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Influence of silicon and nitrogen on chlorophyll content of rice var. TKM-13 in Entisol

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Abstract
Field experiment was conducted to study the influence of various silicon sources viz., Calcium Silicate (CS) and Fly ash (FA) along with graded levels of nitrogen in rice (TKM 13) on Entisol. The soil of experimental field was sandy clay loam with alkaline pH and non-saline in nature. The main plot treatments includes different levels of nitrogen viz., 0%, 75%, 100% and 125% recommended dose of nitrogen. The sub plot treatments includes CS @ 200, 400 and 600 kg ha^{-1} and FA @ 10, 20 and 30 t ha^{-1}. The experiment was conducted in split plot design and the treatments were replicated thrice. The SPAD values and chlorophyll a, b and total chlorophyll content were recorded at tillering, panicle initiation and harvest stages. Regarding Si application the highest SPAD value was noticed with FA 30 t ha^{-1} (29.9) at tillering stage followed by FA 20 t ha^{-1} (28.7) and CS 600 kg ha^{-1} (27.4) and were found to be significant with each other. Similarly application of N levles significantly increased the SPAD values and highest was recorded in 125% N (34.3) followed by 100% N (31.7), 75% N (22.8) and 0% N (18.0) at tillering stage. The similar trend of SPAD value was followed for panicle initiation and harvest stage. The highest total chlorophyll content with regards to Si application along with nitrogen registered the highest value in 125% N + FA 30 t ha^{-1} (1.97, 2.33 and 1.40 mg g^{-1} at tillering, panicle initiation and harvest stage respectively). Similar trend was followed for chlorophyll a and b at all the stages. The results revealed that application of CS or FA along with nitrogen significantly increased the SPAD value and chlorophyll content of rice at all critical stages.

Keywords: Calcium silicate (CS), fly ash (FA), nitrogen (N), SPAD and chlorophyll content

Introduction
Rice (*Oryza sativa*) is a staple food that accounts for more than 22% of world's population calorie intake (Wailes *et al*., 1997) [27]. Silicon is an essential component of rice plants and its accumulation is helpful in maintaining sustainable production (Yamaji and Ma, 2011) [28]. One of the inputs limiting rice production is N (Tirol-Padre *et al*., 1996) [25]. Nitrogen is essential to the rice plant, with about 75% of leaf N associated with chloroplasts, which are physiologically important in dry matter production through photosynthesis (Dalling, 1985) [5]. Nitrogen contributes to carbohydrate accumulation in culms and leaf sheaths during the pre heading stage and in grain during the grain-filling stage by being a component of photosynthesis (Mae., 1997) [12]

Silicon application resulted in an increase of chlorophyll and an improvement in the antioxidant system in plants (Al-aghabary *et al*. 2004) [2]. Silicon nutrition improves the light receiving posture of the plants, thereby stimulating photosynthate production in plants (Savant *et al*., 1997) [20]. It improves the leaf angle, making leaves more erect, thus reducing self-shading, especially under high N-rates (Yoshida *et al*., 1969) [29]. The effect of Si on leaf erectness is mainly due to Si depositions in the epidermal layers of the leaf panicle (Takahashi and Miyake, 1982) [24]. So, that objective was made to study the influence of silicon and nitrogen on chlorophyll content for rice (*Orzya sativa*) in Entisol.

Materials &Methods
The field experiment was carried out at Sugarcane Research Station, Sirugamani, Trichy during *Rabi* season of 2017-18 for the purpose of studying the influence of soil application of different source of silicon along with levels of nitrogen in chlorophyll content in TKM 13 genotypes of rice (*Oryza sativa* L.). The experimental soil was mixed alluvium soil series (*Typic Ustifluvent*). The initial soil was found to be slightly alkaline with low soluble salts, low organic carbon, low available N and low available Silicon, medium in available P and K.

The rice TKM 13 was used as a test crop in the experimental plot was carried out in Split Plot design having four main plot with seven sub plots treatment combinations replicated thrice.

The treatment details are: Main plot with different nitrogen levels M_1- 0% RD of N, M_2- 75% RD of N, M_3-100% RD of N and M_4- 125% RD of N. The subplots treatment with silicon sources includes Si_1 – Control, Si_2 - CS @ 200 kg ha^{-1}, Si_3 - CS @ 400 kg ha^{-1} and Si_4 - CS @ 600 kg ha^{-1} and Si_5 - FA @ 10 t ha^{-1}, Si_6 - FA @ 20 t ha^{-1} and Si_7 - FA @ 30 t ha^{-1}. SPAD Chlorophyll Meter Reading (SCMR) values were measured by using a SPAD meter (SPAD-502) in the third leaf from the top, in the main culm of tagged hills. The Minolta SPAD-502 measures chlorophyll content as ratio of transmittance of light at wavelength of 650 nm and 940 nm. Three readings were taken from each replication and the average value computed using method described by Minolta (1989) [14] and Monje and Bughree (1992) [15].

