EFFECT OF ORTHO SILIC ACID FORMULATIONS ON GROWTH, YIELD AND ECONOMICS OF LOW LAND RICE

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Abstract

Field experiments were conducted at Annamalai University Experimental Farm, Annamalai Nagar, Tamilnadu, India during Navarai (January to April 2017) and Samba (September 2017 – January 2018) to study the effect of ortho silic acid formulations on growth, yield and economics of low land rice. The treatments comprised of 100 % Recommended Dose of Fertilizers (RDF) (T_1), T_1 + Calcium silicate @ 2 t ha^{-1} (T_2),T_1 + 120 kg Si ha^{-1} through Fly ash (T_3) ,T_1 + Silixol granules @ 25 kg ha^{-1}(T_4) ,T_1 + Silixol granules @ 50 kg ha^{-1} (T_5), T_1 + Foliar application of Silixol plus @ 500 ml ha^{-1} on 20,40 and 60 DAT (T_6), 75 % Recommended Dose of Fertilizers (RDF) (T_7) ,T_7 + Calcium silicate @ 2 t ha^{-1} (T_8), T_7 + 120 kg Si ha^{-1} through Fly ash (T_9) , T_7 + Silixol granules @ 25 kg ha^{-1} (T_{10}), T_7 + Silixol granules @ 50 kg ha^{-1} (T_{11}), T_7 + Foliar application of Silixol plus @ 500 ml ha^{-1} on 20,40 and 60 DAT (T_{12}). The experiments were laid out in randomized block design with three replications. Among the different treatments imposed, 100 % RDF + Silixol granules @ 50 kg ha^{-1} (T_5) recorded highest growth (plant height, number of tillers hill^{-1}, leaf area index, chlorophyll content, root length , root volume and dry matter production), yield attributes (number of panicles m^{-2}, number of grains panicle^{-1} and test weight) and yield (grain and straw) of rice. Regarding economics, the treatment T_4 (T_1 + Silixol granules @ 25 kg ha^{-1}) recorded higher net income and BCR. Thus it can be concluded that soil application of silixol granules @ 25 kg ha^{-1} along with 100% RDF holds immense potentiality to boost the productivity and profitability of rice especially under low land condition.

Key words: ortho silic acid formulations, rice, growth, yield, economics

INTRODUCTION

Rice (*Oryza sativa (L.)*) is one of the most important stable food crops in the world. In Asia, more than two billion people are getting 60-70 per cent of their energy requirement from rice and its derived products. In India, rice is cultivated round the year in one or the other part of the country, in diverse ecologies spread over 43.39 mha with a production of 104.32 mt with average productivity of 2.40 t ha^{-1} (Anonymous, 2017). In Tamilnadu, rice is grown in area of 1.80 mha with a production of 7.95 mt and having the productivity of 4.42 t ha^{-1} (Statistical Hand Book, 2017). The burgeoning population of our country may stabilize around 1.4 and 1.6

billion by 2025 and 2050, respectively requiring annually 380 and 450 m.t of food grains respectively. To meet future food requirements, India has to increase its rice productivity by 3 per cent per annum (Gulab Singh Yadav *et al.,* 2009). Rice yields are either decelerating/stagnating/declining in post green revolution era mainly due to imbalance in fertilizer use, soil degradation, type of cropping system practiced, lack of suitable rice genotypes for low moisture adaptability, pests and disease resistance. Among them, inadequate supply of macro and micronutrients greatly affect the growth and yield of rice. In a more specific study of nutrients; an element called silicon has been found equally important as macronutrients and gaining attention of scientist for enhancing the yield and quality of rice (Ma *et al.,* 2007).

Silicon (Si) is the second most abundant element of the earth's surface and plays a significant role in imparting biotic, abiotic stress resistance and enhancing crop productivity (Aroubandi, 2017). It is also crucial in preventing or minimizing lodging in cereal crops, a matter of great importance in agricultural productivity. Silicon addition increased the erectness of the leaves of rice which intern improves light interception, drought resistance and photosynthetic efficiency. Silicon is the only element known that does not damage plants with excess accumulation. It has been has been demonstrated to be necessary for healthy growth and stable production. For this reason, Si has been recognized as an agronomically essential element in Japan and silicate fertilizers have since then been applied to paddy soils (Malav *et al*., 2018).

