindo, *et al.,* 2021) [5].

Material and method
Description of the study area
This experiment was carried out in Typic Haplustepts (Specifically in Rajasthan College of Agriculture Instruction Farm) in North Eastern area, for two successive cropping seasons (2022-2023). The experimental site is located at 24º.35' N latitude and 73º.42' E longitude and altitude of 582.2 metre above sea level. The study area belongs to the sub-tropical and semiarid climate. The daily rainfall and maximum and minimum temperatures of the study site for the 2022 and 2023 cropping years are displayed in Fig.1. The study area is characterized by unimodal rainfall patters, where more than 80-85 of the rainfall is concentrated in the periods of July to September with a mean annual rainfall of 637 nm.

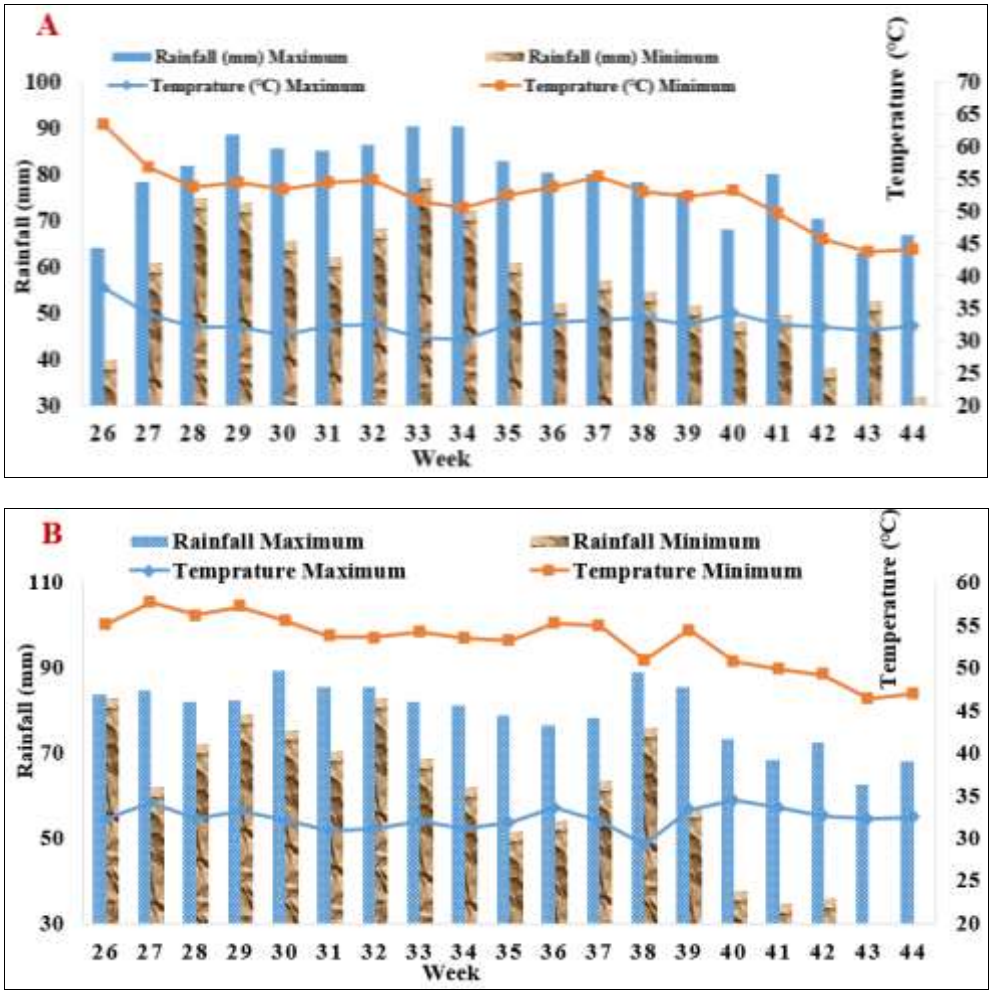

Fig 1: Weekly maximum and minimum rainfall and temperature of the experimental area (A) during 2022 and (B) during 2023