Chlorophyll content was determined on the flag leaf by using the method described by Hiscox and Israelstam (1979) [7] and expressed in mg g^{-1} fresh weight. 100 mg of fully expanded young leaf tissue was placed in vial containing 10 ml of Dimethyl sulphoxide (DMSO) and chlorophyll was extracted without grinding at 65°C by incubating overnight. The extract was transferred to graduated tube and made upto 10 ml with DMSO and assayed immediately.

Result and discussion

SPAD Values

Chlorophyll (Chl) is a photosynthetic pigment and act as an essential factor of the plants photo system. Chlorophyll content of rice leaves measured as SPAD value was significantly influenced by silicon and nitrogen levels at different growth stages over control.

The Chlorophyll content as SPAD values ranged from 18.4 to 34.3 at tillering stage 19.5 to 36.8 at panicle initiation and 14.3 to 26.5 at harvest stage. Chlorophyll content markedly changed with increasing dose of nitrogen applied. It increased linearly and maximum value was noticed with 125% N (34.3, 36.8 and 26.5 (fig 1) in tillering, panicle initiation and harvest stage respectively). It was significantly superior to rest of N levels. The linear relationships for chlorophyll content and N application rate have been documented by Abunyewa *et al*. (2016) [1]. The SPAD value-based N application can increase grain yield and N use efficiency (Peng *et al.*, 1998) [17].

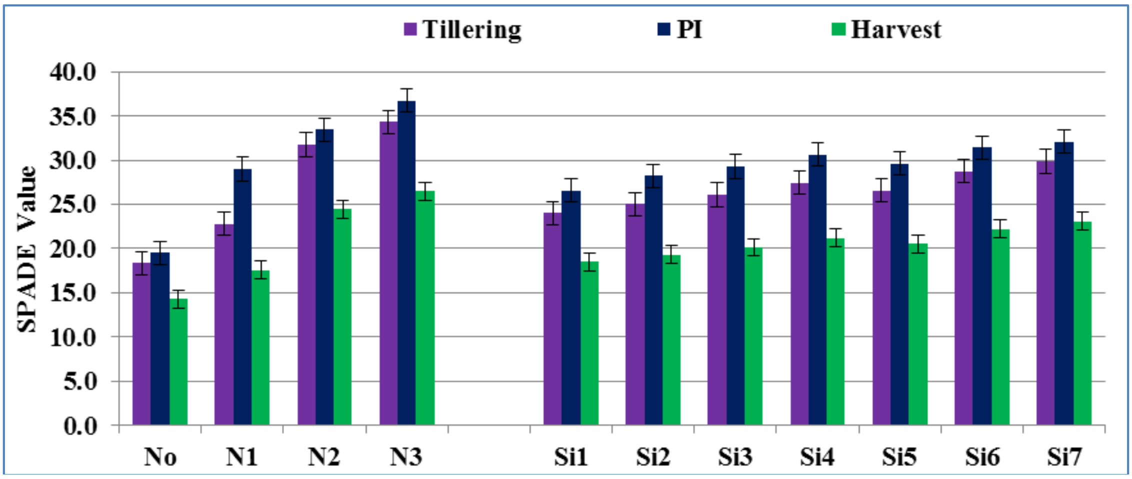

Fig 1: Effect of Si and N on SPAD value of Rice in various growth stages in Entisols

Addition of different source of silicon caused slight increase of SPAD values. The chlorophyll content increased linearly and the highest was noticed with FA 30 t ha^{-1} (29.9, 32.1 and 23.1 during tillering, panicle initiation and harvest stage respectively). It was superior to rest of silicon levels. Similarly application of Si through CS significantly increased the SPAD values (27.4, 30.6 and 21.2 at tillering, panicle initiation and harvest stage respectively). Increase in SPAD value and chlorophyll content by silicon application over control was reported earlier song *et al.*, (2014) [23] in rice.