In recent years Si has been regarded as a quasi essential element and increases crop production and enhance soil fertility (Epstein, 1999).The potential of Si in improving crop yield has been demonstrated in many studies, especially under abiotic and biotic stress conditions like drought, heavy metals, salinity, and pathogens. Although silicon is the second largest element present in the soil but it is not available to the plants due to its presence in the amorphous form. Plants absorb silicon from the soil solution in the form of monosilicic acid, also called orthosilicic acid [H_4SiO_4]. This molecule is highly unstable and readily becomes into non available form i.e. polymeric silicic acid or forms complex with other compounds to form metasilicates. Unstable nature of this molecule is not in many products which are available in market. Hence, it is essential to study the effect of orthosilicic acid based formulations and traditional silicon fertilizers on rice crop. Keeping the aforesaid facts in consideration, the present investigation was carried out to study the effect of ortho silic acid formulations on growth, yield and economics of low land rice.

MATERIALS AND METHODS

Field experiments were conducted at Field No A4 of wet land (January to April 2017) and 11 D (September 2017 – January 2018) of the garden land, Department of Agronomy, Faculty of Agriculture, Annamalai university, Annamalai nagar, Tamilnadu , India to study the effect of ortho silic acid formulations on growth, yield and economics of low land rice. The soil of the Experimental field is low in available N, medium in available P, high in available K and medium in available Si. The treatments comprised of 100 % Recommended Dose of Fertilizers (RDF) (T_1), T_1 + Calcium silicate @ 2 t ha^{-1} (T_2),T_1 + 120 kg Si ha^{-1} through Fly ash (T_3) ,T_1 + Silixol granules @ 25 kg ha^{-1}(T_4) ,T_1 + Silixol granules @ 50 kg ha^{-1} (T_5), T_1 + Foliar application of Silixol plus @ 500 ml ha^{-1} on 20,40 and 60 DAT (T_6), 75 % Recommended Dose of Fertilizers (RDF) (T_7) ,T_7 + Calcium silicate @ 2 t ha^{-1} (T_8), T_7 + 120 kg Si ha^{-1} through Fly ash (T_9) , T_7 + Silixol granules @ 25 kg ha^{-1} (T_{10}), T_7 + Silixol granules @ 50 kg ha^{-1} (T_{11}), T_7 + Foliar application of Silixol plus @ 500 ml ha^{-1} on 20,40 and 60 DAT (T_{12}). The experiments were laid out in randomized block design with three replications. The rice cultivar chosen for study is ADT 43 (Short duration) and ADT49 (Medium duration) respectively for both the seasons. The biometric observations were taken at critical stages of the crop. The gross return per ha for each treatment was worked out based on the present market rate. The net income was calculated by subtracting the cost of cultivation from the gross income. The BCR was calculated treatment wise by dividing the gross income by cost of cultivation.

RESULTS AND DISCUSSION

Growth Attributes

Rice responded well to the exogenous application of silicon sources. Silicon applied through silixol granules @ 50 kg ha^{-1} along with 100% RDF (T_5) recorded the highest growth attributes viz., plant height, number of tillers $hill^{-1}$, leaf area index, chlorophyll content, root length, root volume, dry matter production at all the stages during navarai and samba seasons at 100% and 75% RDF over calcium silicate and fly ash (Table 1and 2). This probably could be due to the low amount of plant available silicon in soil. The rice plant absorbes silicon by the roots in the form of orthosilicic acid (H_4SiO_4) which is available in silixol granules where as fly ash and calcium silicate must undergo several changes to attain orthosilicic acid form, so silixol granules found superior over fly ash and calcium silicate. The findings are in agreement with Jawahar *et al*. (2015). The soil application of silicon sources performed well over foliar spray of silicon. Researchers have documented the benefits of foliarly applied silicon only when plants are under stress (Guevel *et al*., 2007). Foliarly applied silicon does not increase the percentage of leaf silicon content and plant silicon absorption via leaf surface (Rezende *et al*., 2009). Thus soil application of silicon shows better growth and yield over foliar application and it might be due to release of soluble silicon (monosilicic acid) which can be easily taken up by roots (Malav *et al*., 2018).