Experimental Design and Treatment

The experiment was arranged in a split-plot design (SPD) having three replications. Treatments were fertility levels (0, 50, 75 and 100% RDF) and four silicon levels (0, 100, 200 and 300 kg DE per hectare). Fertility levels formed the main plot and silicon levels the subplots. A sub plot measured 3.6 m x 5 m having six rows. Treatment plots and replications were separated by 1.0 metre. Fertilizers (N, P, K::90, 60, 40) were applied during final land preparation. Half of the dose N was given at the time of transplanting and the other half was given in two split doses at 30 DAS and 45 DAS through urea. The entire quantity of P and K in the form of diammonium phosphate (DAP) and muriate of potash (MOP), respectively were applied at the time of transplanting. Diatomaceous earth (DE) was used as a source of silicon. Seeds were sown at the onset of rains on 15 and 8 July 2022 and 2023, respectively. A maize seed rate of 25 kg ha^{-1} was used. Seedlings were manually seeded in open trenches at a depth of 3 - 4 cm in rows with a spacing of 60 cm x 25 cm. Seeds were harvested on October 26, 2022 (first year) and October 22, 2023 (Second year).

Agronomic data collection procedures and analysis

Observations were recorded for growth parameters at 45 DAS and at the time of harvesting. The yield attributes i.e. grains cob^{-1}, weight of cob, seed index and shelling percentage were recorded at the time of harvesting of maize.

Statistical analysis of experimental data for analysis of variance was carried out through the procedure suitable for use in split plot design described by Panse and Sukhatme (1985) [19]. Interpretation of the results was based on the 'F' test. Comparison between means was calculated by significant difference (CD) at 5 percent level of significance. Analysis of data collected for two years was done by the method described by Panse and Sukhatme (1985) [19].

Results and Discussion

Effect of Fertility Levels

Growth parameters

Plant height

In this study (Table 1 and Fig.2), the plant height at 45 DAS and at harvest significantly increased with fertility levels up to 75% RDF compared to control (F_0) and 50% RDF (F_{50}). However, the 100% RDF (F_{100}) was statistically at par with 75% RDF (F_{75}). This could be attributed to the mere fact that higher rates of N may have caused rapid cell division and elongation. A similar study reported by Sarwargaonkar *et al.* (2008) [24] and Gul *et al.* (2015) [6] reported a significant increase in the plant height of *kharif* maize with a 100% RDF.

Plant dry matter accumulation

According the pooled data of the present study (Table 1 and Fig.3 & 4), dry matter accumulation $plant^{-1}$ at 45 DAS and at harvest significantly increased with fertility levels up to 75% RDF (F_{75}) compared rest of the treatments which was at par with 100% RDF. However, the significantly increased dry matter in pooled mean with the application of 100% RDF (F_{100}). The recommended fertilizer dose is the bottom line for numerous physiological and biochemical processes in plants, such as

increasing photosynthetic efficiency and allowing plants to synthesize more carbohydrates, which leads to increased plant dry matter accumulation. Similar outcomes were reported by Sharma *et al*., 2020 [27] and El-Fouly and Shaaban, 2021 [4].

Yield attributes

Grains cob^{-1}

The grains cob^{-1} (Table 1 and Fig.5) increased significantly up to the application of 75% RDF, which was at par with 100% RDF (F_{100}). Adequate nutrition promotes pollen viability and stigma receptivity, increasing the likelihood of successful pollination and grain cob^{-1}. Similar results were reported by Usman *et al*. (2015) [29], Shah and Wani (2017) [25], Ngosai *et al*. (2018) [17] and Shahi *et al*. (2020) [26].

Cob weight

The application of 100% RDF (F_{100}) recorded maximum cob weight of maize followed by 75% RDF (Table 1 and Fig.6). The cobs develop fully and consistently, adding weight, if they receive an adequate amount of nutrients during the important growth phases, especially during grain filling. These are in accordance with the finding of Prajapati *et al*. (2018) [22] and Mohammed *et al*. (2023) [15].

