Research Article

Effect of Silicon and Mg Fertilizer Application to Acidic Soil on Paddy Yield

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Abstract | Feeding escalating population is challenge of the time with ever declining resources. To address this, issue several approaches are under consideration. Nutrient application/addition is one of the best known and adopted strategies. A field experiment was conducted at Agriculture Research Institute (ARI) Mingora Swat, Khyber Pakhtunkhwa in summer 2016 aiming the effect of silicon fertilizer applied to acidic soil on yield of paddy as paddy is mostly affected through lodging in Swat valley. The treatments consisted of control, 50 kg silicon ha^{-1}, 100 kg silicon ha^{-1} and 150 kg silicon ha^{-1}. Field had 12 plots with size of 12 m× 6 m = $72m^2$. The experiment was conducted in randomized complete block design (RCBD) with 4 treatments having three (03) replications. Rice (*Oryza Sativa* L.) variety JP 5 was tested. The maximum plant height (90 cm) was recorded in T_4 when silicon was applied at the rate of 150kg ha^{-1}, followed by plant height (85cm) of T_3, treated with 100kg silicon ha^{-1}. The data on 1000 grain weight and straw yield of rice crop revealed that there were non-significant ($P>0.05$) pair wise differences among the means of the treatments. The significant maximum biological yield (9299 kg ha^{-1}), grain yield (3901 kg ha^{-1}) and Harvest index (42 %) was obtained in T_3 when silicon was applied at the rate of 100 kg ha^{-1}. From these results, it can be concluded that the application of silicon @ 100 kg ha^{-1} was found the best for improving the rice growth, yield and yield components.

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Introduction

Rice (*Oryza sativa* L.) is staple diet of world's half population (Catherine et al., 2012) and 2nd important cereal after wheat in Pakistan that is cultivated on 2.89 million hectares in Pakistan with7.44 million tons' production during 2017-18 (Economic Survey of Pkaistan, 2017-18). Rice is majorly cultivated in Punjab, Sindh and KP with respective contribution of 60, 25 and 10% in production (MINFAL, 2013). Rice production is based upon coarse (60%) and fine (40%) declaring it major cash crop of Pakistan (Memon, 2013). Forty eight thousand acres of KP are under rice cultivation, but Charsadda and Swat are chief producers.

Silicon (Si), 2nd most abundant element in earth crust (Epstein et al., 1994) has not yet declared as essential element but, its beneficial roles in stimulating plant growth, grain yield and resistance to abiotic (metal, salt, drought, nutrient, and temperature) and biotic (pathogen, insect and pest) stresses have been well documented (Epstein et al., 1999).

Brown spot of rice is caused by the fungus (*Bipolarisoryzae*), that is one of the most devastating and prevalent diseases which cause significant yield losses (Motlagh et al., 2008) and is controlled by fungicides (Oushe, 1985). However, soil nutrients (K, Ca, Mg, Mn, Fe and Si etc.) are considered governors of disease severity (Marchetti et al., 1984). Silicon fertilization is suggested for brown spot mitigation (Dallagnol et al., 2009). Rice is also a typical Si hyper-accumulating plant species, containing Si up to 10% in shoots on a dry weight basis (Ma and Takahashi, 2002). Rice roots take up Si in the form of silicic acid (H_4SiO_4) from the soilIn tropical and subtropical areas, because of heavy desilication-aluminization arising from high temperature and rainfall, plant-available Si is low in these highly-weathered soils (Raven et al., 2003).

Magnesium (Mg) has long been illustrious for its vital role in chlorophyll formation, particularly regulating life sustaining metabolic processes i.e. photophosphorylation, photosynthetic carbon dioxide (CO_2) fixation, protein synthesis, phloem loading, partitioning and utilization of photo assimilates, generation of reactive oxygen species, and photo oxidation in leaf tissues as it activates several enzymes, e.g. ribulose-1,5bisphosphate (RuBP) carboxylase, a key enzyme in the photosynthesis process (Biswas et al., 2013). Furthermore, Mg addition reduces NH_3 volatilization (Fenn and Kissel, 1973) as it formulates of NH_4Cl and nitrate ultimately increasing urea use efficacy of fertilizer (Fenn et al., 1981). This study was undertaken to evaluate the effect of Si and Mg fertilization on rice yield and nutrient uptake efficiency using super silica fertilizers.

