Impact of Nitrogen and Silicon levels on yield and relative economics of transplanted rice under temperate conditions

Abstract

The field experiment entitled "Impact of Nitrogen and Silicon application on yield and relative economics of transplanted rice under temperate conditions" was conducted at Agronomy Research Farm of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir during Kharif seasons 2014-2015. The soil of the experiment was silty clay loam in texture, neutral in reaction with medium available nitrogen (442.88kg ha^{-1}), phosphorus (9.3kg ha^{-1}), potassium (221.60kg ha^{-1}) and low available silicon (280.23kg ha^{-1}). The experiment was laidout in Factorial Randomized Completely Block Design assigning combinations of three nitrogen levels viz. 120, 150 and 180N kg ha^{-1} and four silicon levels viz. Control, 5%, 10% and 15% Si with four replications. The results revealed that higher grain yield (76.00q ha^{-1}), straw yield (93.97q ha^{-1}) and harvest index (44.84%) were recorded with 120Nkgha^{-1}. So far as silicon levels are concerned, 15%Si observed higher grain yield (76 q ha^{-1}), straw yield (93.97 q ha^{-1}) and harvest index (44.84%). Relative economics revealed that 120Nkgha^{-1} with 15%Si realized higher benefit cost ratio (Rs. 2.12).

Keywords: Benefit Cost Ratio, Nitrogen, Rice, Silicon and Yield.

Introduction

Rice is a staple food for more than half of the worlds population. Globally it is grown on an acreage of 164.19mha with total production of 509.87 million tonnes and productivity 3.10 ton per hectare (DES, 2020). In Jammu and Kashmir rice is grown on an area of 0.3million ha with a production of 0.6 million tonnes and productivity of 2 tonnes per hectare (DES, 2020). It is essential to the rice plant, with about 75% of leaf nitrogen associated with chloroplasts, which are physiologically important in dry matter production. (Dalling, 1995). There are many factors affecting rice yield and quality, such as variety, accumulation temperature during the growth period, and relatively minor factors such as cultivation techniques (fertilizer rates, fertilization period, water management, etc.) Laenoi et al; 2018, Zhu et al; 2017, Cao et al; 2017 and Zhou et al; 2018. Due to the effect of increased yield brought by the application of nitrogen fertilizer, an increasing number of nitrogen fertilizers have been applied in rice production.

Silicon is the second most abundant element in soil after oxygen. Rice is considered to be a silicon accumulator plant and tends to actively accumulate Si to tissue concentrations of 5% or higher (Epstein, 2002). Reduced amount of silicon in plant produces necrosis, disturbance in leaf photosynthetic efficiency, growth retardation and reduces grain yield in cereals especially rice

(Shashidhar et al., 2008). The positive effects of silicon on rice growth and production, manifested when it was specifically supplied during the reproductive growth stage (panicle initiation to heading) than that of vegetative and ripening stages, which exerted a feed-forward effect on photosynthesis coupled with increased in both stomatal conductance and biochemical capacity to fix CO_2 was reported by Lavinsky et al., (2016), who surmised that proper levels of Si in reproductive structures played an unidentified role in increasing the yields of rice. Silicon also has a major role in increasing yield attributing characters like number of spikelets, filled spikelet percentage, test weight and total grain yield (Rani et al., 1997; Ahmad et al., 2013 and Jawahar et al., 2015) in rice. Keeping in view the above facts, the study was designed with the objective to study the impact of Nitrogen and Silicon levels on yield and relative economics of transplanted rice under temperate conditions**.**

Material and methods

The field experiment was carried out at Research Farm of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar during 2014-2015. The mean maximum (27.50^{0}C and 27.30^{0}C), mean minimum temperatures (12.60^{0}C and 13.20^{0}C), mean maximum relative humdities (82.50% and 82.80%) and mean minimum relative humidities (55.30% and 56.20%) were recorded for the entire cropping seasons during 2014 and 2015 respectively. The total rainfall received during the experimentation period was 33.3mm during 2014 and 29.5mm during 2015. The experiment comprised two factors (three nitrogen levels and four silicon levels) was laidout in a randomised completely block design with four replications. The factors included three nitrogen levels: N_1: 120kg/ha, N_2:150kg/ha and N_3:180kg/ha and four silicon levels: Si_0: Control, Si_1:5%, Si_2:10% and Si_3:15%. The following observations were recorded during the experiment are:

Grain yield: Grain yield of each plot was recorded separately as kg plot^{-1} and then converted into q ha^{-1}.

Straw yield: Straw yield of each plot was computed by deducting the grain yield from biological yield and expressed as q ha^{-1}.