Seed index

The seed index was significantly increased with the application of 75% RDF (F_{75}) which was at par with the 100% RDF. Among, the maximum seed index was found in 100% fertility level (Table 1 and Fig.7). Fertilizer application increased vegetative growth, energy transfer, root development, water regulation and disease resistance. They support healthy and heavy grains in cob which leads to improved seed index. Many researchers (Laghari *et al.*, 2024 and Ibrahim *et al.*, 2022) [13, 7] observed that different fertility levels did significantly improved the seed index of maize.

Shelling percentage

The maximum shelling percentage was found under the application of 100% RDF (F_{100}) which was at par with 75% RDF (Table 1 and Fig.8). These fertility levels improve kernel development and filling, increasing the percentage of kernels to shells. Similar studies were given by Remison and Eifediyi (2014) [23] and Laghari *et al*. (2024) [13].

Effect of Silicon Levels

Growth parameters

Plant height

The plant height at 45 DAS and harvest significantly increased with fertility levels up to 200 kg DE ha^{-1} (Si_{200}) compared to control (Si_0) and 100 kg DE ha^{-1} (Si_{100}); however, the fertility levels 300 kg DE ha^{-1} (Si_{300}) was statistically at par with Si_{200} (Table 1 and Fig.2). A significant increase in plant height of maize with different levels of silicon was observed which may be attributed to increased cell division and elongation with Si which is positively correlated to the productive potential of the crop. Amoli (2012) [2], Pati *et al.* (2016) [20] and Jan *et al*. (2018) [8] were also reported similar findings.

Dry matter accumulation plant^{-1}

The largest plant dry matter accumulation occurred when 300 kg DE ha^{-1} (Si_{300}) was applied, at par with 200 kg DE ha^{-1} (Table 1 and Fig.3 & 4). Silicon is accumulated into plant cell walls, increasing their stiffness and mechanical strength. This improves the structural integrity of plant tissues, allowing for increased biomass accumulation. Similar results were found by Pati *et al*., 2018 [22].

Yield attributes

Grains cob^{-1}

The maximum grains cob^{-1}, cob weight, seed index and shelling percentage was recorded under 300 kg DE ha^{-1} (Si_{200}), which was at par with 200 kg DE ha^{-1} (Table 1 and Fig.5). Applying silicon promotes better root development, improving nutrient uptake and water absorption, leading to stronger and more productive crops. Jawahar *et al*. (2019) [9] also reported that the increased photosynthetic activity, synthesis of starch content and dry matter accumulation. Similar results were given by Stephano *et al*. (2021) [28] and Nagaratna *et al*. (2023) [16].

Cob weight

The cob weight increased (Table 1 and Fig.6) with the increasing levels of silicon but significantly up to 200 kg DE ha^{-1} (Si_{200}). Cob weight was statistically at par 200 and 300 kg DE ha^{-1}. Silicon increases the photosynthetic efficiency of maize plants which leads to increased energy availability for cob and grain development. Similar results were also observed in maize by Kumar *et al*. (2018) [11].

Seed index

The seed index (Table 1 and Fig.7) increased as silicon levels increased, but only considerably up to 200 kg DE ha^{-1}, which was at par with 300 kg DE ha^{-1} (Si_{300}). Applying silicon to plants improves their resistance to several abiotic stress, including salt, drought, and heavy metal toxicity. The plants become healthier and more productive as their stress resistance increases, which raises the seed index. Similar studies were reported by Kalyani *et al.* (2023) [10].

Shelling percentage

The maximum shelling percentage (Table 1 and Fig.8) of maize was recorded under the application of 300 kg DE ha^{-1} (Si_{300}). Silicon helps plants deal with a variety of abiotic stress, including drought, salt, and severe temperatures. By decreasing the impact of these pressures, plants can devote more energy to seed development, resulting in better seed filling and higher shelling rate. The same results were quoted by Atta *et al*. (2022) [3].