When silicon and nitrogen were applied together SPAD value increased further compared to the individual application of silicon and nitrogen. The highest chlorophyll content was registered in 125% N + FA 30 t ha^{-1} (37.3, 39.5 and 28.8 at tillering, panicle initiation and harvest stage respectively). The maintenance of high photosynthetic activity and higher utilization of light and translocation of assimilated product to sink (Rani and Narayanan, 1994) [18] due to silicon application along with nitrogen could be the possible reason for increasing SPAD readings. Si treatments of plants induces an accumulation of enzymes involved in photosynthesis and detoxification of reactive oxygen species (Schmidst *et al.*, 1999) [21] and also phytohormone synthesis (Rodrigues *et al.*, 2015) [19]. SPAD values and net photosynthetic activity remained significantly higher in + Si resupplied with N plants in –Si with N mature leaves observed by Haddad *et al.*, 2018 [8].

Chlorophyll a

The influence of silicon source on chlorophyll content in flag leaf of TKM 13 at the time of Panicle initiation was evaluated. FA 30 t ha^{-1} (1.33 mg g^{-1}) showed maximum chlorophyll a content and the minimum in without Si (1.23 mg g^{-1}). However silicon applied treatment showed maximum increase (8.13%) in FA @ 30 t ha^{-1} and minimum (2.43%) in CS @ 200 kg ha^{-1} where compared to control. Among all the Si applied treatments the chlorophyll a content of FA @ 30 t ha^{-1} (1.33 mg g^{-1}), FA @ 20 t ha^{-1} (1.31 mg g^{-1}), CS @ 600 kg ha^{-1} (1.30 mg g^{-1}) and FA @ 10 t ha^{-1} (1.28 mg g^{-1}) was found statistically significant with respect to each other compared to control. Similarly chlorophyll a recorded by the application of N @ 125%, 100%, 75% and 0% (1.45, 1.42, 1.29 and 0.98 mg g^{-1}) (fig. 2) at panicle initiation respectively, which is found to record highest chlorophyll a compare to tillering and harvest stage. The highest chlorophyll a content was registered in 125% N + FA 30 t ha^{-1} (1.26 mg g^{-1}) at tillering, (1.50 mg g^{-1}) panicle initiation and (0.80 mg g^{-1}) harvest stage respectively. The results are in line with Ávila *et al.* (2010) [4] where the interaction between silicon and nitrogen as it increases the levels of chlorophyll a in *Oryza sativa* plants.

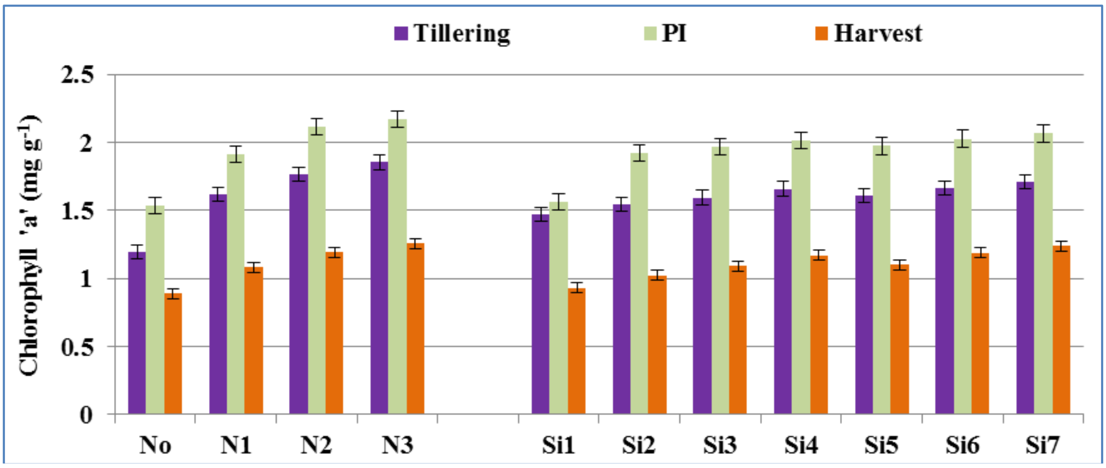

Fig 2: Effect of Si and N on Chl 'a' of Rice in various growth stages in Entisols