Harvest index: It was calculated by the following formula:

H.I= Economic yield/ Biological yield×100

Relative economics

Economics of different treatments was worked out on the basis of grain and straw yield per hectare. The cost of input and output was estimated as per prevailing market rates. The benefit : cost ratio (returns per rupee invested) was determined as:

$$\text{Benefit cost ratio} = \frac{\text{Net returns}}{\text{Total cost of cultivation}}$$

Statistical analysis

The data obtained in respect of various observations were statistically analysed by the method described by Cochran and Cox (1963) using Ne-software. The significance of 'F' and 'T ' was tested at 5% level of significance. The critical difference value was determined wherever 'F' test was found to be significant.

Result and Discussion

From the table 1 and fig. 1 indicated that the grain yield, straw yield and harvest index showed the significant variation among the nitrogen and silicon levels. Significantly higher grain yield (76.00q ha^{-1}), straw yield (93.97q ha^{-1}) and harvest index (44.84%) were observed with 120kg N ha^{-1} followed by 150kg N ha^{-1} (grain yield: 74.03q ha^{-1}, straw yield: 91.66q ha^{-1} and harvest index: 44.51%). It is because of higher yield attributing characters which ultimately caused the increase of rice grain yield. Similar results were reported by Huang et al; 2011. Also, the increment of grain yield by the application of nitrogen upto a certain level was reported by Zhaowen et al; 2013. Similar trend of the effect of nitrogen levels on straw yield were also reported by Pramanik and Bera (2013). However, harvest index were significantly higher with 120kgN ha^{-1}. Similar trend was also reported by Rahman et al; 2007. Significantly lower grain yield (68.83q ha^{-1}) straw yield (88.19q ha^{-1}) and harvest index (43.96%) were recorded with 180kg N ha^{-1}. Among different silicon levels, 15% Si recorded the higher grain yield (76.76q ha^{-1}), straw yield (94.72q ha^{-1}) and harvest index (44.80%) followed by 10%Si (grain yield: 74.58q ha^{-1}, straw yield:92.89q ha^{-1}, and harvest index:44.40%) being at par with 5%Si (grain yield:73.21q ha^{-1} , straw yield:91.96q ha^{-1}, and harvest index:44.24%). It is because of silicon is responsible to control stomatal activity, photosynthesis, water use efficiency which ultimately results in better vegetative growth results in higher yield. And it may also be attributed to leaf erectness which facilitated better penetration of sunlight leading to higher photosynthetic activity of plant and higher production of carbohydrates. Similar results were also noticed by Singh et al; 2006 and Pati et al; 2015. Significantly lower grain yield (67.27q ha^{-1}) straw yield (85.52q ha^{-1}) and harvest index (43.84%) were observed with control.

Table 1. Impact of nitrogen and silicon levels on grain yield, straw yield and harvest index of transplanted rice (Pooled data of two years)

Treatments	**Grain yield (q ha^{-1})**	**Straw yield (q ha^{-1})**	**Harvest index (%)**
Nitrogen levels (kg ha^{-1})			
N_1 :120	76.00	93.97	44.84
N_2 :150	74.03	91.66	44.51

N_3 :180	68.83	88.19	43.96
SEm±	0.51	0.54	0.09
CD(p≤0.05)	1.52	1.59	0.28
Silicon levels			
Si_0 :Control	67.27	85.52	43.84
Si_1 : 5%	73.21	91.96	44.24
Si_2 :10%	74.58	92.89	44.40
Si_3 :15%	76.76	94.72	44.80
SEm±	0.57	0.63	0.12
CD(p≤0.05)	1.71	1.84	0.37