Table 1: Effect of fertility and silicon levels on growth and yield attributes of maize

Treatments	Growth parameters				Yield attributes			
	Plant height (cm)		DMA (g plant^{-1})		Grains cob^{-1}	Cob weight (g)	Seed index (g)	Shelling percentage
	At 45 DAS	At harvest	At 45 DAS	At harvest				
Fertility levels								
Control	102.7	153.9	44.85	177.9	338.5	182.8	19.76	64.78
50% RDF	121.8	194.1	54.59	203.4	407.2	208.3	21.84	69.89
75% RDF	133.7	214.4	63.98	224.5	455.0	229.4	23.62	74.00
100% RDF	136.0	222.5	67.42	237.5	476.6	241.4	24.34	74.99
S.Em.±	1.87	3.67	1.12	2.92	7.1	3.0	0.36	0.44
C.D. (P=0.05)	5.77	11.32	3.46	9.00	21.9	9.4	1.10	1.37
Fertility levels								
Control	112.6	177.0	50.65	189.1	341.6	193.8	20.54	66.53
100 kg DE ha^{-1}	120.5	190.3	56.19	205.3	406.9	209.9	21.93	70.16
200 kg DE ha^{-1}	128.6	205.3	60.63	221.1	456.2	225.8	23.32	72.84
300 kg DE ha^{-1}	132.4	212.4	63.38	227.8	472.7	232.4	23.75	74.14
S.Em.±	1.57	2.80	1.04	2.31	7.0	2.3	0.33	0.39
C.D. (P=0.05)	4.45	7.95	2.96	6.57	19.8	6.7	0.94	1.12

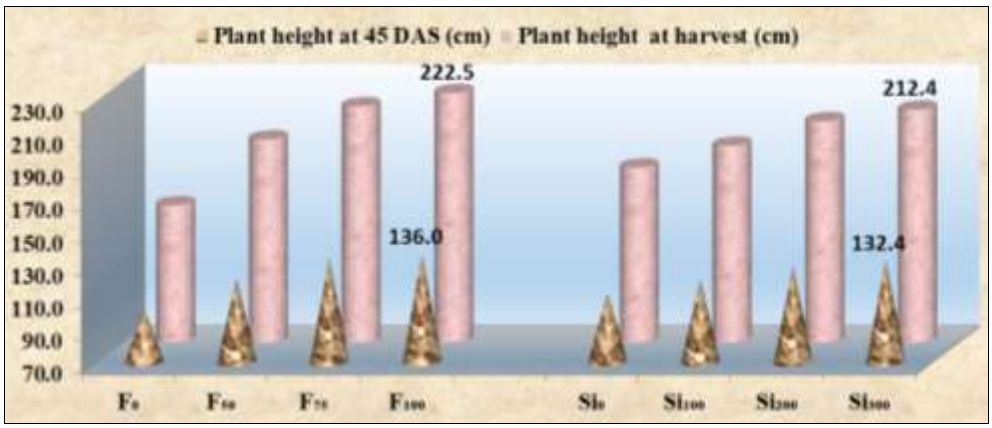

Fig 2: Effect of fertility and silicon levels on plant height

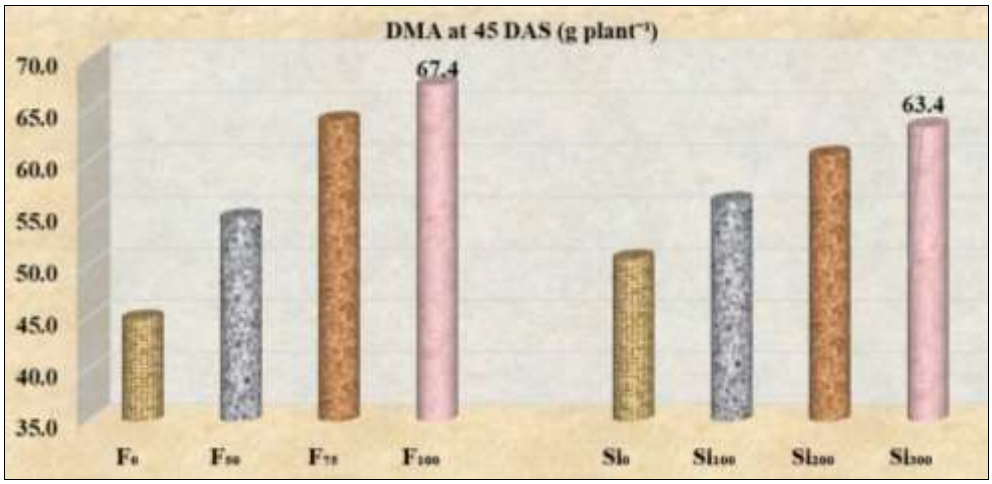

Fig 3: Effect of fertility and silicon levels on plant dry matter accumulation at 45 DAS