Material and Methods

A field experiment on the effect of super silicon fertilizer applied to acidic soil on lodging and yield of paddy rice (*Oryza sativa* L.) was carried out under Agro-climatic condition of Swat during Summer 2016.The test verities of rice was JP 5 on acidic soil and applied different doses of super silica fertilizer as silicon and Mg source for the yield of paddy. The collected soil sample before sowing was analyzed for some physiochemical properties as given in Table 1. Treatments comprised of super silica fertilizer (Si:Ca:Mg) @ 50, 100 and 150 kg ha^{-1} and untreated control. Each treatment was thrice replicated with plot size of 72 m^2 each to minimize error following randomized complete block design (RCBD). Rice variety JP-5 was tested and recommended agronomic, protection and weeding managements were used. Fertilizer NPK was applied @ 120: 90: 50 kg ha^{-1}. Urea, SSP and SOP were used as fertilizer sources, whole of P and K were applied as basal dose while nitrogen was applied in three splits (1st, 2nd and 3rd irrigation). Experimental soil was taken from 30 cm depth before sowing and was analyzed for different soil physiochemical characteristics as is mentioned below in Table 1. At maturity plant height was measured selecting three plants from each plot randomly using meter rod. Crop was harvested at maturity and total biological and grain mass (kg ha^{-1}) was measured on weight balance, while straw yield was calculated by difference method.

$$Straw\ Yield = Plant\ Biomass - Grain\ Yield$$

1000 grains from each plot were counted and weighed on electronic weighing balance. Harvest index was calculated using following equation

$$Harvest\ index = (Economic\ yield / Biological\ yield) \times 100$$

Table 1: *Soil physical and chemical characteristics of the experimental field.*

Physic-Chemical Properties	Units	Values	Method Used
Clay	%	8.5	
Silt	%	51.7	
Sand	%	39.8	
Texture class	-	Silt loam	Bouyoucos method (1962)
pH	-	6.4	(Melean,1982)
EC	dSm^{-1}	0.042	(Richards,1954)
Organic matter	%	1.04	(Nelson and Somers., 1996)
Lime content	%	2.61	(US Salinity Staff, 1954)
N	%	0.048	(Bremner, 1996)
P	mg kg^{-1}	5.79	Olson Method
K	mg kg^{-1}	117	Knudsen et al. (1982)

Statistical analysis

The data was statistically analyzed using analysis of variance techniques appropriate for randomized complete block design (RCBD). Mean were compared using LSD test at 0.05 level of probability, (Steel and Toori, 1980).

Results and Discussion

Plant parameter

Plant height (cm): The statistical analysis of the data on plant height (cm) of rice crop showed that all 4 treatment means are provocatively ($p< 0.05$) different from one another, (Table 2). The maximum plant height (90 cm) was recorded in T_4 when super silica was applied at the rate of 150 kg ha^{-1}, followed by plant height (85cm) of T_3, treated with 100 kg silicon ha^{-1} while the minimum plant height (70 cm) was noted in T_1. Ahmad et al. (2013) also found that the height of rice was significantly increased with the application of silicon.

Table 2: *Plant height (cm), 1000 grain weight (kg ha^{-1}) and Straw yield (kg ha^{-1}) of rice crop as affected by different doses of silicon.*

Treatments	Plant height (cm)	1000 grain weight (g)	Straw yield (kg ha^{-1})
T1	70 d	25	5013
T2	76 c	25	4823
T3	85 b	25	5398
T4	90 a	26	4714

Mean data followed by different litters are significantly different; LSD critical valve of probability is (p< 0.05); LSD Critical value of treatment comparison of plant height = 3.1059 (Significant); LSD Critical value of treatment comparison of 1000 grain weight = 6.8218 (Non-Significant); LSD critical value of treatment comparison of straw yield = 929.13 (Non-Significant).