The increase in plant height could be due to deposition of silica on plant tissues causing erectness of leaves and stem (Yavarzadesh *et al*., 2008). This was in harmony with the findings of Yoshida *et al.* (1969) who mentioned that the deposition of silicon in cell wall can increase rice plant height by making the leaves and stem more erect, results in decreasing of mutual shading caused by high density of plant there by increasing the photosynthetic rate of plant due to better light interception. This was in agreement with the findings of Jawahar (2011).

Tillering is the production of expanding auxiliary bud which is clearly associated with nutritional condition of the mother clump because tillers receive carbohydrate from mother clump during early growth period and this was improved by silicon application (Liang *et al.,* 1994). The LAI and chlorophyll content of rice at tillering and flowering stages was due to silicon application which caused the erectness of leaves, and in turn reduced self shading and increase the rate of photosynthesis. Adatia and Besford (1986) reported that the highest LAI and chlorophyll content at flowering stages was due to erectness of leaves and synthesis of chloroplast which resulted in higher concentration of chlorophyll per unit area of leaf tissue. This was in agreement with the findings of Ma *et al.*(2004). The maximum root length and root volume at tillering and flowering of rice could be due to the silicon fertilization which caused increase in the development of secondary and tertiary cells of endodermis, thus allowing better root resistance in soils and a faster growth of roots. This was in synchrony with the findings of Hattori *et al*. (2005).

The maximum dry matter production under the treatment T_5 (100% RDF + Silixol granules @ 50 kg ha^{-1}) could be due to the maintenance of high photosynthetic activity and efficient utilization of light and translocation of assimilated products to sink (Rani *et al.,* 1997). Larger leaf area and high chlorophyll content might have accumulated more photosynthates and produced higher biological yield (DMP). This is in conformity with the results of Jawahar and Vaiyapuri (2010) and Jawahar *et al*.(2015). In addition, silicon improved high interception of sunlight leaves due to leaf erectness three by stimulating canopy photosynthesis in rice. Similar results were reported by Singh *et al*.(2005). Further the balanced supply of growth limiting nutrients might have converged their influence on their physiological functioning and synthesis of other assimilate which favourably influenced the carbohydrate metabolism, energy transformation , activation of carbon fixing enzymes and synthesis of auxin. This favourably influenced the DMP of rice (Dhanasekara Pandiyan, 2010).

Yield Attributes

Rice performed well to the external application of N, P and K and Si. Among the treatments, 100% RDF + silixol granules @ 50 kg ha^{-1}(T_5) recorded the highest yield attributes viz., number of panicles m^{-2}, number of grains $panicle^{-1}$, test weight of rice during navarai and samba seasons (Table 3 and 4). It was significantly superior to rest of the treatments. The higher nitrogen level along with silicon manifested significant increase in the growth, yield attributes and yield of rice (Singh *et al*., 2006). This might be due to higher N rates, which primarily increased the chlorophyll concentration in leaves there by higher photosynthesis and ultimately plenty of photosynthates available during grain development (Mahzoor *et al.*,2006). The application of N fertilizer showed grater accumulation of silicon in soil(Inanaga *et al*., 2002). The results are in harmony with the findings of Shivay and Dinesh (2009). More over the application of silicon in combination with RDF not only increased the yield but also enhance the uptake of other nutrients (Pati *et al.,* 2016). Balanced supply of NPK is essential for rice to reach maximum potential yield. The lesser supply of NPK levels (75% RDF) caused reduction in growth, yield attributes and yield of rice (Dobermann, 2000).The increase in number of panicles m^{-2} probably could be due to the number of productive tillers, which resulted in higher number of panicles per unit area. This was in harmony with the findings of Rani and Narayanan (1994).