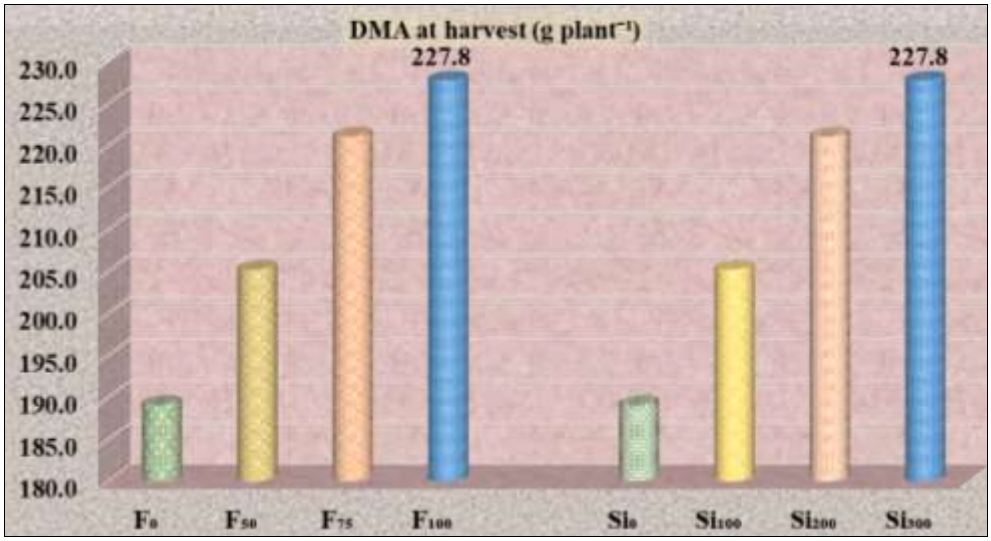

Fig 4: Effect of fertility and silicon on plant dry matter accumulation at harvest