Chlorophyll b

Chlorophyll b content (mg g^{-1}) silicon applied treatment FA @ 30 t ha^{-1} (0.61 mg g^{-1}) showed maximum chlorophyll b content and the minimum in CS @ 200 kg ha^{-1} (0.54 mg g^{-1}). chlorophyll b recorded by the application of N @ 125%, 100%, 75% and 0% (0.65, 0.62, 0.55 and 0.45 mg g^{-1}) (fig. 3) at panicle initiation was found statistically significant. The interaction between Si and N was found statistically significant with respect to almost all the treatments. The steady increase of chlorophyll a and b was noticed upto PI later slight decrease was observed at harvest stage. The result are in line with Liu *et al.*, 2014 [9], where the Silixol in different concentration can induced progressive increased in chlorophyll a, chlorophyll b, as well as total chlorophyll in rice. Silicon helps in increasing the extent of photosynthesis, the improvement of performance, the prevention of lodging (Jeer *et al*., 2017) as well as the reduction of the negative effects of ultraviolet radiation on the physiological processes of photosynthesis and transpiration (Lou *et al.*, 2016). Significant relationship between SPAD values and chlorophyll content has been reported by Martinez and Guiamet (2004) [13].

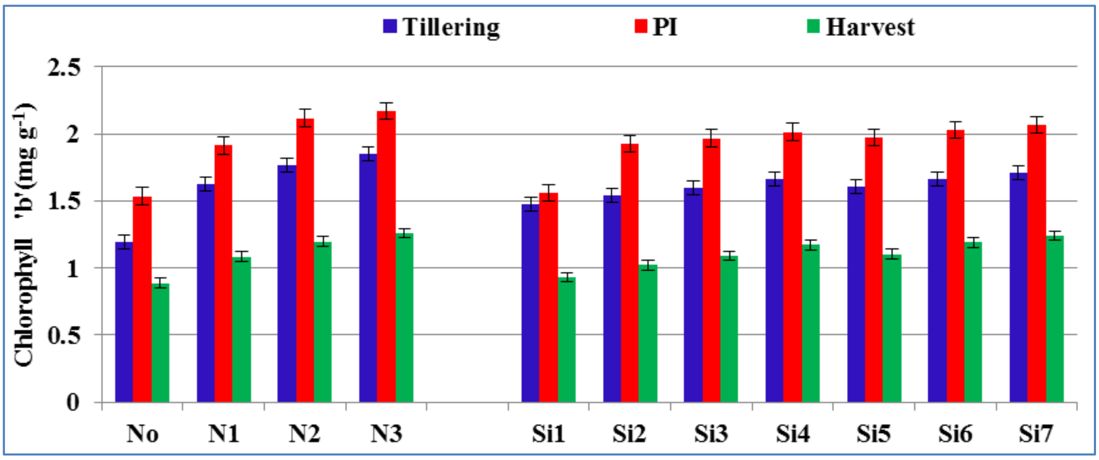

Fig 3: Effect of Si and N on Chl 'b' of Rice in various growth stages in Entisols

Total Chlorophyll

Total Chlorophyll content markedly changes with increasing dose of nitrogen applied. It increased linearly and maximum value was noticed with 125% N (1.71, 2.01 and 1.26 mg g^{-1}) in tillering, panicle initiation and harvest stage respectively. It was significantly superior to rest of N levels. Nitrogen applied treatment showed maximum increase in 125% N followed by 100% N where compared to 0% N.

Addition of different source of silicon caused slight increase of total chlorophyll content. Similarly application of Si through CS significantly increased the total chlorophyll to (1.59, 1.85 and 1.17 mg g^{-1} at tillering, panicle initiation and harvest stage respectively). The total chlorophyll content increased slightly and the highest was noticed with FA30 t ha^{-1} (1.61, 1.91 and 1.24 mg g^{-1}) during tillering, panicle initiation and harvest stage respectively. It was superior to rest of silicon levels. However silicon applied treatment showed maximum increase percentage in FA 30 t ha^{-1} and minimum in CS 200 kg ha^{-1} when compared to control. Among all the treatments. Similar results observed were Si priming significantly enhanced their biomass and improved the levels of photosynthetic pigments recorded by Parveen *et al.*, (2019) [16]

When silicon and nitrogen were applied together total chlorophyll content increased further compared to the individual application of silicon and nitrogen. The highest total chlorophyll content of silicon was registered in 125% N and FA 30 t ha^{-1} (1.71 mg g^{-1}) at tillering, (2.01 mg g^{-1}), panicle initiation and (1.26 mg g^{-1}) (fig 4) harvest stage respectively. The rice seedlings showed that the chlorophyll content of leaves decreases during senescence suggesting that the loss of chlorophyll is a main cause of inactivation of photosynthesis. Silicon uptake leads to stronger straw and reduces lodging. It also appears to promote photosynthesis through the depression of excessive transpiration (Ma and Takahashi, 1990) [11]. By addition of higher Si application to the soil, Chl a, Chl b and Chl (a + b) contents in leaves found to be increased reported by Verma *et al*., 2019 [26]