Increased filled grain number was due to better assimilation of carbohydrate in panicles. This was in agreement with Jawahar *et al*. (2015) who reported the effectiveness of fertilizer in promoting the assimilation of carbohydrates in panicles, which led to increase number of filled grains. Jawahar and Vaiyapuri (2010) reported that the adequate supply of silicon might have improved the photosynthetic activity thus enabled the rice plant to accumulate sufficient photosynthates thereby resulted in more number of filled grains of the crop. This was in agreement with the findings of Jaiswal and Singh (2001). Higher test weight was attributed to better availability and translocation of nutrients as well as photosynthesis from source to sink. The increase in trend of test weight was observed with increasing levels of fertility of silicon which in line with Prabhu *et al*. (2001) who reported 20 to 40 % increase in grain weight when Si level was increased up to 800 kg ha^{-1}. Dallagnol *et al*. (2014) also mentioned that 12 % increase in test weight with supply of silicon.

Yield

Rice yield was significantly influenced by different silicon sources applied along with graded levels of NPK (Table 3 and 4). Among the treatments, application of silixol granules @ 50 kg ha^{-1} along with 100% RDF (T_5) recorded the highest grain and straw yield of rice during navarai and samba seasons. The per cent increase in grain and straw yield over 100% RDF was 7.75 to 34.80 and 6.84 to 31.60, 7.55 to 33.71 and 7.52 to 39.91 during navarai and samba seasons. The grain yield response ranged from 325.95 to 1463.52 and 309.17 to 1427.81 kg kg^{-1} during both seasons. The higher grain and straw yield was due to the sustained nutrient supply in silicon applied plots and its synergistic effect with N, P and K which ultimately led to better photosynthetic activity by the crop and resulted in higher yield attributes and yield. These results are in conformity with the findings of Sudhakar *et al*. (2004). The increase in both grain and straw yield may be due to the positive effect of silicon in increasing growth and yield character by enhancing the pollen viability and photynthetic activity. This was in harmony with Pati *et al.* (2016). The increase in grain yield could also be due to increased production of number of panicles m^{-2}, number of grains $panicle^{-1}$, test weight and increase in straw yield could be due to increased plant height, number of tillers $hill^{-1}$, LAI, chlorophyll content and dry matter production during navarai and samba seasons. Rani and Narayanan (1994) reported that the sustained supply and readily available form of silicon (Orthosilicic acid) to the crop and its synergistic effect with other nutrients ultimately lead to better photosynthetic activity by the crop and resulted in higher yield. This was in harmony with the findings of Singh *et al* (2006). In addition the increase in yield might be due to supply of readily available silicon as a silicon source than Calcium silicate and Fly ash (Yogendra *et al.*, 2013).

Economics

Among the different treatments imposed on rice, addition of silixol granules @ 25 kg ha^{-1} along with 100 % RDF registered more net return and BCR (Table 3 and 4). However, the best yield was recorded under T_5 (100 % RDF + silixol granules 50 kg ha^{-1}), the higher net income and BCR recorded in T_4 (100 % RDF + silixol granules 25 kg ha^{-1}) could be due to lesser cost of cultivation over T_5.

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REFERENCES

Adatia, M. H and A. T. Besford. 1986. The effects of silicon on cucumber plants grown in recirculating nutrient solution. *Ann. Bot*. 58: 343-351.

Aroubandi, H. 2017. Impact of silicon in managing rice diseases, Yield and quality of rice. Scinzer *J. Agric. Biol. Sci*, 3(1): 22-36.

Dallagnol, L. J., F. A. Rodrigues, M. V. B. Mielli, and J. F. Ma. 2014. Rice grain resistance to brown spot and yield are increased by silicon. *Trop Plant Pathol*, 39(1): 56-63.

Dhanasekara Pandian, R. 2010. Enhancing the productivity of low land rice through silicon nutrition. M.Sc. (Ag.) thesis, Annamalai University, Chidambaram.

Dobermann, A. 2000. Rice: Nutrient disorders and nutrient management, handbook series. Pp: 41-83.

Epstein, E. 1999. Silicon. Annu. Rev. *Plant Physiol. Plant Mol. Biol*. 50:641-664.