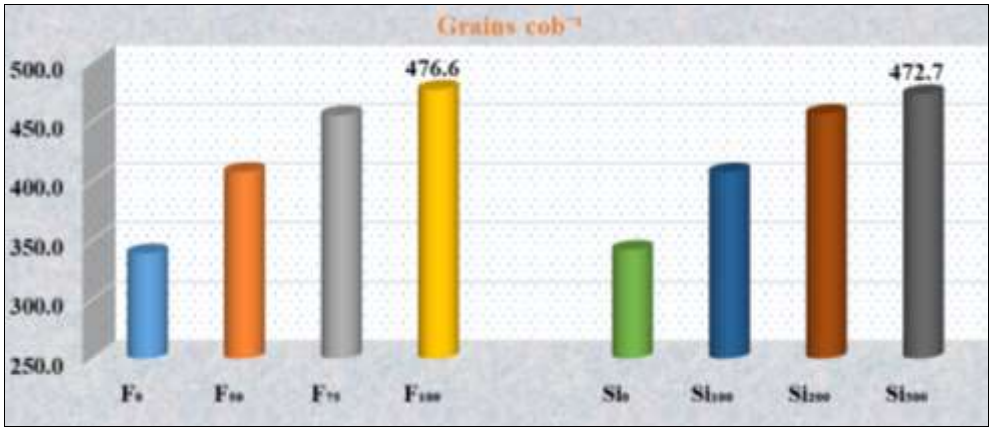

Fig 5: Effect of fertility and silicon on grains cob^{-1}

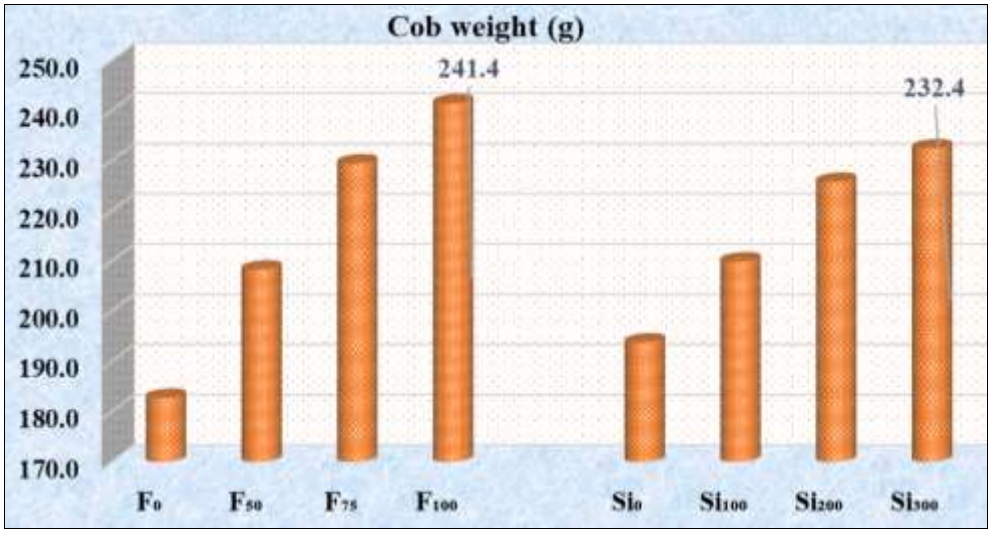

Fig 6: Effect of fertility and silicon on cob weight

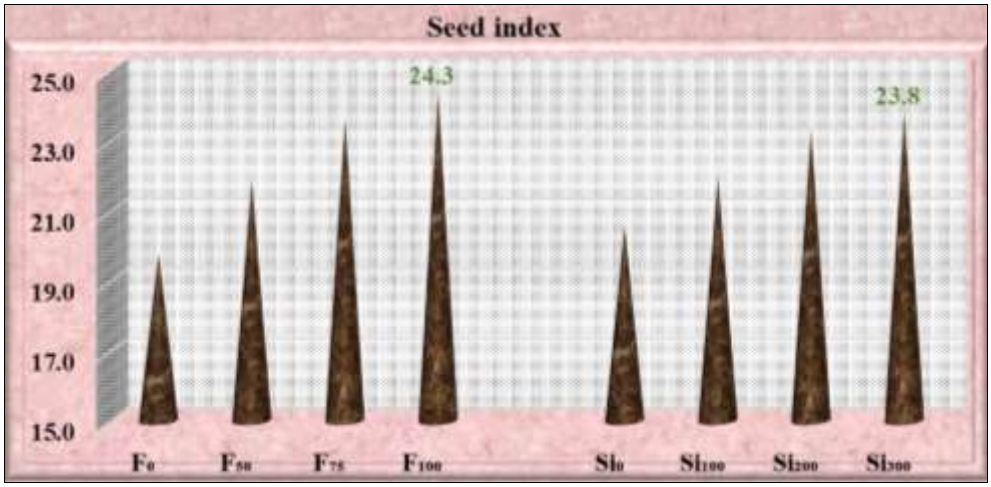

Fig 7: Effect of fertility and silicon on seed index

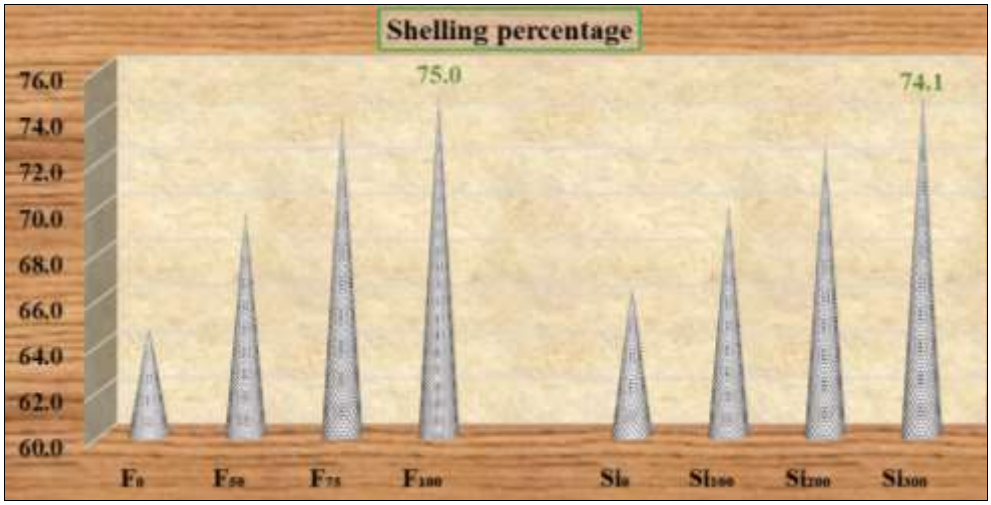

Fig 8: Effect of fertility and silicon on shelling percentage

Conclusion

The study concluded that farmers had increased plant height, dry matter accumulation, grains cob^{-1}, cob weight, seed index, and shelling % by increasing fertilizer and silicon application rates. The maximum growth and yield attributes were found under 100% RDF (F_{100}) level. On the other hand, the application of 300 kg DE ha^{-1} (Si_{300}) recorded higher agronomic performance of maize.

Statement for data availability

The data about the research entitled, "Agronomic Performance of Maize (*Zea maize* L.) under varying Fertility and Silicon Levels in Typic Haplustepts" is available on a special request basis and will be submitted to you if needed.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

This research was fully funded by Rajasthan College of Agriculture, (MPUAT), Udaipur. The authors are grateful for the financial support provided by University.

References