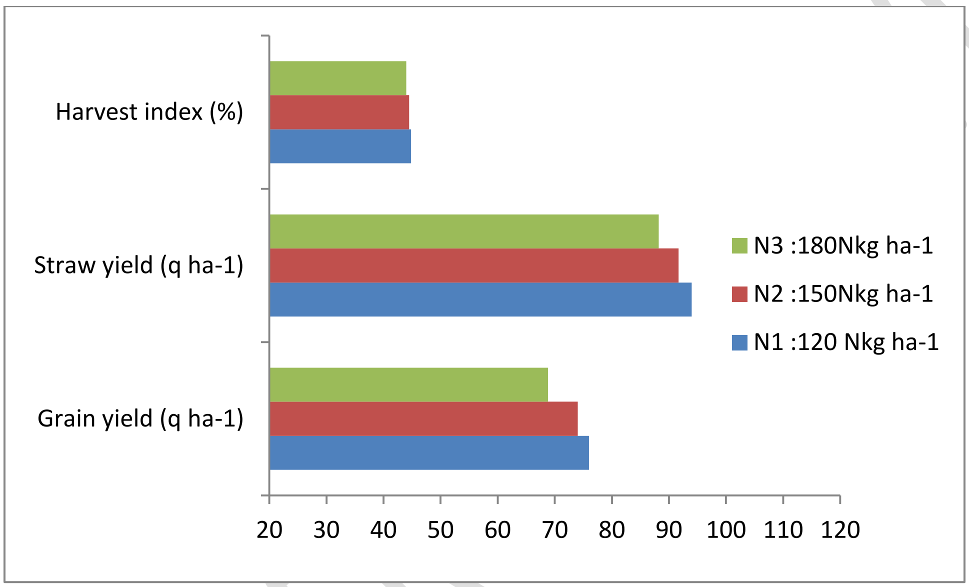

Fig. 1 (a)

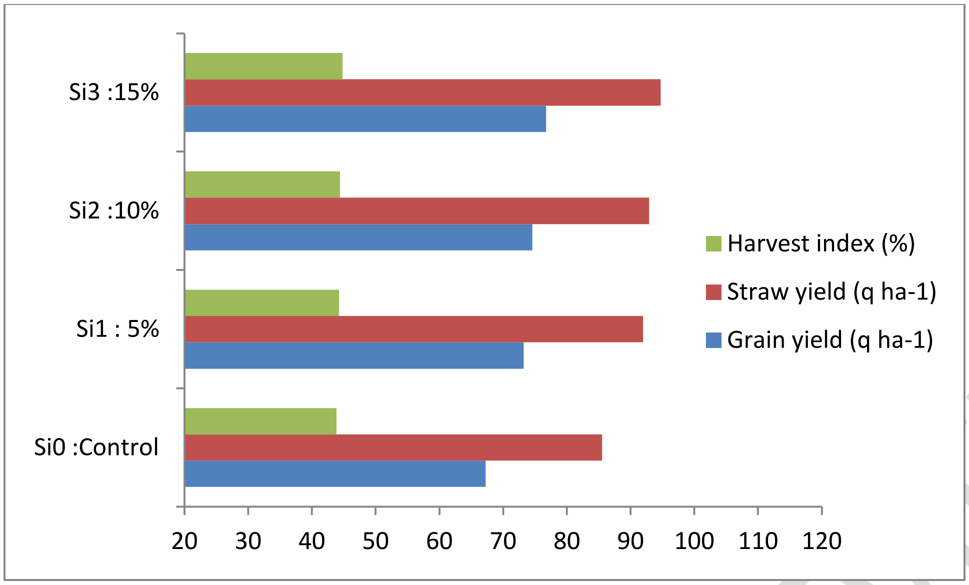

Fig. 1 (b)

Fig. 1 (a and b). Impact of nitrogen and silicon levels on grain yield, straw yield and harvest index of transplanted rice (Pooled data of two years)

The data relative economics presented in table 2 revealed that benefit cost ratio remained higher (Rs.2.13) when 120 kg N ha^{-1} and 15% Si were applied. The same treatment also recorded the higher net returns of Rs.106107. The efficiency of a treatment is finally decided in terms of economics (benefit cost ratio) of the treatment and it might be due to the higher grain and straw yield and minimum cost of nitrogen fertilizers as cost of silicon does not have a greater effect.

Table 2. Relative economics of transplanted rice as influenced by nitrogen and silicon levels (pooled data of two years)

Treatments	Cost of Cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C
N_1Si_0	48522	138929	90407	1.86
N_1 Si_1	49146	148280	99134	2.01
N_1 Si_2	49490	150174	100684	2.03
N_1 Si_3	49834	155941	106107	2.13
N_2 Si_0	48687	132364	83677	1.71
N_2 Si_1	49311	145581	96270	1.95
N_2 Si_2	49655	147330	97675	1.96
N_2 Si_3	49999	153206	103207	2.06
N_3 Si_0	48852	128447	79595	1.62
N_3 Si_1	49476	137549	88073	1.78

N_3 Si_2	49820	139223	89403	1.79
N_3 Si_3	50164	140566	90402	1.80

Conclusion

From this study we concluded that silicon applications can significantly improve rice yield if applied at proper time with feasible concentration. Optimum nitrogen fertilizer is an important practice for increasing rice yield. Considering the influence of nitrogen and silicon levels, it can be suggested that for realizing economically higher grain yield of rice with 120Nkg ha^{-1} and 15% Si based nutrient management, as it helped to achieve the higher net returns (Rs. 106107) and the higher B:C ratio (Rs. 2.13).

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