Guevel, M. H., J. G. Menzis, and R. R. Belanger. 2007. Effect of roof and foliar applications of soluble silicon on powdery mildew control and growth of wheat plants. *Eur. J. Plant. Pathol.*, 119: 429-436.

Gulab Singh Yadav., Dinesh Kumar, T. S. Shivay and H. Singh.2009. Zinc enriched urea improves grain yield and quality of Aromatic rice. *Better Crops*, 3(1): 4-5.

Hattori, T., S. Inanagaa, H. Arakib. 2005. Application of silicon enhanced drought tolerance in *Sorghum bicolor*. *Physiol Plant* 123: 459-466.

Inanaga, S., Y. Higues and C. Naoya. 2002. Effect of silicon application on reproductive growth of rice plant. *Soil Sci. and Plant Nut*., 48, 341-347.

Jaiswal, V. P. And G. R. Singh. 2001. Effect of planting method, source and level of nitrogen on the growth and yield of rice on succeeding wheat. *Ind. J. Agron.,* 46(1): 5-11.

Jawahar, S. 2011. Studies on the effect of sulphur and silicon fertilization in rice – pulse cropping system in Cauvery delta zone. Ph D. Thesis submitted to Annamalai University, Chidambaram.

Jawahar, S., D. Vijayakumar, Raj Bommera, Neeru Jain, and Jeevanandham. 2015. Effect of silixol granules on growth and yield of rice. *Int.J.Curr. Res.Aca. Rev*., 3(1): 168-174.

Jawahar. S and V. Vaiyapuri. 2010. Effect of sulphur and silicon fertilization on growth and yield of rice. *Int. J. Curr. Res. Aca. Rev*., 9 (1): 36-38. 2010.

Liang, Y.C., T. S. Ma, F. S. Li and Y. J. Feng. 1994. Silicon availability and response of rice and wheat to silicon in calcareous soils. *Soil Sci. Plant Anal*.. 25 (13& 14): 2285-97.

Ma J. F., K. Tamai, N. Yamaji, N. Mitani, S. Konishi, M. Katsuhara, T. Fujiwara, M. Yano. 2007. An efflux transporter of silicon in rice. Vol. 448/12.

Ma, J. F., N. Mitani, S. Nagao, S. Konishi, K. Tamai, T. Iwashita and M. Yano. 2004. Characterization of the silicon uptake and molecular mapping of hte silicon transporter gene in rice. *Plant Physiology* 136:3284-89.

Mahzoor, Z., R. I. Ali, T. H. Awan, N. Khalid and Ahmadm. 2006. Appropriate time of nitrogen application to fine rice. *J. Agric. Res.*, 44(4): 36-42.

Malav, J. K., V. P. Ramani, J. K. Patel, R. P. Pavaya, B. B. Patel, I. M. Patel and V. R. Patel. 2018. Rice yield and available nutrients status of loamy sand soil as influenced by different levels of silicon and nitrogen. *Int. J. Curr. Microbiol. App. Sci*, 7(2): 619-632.

Pati, S.B. Pal, S. Badole, G. C. Hazara, B. Mandal. 2016. Effect of silicon fertilization on growth, yield and nutrient uptake of rice. *Commun. Soil. Sci. Plant. Anal*., 47: 284-290.

Prabhu, A. S., M. C. Filho. Fillippi, L. E. Datnoff and G. H. Snyder. 2001. Silicon from rice disease control prospective in Brazil. In L. E. Datnoff, G. H Korndorfer and Snyder (eds.) - *Silicon in Agriculture*, *Elsevier Science* publisher, New York. 293 - 311.

Rani, A. Y. and A. Narayanan. 1994. Role of silicon in plant growth. *Agro Annual Review of Plant Physiol (B&A)*, 1: 243-262.

Rani, A.Y., S. S. Yadav and P. K. Jain. 1997. The effect of silicon application on growth and yield of rice plants. *Ann. Plant physiol. Cpmm.*, 3: 20-24.

Rezende, D. C., F. A. Rodrigues, V. Carre-Missio, D. A. Schurt, I. K. Kawamura and G. H. Korndo. 2009. Effect of root and foliar applications of silicon on brown spot development in rice. *Aust. Plant Pathology*. 38: 67–73.