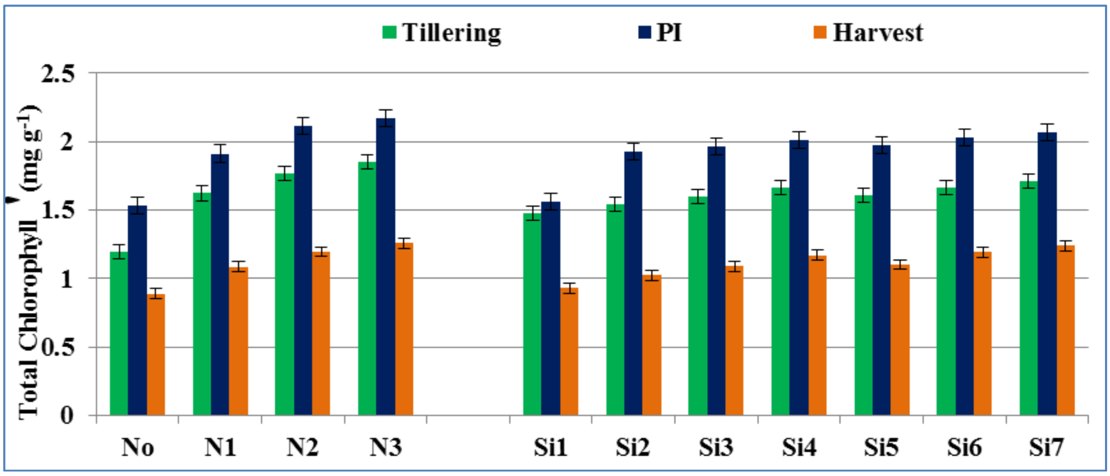

Fig 4: Effect of Si and N on total chlorophyll of Rice in various growth stages in Entisols

Conclusion
The present study concluded that silicon fertilizers along with nitrogen were efficiently used by rice for increasing the chlorophyll content which converts light into chemical energy needed for photosynthesis. Application of Si induced erectness of leaves result in the increase of photosynthesis. An adequate supply of nitrogen might result in high photosynthetic activity. As nitrogen is an integral part of chlorophyll, vigorous vegetative growth and gives dark green colour. The results clearly indicated that silicon either through calcium silicate or through fly ash along with nitrogen is required for rice for the growth and development of crop which will result in ultimately the yield.