1000 grain weight (g): Table 2 reveals a non-enticed difference in weight of 1000 grains of rice among treatments ($p<0.05$). Photosynthates movement towards grains is not affected by silicon (Mobasser et al., 2008), so individual grain weight of same variety is not increased by silicon application.

Straw yield (kg ha^{-1}): Non-significant variation in rice straw yield was observed (Table 2), which illustrates 5398 kg ha^{-1}in T_3that was statistically at par with 4714, 4823 and 5013 kg ha^{-1} straw in T_4, T_2 and T_1, respectively. A similar result in study of (Hakim et al., 2012) strengthens our evidence.

Biological yield (kg ha^{-1}): The maximum biological yield (9299 kg ha^{-1}) was obtained in T_3 when silicon was applied at the rate of 100 kg ha^{-1} followed by biological yield (8004 kg ha^{-1}) of T_4, treated with 150 kg silicon ha^{-1}, while the minimum biological yield (7284 kg ha^{-1}) was noticed in T_1 (Table 3). Ahmad et al. (2012) also found increase in biological yield (kg ha^{-1}) with the increasing rates of silicon to rice crop.

Table 3: *Biological yield (kg ha^{-1}), grain yield (kg ha^{-1}) and harvest index (%) of rice crop as affected by different doses of silicon.*

Treatments	Biological yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Harvest index (%)
T1	7284 b	2271 c	31 b
T2	7449 b	2626 c	35 ab
T3	9299 a	3901 a	42 a
T4	8004 b	3289 b	41 a

Mean data followed by different litters are significantly different; LSD Critical valve of probability is (P<0.05); LSD Critical value of treatment comparison of Biological yield = 961.50 (Significant); LSD Critical value of treatment comparison of Grain yield = 574.44 (Significant); LSD Critical value of treatment comparison of Harvest index = 7.3743 (Significant).

Grain yield (kg ha^{-1}): The Statistical analysis of the data on grain yield (kg ha^{-1}) of rice crop showed that all 4 treatment means are Significantly ($P< 0.05$) different from one another (Table 3). Maximum grain yield (3901 kg ha^{-1}) was obtained in T_3 when silicon was applied at the rate of 100 kg ha^{-1} followed by grain yield (3289 and 2626 kg ha^{-1}) of T_4 and T_2, treated 150 and 50 kg silicon ha^{-1}while the minimum grain yield (2271 kg ha^{-1}) was noticed in T_1. Increase in rice grain output was in consequence with increasing application of silicon (Hakim et al., 2012). Our findings are also in line with that of Agostino et al. (2017) who reported an an improvement in biomass (42%) and tiller production (25%) for rice receiving foliar Si.

Harvest index (%): Harvest index an economic indicator of the study has been presented in Table 3, which illustrates significant difference ofall of the treatments from control. 42, 41% harvest index was found in T_3 and T_4 that was suggestively greater than T_1 but harvest index of T_2 was statistically in line with T_1. Abbas et al. (2011) found an increasing trend with increased application of silicon but up to a limit then it got declined, as it is observed in our study.

Links Researchers

Conclusions and Recommendations

It can be concluded from this research work/study that the application of silicon @ 100 kg silicon ha^{-1} and 150 kg silicon ha^{-1} showed better performance for plant height, biological yield, grain yield and harvest index compared to all other level of super silica fertilizer. Increased rates of super silica produced better yield of paddy but there is no statistical difference between 100 kg ha^{-1}and 150 kg ha^{-1}application rate. It is therefore, recommended that 100 kg ha^{-1} application rate of super silica is economically viable option for the farmers to be used in paddy cultivation in swat valley.

Author's Contribution

Roshan Ali, Afsar Ali, Shamsher Ali and Murad Ali conceive the idea and overall management of the research work. Muhammad Arshad Khan, Haroon Shahzad, Nomman Latif, Muhammad Waheed and Ashraf Khan, technical inputs, data analysis and writing of the article.

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