Shivay, Y. S and Dinesh, K. 2009. Importance and management of silicon deficiency in rice. *Indian farming* 34-36.

Singh, A. K., R. Singh, K. Singh. 2005. Growth yield and economics of rice (*Oryza sativa* L.)as influenced by level and time of silicon application. *Ind.J Agron*. 50(3): 190-193.

Singh, K. K., K. Singh, R. Singh, Y. Singh and C.S. Singh. 2006. Response of nitrogen and silicon levels on growth, yield and nutrient uptake of rice. *Oryza.* 43(3): 220-223.

Statistical hand book, 2017. Released under Tamil Nadu Open Data Policy (TNODAP).

Sudhakar, P. C., J. P. Singh and Kalyan Singh. 2004. Effect of silicon sources and fertility levels on transplanted rice. *IRRN.*, 29(2): 61- 63.

Yavarzadeh, M. R., R.S. Gavali and K.N. Dhumal. 2008. Impact of soil application of flyash on growth and yield of wheat. *J. Maharashtra Agri. Univ*., 33(2): 158-160.

Yogendra, N. D., N. B. Prakash, M. T. Malagi, B. H. Kumara, R. Mohan Kumar and N. Chandrasekar. 2013. Effect of calcium silicate on yield and Nitrogen use efficiency of wet land rice. *Plant Archives*, 13(1): 89-91.

Yoshida, S., S. A. Navasero, and E. A. Ramirez. 1969. Effects of silica and nitrogen supply on some leaf characters of the rice plant. *Plant Soil*, 31 (1): 48-56.

Table 1.Effect of Silicon Sources on Growth Attributes of Rice during Navarai Season

Treatments	Plant height at harvest (cm)	Number of tillers hill^{-1}	LAI at flowering	Chlorophyll content at flowering (mg g^{-1})	Root Length (cm) at flowering	Root Volume (cc) at flowering	DMP (kg ha^{-1}) at harvest
T_1	78.44	9.96	4.20	3.58	16.58	25.01	11313
T_2	90.98	11.99	5.27	4.20	20.54	30.36	13295
T_3	93.49	12.40	5.49	4.32	21.33	31.44	13721
T_4	100.86	13.88	6.05	4.66	23.40	34.47	14727
T_5	102.87	13.51	6.14	4.72	23.92	34.71	14984
T_6	84.34	10.81	4.64	3.82	18.26	27.13	12154
T_7	75.43	9.57	3.95	3.45	15.79	23.89	10837
T_8	86.92	11.26	4.87	3.96	19.07	28.25	12576
T_9	89.33	11.68	5.11	4.09	19.98	29.33	13013
T_{10}	95.94	12.80	5.72	4.46	22.13	32.53	14122
T_{11}	98.01	12.99	5.83	4.54	22.61	33.39	14321
T_{12}	81.91	10.37	4.42	3.70	17.41	26.05	11755
SEd	1.15	0.18	0.10	0.05	0.37	0.49	191.24
CD (P= 0.05)	2.39	0.38	0.21	0.11	0.78	1.03	396.64

Table 2. Effect of Silicon Sources on Growth Attributes of Rice during Samba season

Treatments	Plant height at harvest (cm)	Number of tillers $hill^{-1}$	LAI at flowering	Chlorophyll content at flowering ($mg\ g^{-1}$)	Root Length (cm) at flowering	Root Volume (cc) at flowering	DMP ($kg\ ha^{-1}$) at harvest
T_1	83.85	12.08	4.57	3.79	20.31	31.83	11634
T_2	100.88	14.50	5.49	4.41	24.59	37.99	13983
T_3	104.36	15.07	5.73	4.57	25.64	39.33	14429
T_4	113.77	16.59	6.27	4.87	28.35	42.54	15655
T_5	116.32	16.80	6.36	4.96	29.20	43.40	15980
T_6	90.79	13.19	5.01	4.08	22.19	34.38	12702
T_7	80.36	11.50	4.35	3.64	19.37	30.44	11140
T_8	94.30	13.74	5.21	4.22	23.14	35.69	13207
T_9	97.77	14.27	5.42	4.34	24.12	36.95	13704
T_{10}	107.83	15.62	5.94	4.68	26.62	40.59	14858
T_{11}	110.31	16.05	6.06	4.73	27.33	41.27	15203
T_{12}	87.31	12.63	4.80	3.91	21.27	33.09	12176
SEd	1.66	0.25	0.09	0.04	0.43	0.60	202.73
CD (P= 0.05)	3.45	0.52	0.19	0.10	0.91	1.25	420.48