Reference

1. Abunyewa AA, Richard B Ferguson, Charles S Wortmann, Stephen C Mason. Grain sorghum leaf reflectance and nitrogen status. Afr. J Agri. Res. 2016; 11(10):825-836.
2. Al-aghabary K, Zhu Z, Shi Q. Influence of silicon supply on chlorophyll content, chlorophyll fluorescence, and antioxidant enzyme activities in tomato plants under salt stress. Journal of Plant Nutrition. 2004; 27:2101-2115.
3. Amujoyegbe BJ, Opabode JT, Olayinka A. Effect of organic and inorganic fertilizer on yield and chlorophyll content of maize (*Zea mays* L.) and sorghum *Sorghum bicolour* (L.) Moench). Afr. J Biotechnol. 2010; 6(16):1869-1873.
4. Avila FW, Baliza DP, Faquin V, Araujo JL, Ramos SJ. Silicon-nitrogen interaction in rice cultivated under nutrient solution. Rev. Cien. Agron. 2010; 41:184-190
5. Dalling MJ. The physiological basis of nitrogen redistribution during filling in cereals. p. 55-71. In J.E. Harper *et al.* (ed.) Exploitation of physiological and genetic variability to enhance crop productivity. Am. Soc. of Plant Physiologists, Rockville, MD, 1985.
6. Georgescu M, Lobell DB, Field CB. Direct climate effects of perennial bioenergy crops in the United States. Proceedings of the National Academy of Sciences (USA). 2011; 108:4307-4312.
7. Hiscox JD, Isralesham GF. A method for extraction of chlorophyll from leaf tissue without maceration. Can. J Bot. 1979; 57:1332-1334.
8. Haddad, Cylia, Mustapha Arkoun, Franck Jamois, Adrian Schwarzenberg, Jean – Claude Yvin, *et al.* Silicon promotes Growth of *Brassica napus* L and Delays Leaf Senescence Induces by Nitrogen Stravation. Front. Plant Sci., 2018.
9. Li S, Li B, Cheng C, Xiong Z, Liu Q, Lai J. Genomic signatures of near-extinction and rebirth of the crested ibis and other endangered bird species. Genome Biology. 2014; 15(12):1-17.
10. Liang Y, Sun W, Zhu YG, Christie P. Mechanisms of silicon-mediated alleviation of abiotic stresses in higher plants: A review. Environmental Pollution. 2007; 147:422-428.
11. Ma J, Takahashi E. 'The effect of silicic acid on rice in a P-deficient soil', Plant and Soil. 1990; 126:121-125.
12. Mae T. Physiological nitrogen efficiency in rice: Nitrogen utilization, photosynthesis, and yield potential. Plant Soil. 1997; 196:201-210.
13. Martinez D, Juan Guiamet. Distortion of the SPAD 502 chlorophyll meter readings by changes in irradiance and leaf water status**.** Agronomie. 2004; 24:41-46.
14. Minolta C. Manual for Chlorophyll meter SPAD-502. Minolta Cameraco, Osaka, Japan, 1989.
15. Monje OA, Bughree B. Inherent limitation of non-destructive chlorophyll meters. A comparison of two types of meters. Horti. Sci. 1992; 27:71-89.
16. Parveen Abida, Wei Liu, Saddam Hussain, Jaleel Asghar, Shagufta Parveen, Yousheng Xiong. Silicon Priming Regulates Morpho – Physiological Growth and Oxidative Metabolism in Maize under Drought Stress. Plants. 2019; 8(10):431.
17. Peng S, Yang JU, Carcia FV, Laza RC. Physiology based crop management for yield maximization of hybrid rice. In: "Advances in Hybrid Rice Technology". In: Proc. 3rd Intl. Symp. on Hybrid rice. Intl. Rice Res. Ins., Los Banos, Philippines, 1998, 157-176p.
18. Rani YA, Narayanan A. Role of silicon in plant growth. Annual Review of Plant SIM Physiology and Plant Molecular biology. 1994; 1:243-262.
19. Rodrigues FA, Resende RS, Dallagnol LJ, Datnoff LE. Silicon potentiates host defence mechanisms against infection by plant pathogens, in silicon and plant disease, eds. Springer, 2015, 109-138.
20. Savant NK, Snyder GH, Datnoff LE. Silicon management and sustainable rice production. Advances in Agronomy. 1997; 58:151-199.
21. Schmidt RE, Zhang X, Chalmeurs DR. Response of photosynthesis and superoxide dismutase to silica apply to creeping bentgrass grown under to fertility levels. J.

Plant Nutr. 1999; 22:1763-1773. doi: 10.1080/01904169909365752.
22. Singh KK, Singh S, Ragevendra S, Yogeshvar S, Singh CS. Response of Nitrogen and silicon levels on growth, yield. attribute and nutrient uptake of rice (*Oryza sativa* L.). Oryza. 2006; 43:220-223.
23. Song A, Li P, Fan F, Li Z, Liang Y. The effect of silicon on photosynthesis and expression of its relevant genes in rice (*Oryza sativa* L.) under high-zinc stress. PLoS One. 2014; 9(11):e113782.
24. Takahashi E, Miyake Y. The effect of silicon on the growth of cucumber plant. (In): Proceedings of 9th International plant nutrition Colloquium, Warwick University, Coventry, UK, 1982, 22-27p.
25. Tirol-Padre A, Ladha JK, Singh U, Laureles E, Punzalan G, Akita S. Grain yield performance of rice genotypes at suboptimal levels of soil N as affected by N uptake and utilization efficiency. Field Crops Res. 1996; 46:127-143.
26. Verma KK, Wu KC, Singh P, Malviya MK, Singh RK, Song X-P *et al*. The protective role of silicon in sugarcane under water stress: photosynthesis and antioxidant enzymes. Biomed J Sci. Tech Res. 2019; 15(2):1–7
27. Wailes EJ, Cramer GL, Chavez EC, Hansen JM. Arkansas global rice model: international baseline projections for 1997-2010. Arkansas Agricultural Experiment Station Special Report, 1997, 177.
28. Yamaji N, Ma JF. Further characterization of a rice silicon efflux transporter, Lsi2. Soil Science and Plant Nutrition. 2011; 57(2):259-264.
29. Yoshida S, Naveser SA, Ramirez EA. Effects of silica and nitrogen supply on some leaf characters of rice plant. Journal of Plant and Soil. 1969; 31:48-56.