1. Amin M, Ahmad R, Ali A, Hussain I, Mahmood R, Aslam M, Lee DJ. Influence of silicon fertilization on maize performance under limited water supply. Silicon. 2018;10:177-183.
2. Amoli N. Investigation adaptation of lettuce varieties in different date sowing climatic condition. Indian J Adv Chem Sci. 2012;4:1867-1873.
3. Atta MMM, Abd-El-Salam RM, Abdel-Lattif HM, Garang MA. Effect of silicon on maize under water deficit conditions at flowering stage. J Breed Genet. 2022;54(4):948-962.
4. El-Fouly MM, Shaaban SHA. Effect of different levels of NPK and micronutrient on yield and distribution of nutrients in maize under irrigated agriculture. Agric Eng Int: CIGR J. 2021;23(4):198-208.
5. Galindo FS, Pagliari PH, Rodrigues WL, Fernandes GC, Boleta EHM, Santini JMK, *et al*. Silicon amendment enhances agronomic efficiency of nitrogen fertilization in maize and wheat crops under tropical conditions. Plants. 2021;10(7):1329.
6. Gul S, Khan MH, Khanday BA, Nabi S. Effect of sowing methods and NPK levels on growth and yield of rainfed maize (*Zea mays* L.). Scientifica. 2015;2015:198575. Available from: https://doi.org/10.1155/2015/198575.
7. Ibrahim AK, Ahmed U, Girei AH. Effect of NPK fertilizer and agrolyser on growth, yield and yield components of maize in Northeastern Nigeria. Ife J Agric. 2022;34(2):61-74.
8. Jan R, Aga FA, Bahar FA, Singh T, Lone R. Effect of nitrogen and silicon on growth and yield attributes of