Table 3.Effect of Silicon Sources on Yield Attributes, Yields and Economics of Rice during Navarai Season

Treatments	Yield Attributes			Yield(kg ha^{-1})		Economics			
	No. of panicles m^{-2}	No. of grains $panicle^{-1}$	Test Weight (g)	Grain	Straw	Cost of cultivation (Rs.)	Gross income (Rs.)	Net income (Rs.)	BCR
T_1	282	95.96	16.42	4205	6728	34707.56	76533.54	41825.98	2.20
T_2	344	102.19	16.63	4946	7814	70707.56	87034.83	16327.27	1.23
T_3	357	103.35	16.68	5112	8013	34808.56	87354.38	52545.82	2.50
T_4	398	105.83	16.79	5579	8895	38457.56	99622.35	61164.79	2.59
T_5	409	106.68	16.81	5668	8996	42207.56	101323.00	59115.44	2.40
T_6	310	98.34	16.48	4531	7249	35307.56	81106.50	45798.94	2.29
T_7	266	94.79	16.39	3983	6213	33643.01	69508.55	35865.54	2.06
T_8	323	99.55	16.54	4700	7521	69643.01	84230.89	14587.88	1.20
T_9	335	101.51	16.58	4872	7683	33743.01	84919.38	51176.37	2.51
T_{10}	372	104.55	16.72	5381	8482	37393.01	96256.08	58863.07	2.57
T_{11}	384	104.67	16.76	5425	8633	41143.01	97027.06	55884.05	2.35
T_{12}	295	97.15	16.43	4358	7081	34243.01	78237.08	43994.07	2.28
SEd	5.79	0.55	0.05	54.24	77.75	-	-	-	-
CD (P= 0.05)	12.02	1.15	NS	112.50	161.26	-	-	-	-

Table 4. Effect of Silicon Sources on Yield Attributes, Yields and Economics of Rice during Samba Season

Treatments	Yield Attributes			Yield(kg ha^{-1})		Economics			
	No. of panicles m^{-2}	No. of grains panicle^{-1}	Test Weight (g)	Grain	Straw	Cost of cultivation (Rs.)	Gross income (Rs.)	Net income (Rs.)	BCR
T_1	302	101.5	13.71	4517	6941	36283.01	81643.44	45360.43	2.25
T_2	368	116.8	14.05	5252	8174	72283.01	95138.14	22855.13	1.31
T_3	384	120.1	14.07	5395	8390	36383.01	95836.75	59453.74	2.63
T_4	416	129.7	14.13	5849	9514	40033.01	106777.91	66744.90	2.66
T_5	421	131.0	14.20	5945	9712	43783.01	108602.13	64819.12	2.48
T_6	329	107.8	13.90	4826	7464	36883.01	87326.09	50443.08	2.36
T_7	285	98.1	13.60	4345	6619	34596.28	78418.63	43822.35	2.26
T_8	345	110.9	13.98	4986	7693	70596.28	90178.75	19582.47	1.27
T_9	359	114.1	14.03	5182	7965	34696.28	91876.32	57180.04	2.64
T_{10}	398	123.5	14.08	5644	8853	38346.28	101810.57	63464.29	2.65
T_{11}	402	126.4	14.10	5700	9053	42096.28	103618.88	61522.60	2.46
T_{12}	315	104.7	13.85	4680	7228	35196.28	84671.51	49475.23	2.40
SEd	6.24	1.39	0.07	68.10	100.90	-	-	-	-
CD (P= 0.05)	12.96	2.90	NS	141.26	209.28	-	-	-	-