transplanted rice (*Oryza sativa* L.) under Kashmir conditions. J Pharmacogn Phytochem. 2018;7(1):328-332.
9. Jawahar S, Jain N, Kumar SRV, Kalaiyarasam C, Arivukkarasu K, Ramesh S, *et al*. Effect of silicon on silicon uptake and blast incidence in low land rice. J Pharmacogn Phytochem. 2019;8(3):2275-2278.
10. Kalyani M, Mehera B, Kumar P. Effect of zinc and foliar application of silicon on growth and yield of maize (*Zea mays* L.). Int J Plant Soil Sci. 2023;35(5):141-146.
11. Kumar MS, Karthikeyan R, Maragatham N. Effect of silicon fertilization on growth and yield of hybrid maize under irrigated and rainfed conditions. Madras Agric J. 2018;105(10-12). Available from: https://doi:10.29321/MAJ 2018.000198.
12. Kumar R, Srinivas K, Sivaramane N. Assessment of the maize situation, outlook and investment opportunities in India. Country Report-Regional Assessment Asia (MAIZE-CRP). National Academy of Agricultural Research Management; 2013. p. 133.
13. Laghari A, Buriro M, Talpur KH. Impact of different NPK levels and sowing methods on maize growth, yield, and quality characteristics. Pak J Biotechnol. 2024;21(1):61-66.
14. Laing MD, Gatarayiha MC, Adandonon A. Silicon use for pest control in agriculture: a review. In: Proceedings of the South African Sugar Technologists' Association. 2006;80:278-286.
15. Mohammed BA, Khandaker MM, Arshad AM, Nudin NFH, Majrashi A, Mohd KS. Effects of foliar NPK application on growth, yield and nutrient content of sweet corn grown on Rengam Series soil. Basrah J Agric Sci. 2023;36(1):254-270.
16. Nagaratna W, Kalleshwaraswamy CM, Dhananjaya BC, Prakash NB, Deshmukh SS, Sunil C, *et al*. Silicon accumulation in leaves reduces the herbivory by invasive fall armyworm Spodoptera frugiperda and enhances the yield of maize. Int J Plant Biol. 2023;14(3):701-713.
17. Ngosai K, Sharma YK, Sharma SK, Bordoloi J. Maize (*Zea mays* L.) productivity and soil properties as affected by fertility levels under Nagaland condition. Ann Plant Soil Res. 2018;20(4):349-353.
18. Olaniyi OA, Adewale JG. Information on maize production among rural youth: A solution for sustainable food security in Nigeria. Libr Philos Pract. 2012;724. Available from: https://digitalcommons.unl.edu/libphilprac/724.
19. Panse VG, Sukhatme PV. Statistical methods for agriculture workers. New Delhi: ICAR; c1985.
20. Pati S, Pal B, Badole S, Hazra GC, Mandal B. Effect of silicon fertilization on growth, yield, and nutrient uptake of rice. Commun Soil Sci Plant Anal. 2016;47(3):284-290.
21. Pati S, Saha S, Saha S, Pal B, Saha B, Hazra GC. Soil application of silicon: effects on economic yield and nutrition of phosphorus, zinc and iron in rice. J Indian Soc Soil Sci. 2018;66:329-335.
22. Prajapati VK, Swaroop N, Masih A, Lakra R. Effect of different doses of NPK and vermicompost on growth and yield attributes of maize [*Zea mays* (L.)] Cv. MM2255. J Pharmacogn Phytochem. 2018;7(1):2830-2832.
23. Remison SU, Eifediy EK. Effects of different organic materials and NPK fertilizer on the performance of maize. Poljoprivreda. 2014;20(1):16-12.
24. Sarwargaonkar GL, Shelke DK, Shinde SA, Kshirsagar S. Performance of kharif maize based legume intercropping system under different fertilizer doses. Int J Agric Sci. 2008;4(1):152-155.
25. Shah RA, Wani BA. Yield, nutrient uptake and soil fertility of maize (*Zea mays* L.) as influenced by varying nutrient management practices under temperate conditions of Kashmir Valley, India. Plant Arch. 2017;17(1):75-78.
26. Shahi UP, Singh VK, Kumar A, Singh P, Dhyani BP, Singh A. Effect of site-specific nutrient management on productivity, soil fertility and nutrient uptake in maize (*Zea mays*). Indian J Agronomy. 2020;65(4):432-438.
27. Sharma V, Singh MJ, Khokhar AK. Productivity, nutrient uptake and soil properties as influenced by integrated nutrient management in maize-wheat cropping system under rainfed conditions of sub-montane Punjab. Agric Res J. 2020;57(6):839-847.
28. Stephano MF, Geng Y, Cao G, Wang L, Meng W, Meiling Z. Effect of silicon fertilizer and straw return on the maize yield and phosphorus efficiency in Northeast China. Commun Soil Sci Plant Anal. 2021;52(2):116-127.
29. Usman M, Nangere MG, Musa I. Effect of three levels of NPK fertilizer on growth parameters and yield of maize-soybean intercrop. Int. J Sci. Res Publ. 2015;5(9):1-6.