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Effect of Silicon Solublizers on Growth Parameters and Yields Attributes in Different Rice Genotypes

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ABSTRACT

A field experiment was conducted in kharif season of 2015 to investigate the influence of silicon solublizer on different rice genotypes namely PA-6129, PA-6201, PA-6444, PHB-71, US-312, and BPT-5204. Soil application of silicon solubilizers was given at the time of maximum tillering, panicle initiation and 50% flowering stage. The experiment was arranged as split plot design with three treatments and three replications. Various growth parameter mainly plant height, leaf area index, at maximum tillering, panicle initiation, and 50% flowering, and yield attributes mainlypanicle weight, grains per panicle ,test weight,economic yields, harvest index were evaluated at maturity stage. All rice genotypes showed the positive correlation with silicon solublizers aplication which increases, plant height, leaf area index,at three different stages and also show higher panicle per square meter, spikelet per panicle, biological yield, economic yield (g/m2), harvest index at maturity stages. The purpose of this study was to investigate whether the silicon solublizers influences the growth,yields and physiological attributes in different rice genotypes. By using the silicon solublizers one would expect to raise the yield many fold, of rice and fulfilling the demand of overgrowing population in the up coming years.

Key words: *Silicon, Plant, Economic, Yields*

INTRODUCTION

Rice is most widely consumed staple food crop of about two third of the world human population especially in Asia. It ranks third in worldwide production after sugarcane and maize. Rice contributes 42% of total food grains production and 45% of the cereal production. It is the most important crop with respect to nutrition and calorie intake, providing more than one fifth of the total calories consumed by human population[13]. Today, rice is grown in more than 100 countries of the world across the north to south span from 40^0S to 53^0N latitude. On an average, rice produces a higher grain yield than wheat or maize and can support more people per hectare of land. It has great tendency to adopt environmental variables. To cope up this challenges and growing demands of needs to be produced with nutritionally improved genotypes which should be produced 50% more than what is produced now. Various scientists working on rice have tangled themselves in developing high yielding varieties to increase the productivity of rice by using silicon[12].

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Silicon is the major constituent of the Earth's crust, and second most abundant element after oxygen. It is not considered as an essential element for higher plants, however, it has been regarded as a beneficial element for plant growth, which means it brings significant benefits to any type of plant at any stage of growth. It was found silicon content in the soil solution at concentration range from 0.1 to 0.6 mM[7]. Rice was consider as a great silicon accumulator and its shoot silicon content ranges above 10% of culm dry matter, glyceroporins lsi1 and lsi2 helps in assimilation of silicon from silicic acid which are present in soil solution by xylem transport system[15]. In Several grasses, accumulation of silicon in epidermal cell can defence against pest, plant necrotopic pathogen, tolerance to lodging, saline stress, drought stress, UV light stress, heavy metal stress[10]. Silicon increases the total dry matter of leaves, decrease transpiration and number of leaves, tillers, spikelets, and seed weight[16]. Due to the application of silicon rice plants become more resistant to fungal disease, and raises the percentage of the filled spikelets and seed yield by increase of cell wall thickness below the cuticle, imparting mechanical resistance to the penetration of fungi, and improvement of the leaf angle, making leaves more erect. In the absence of silicon the rice leaves become soft and droopy which causes mutual shading and reduce the photosynthetic efficiency. Silicon application enhances plant height because silicon accumulation increases in leaves and stem thus increased lodging capacity and photosynthetic rate especially under conditions of high population densities and high dose of nitrogen[2]. The application of calcium and magnesium silicates in the place of dolomitic limestone (in areas with acidic soil) increased potato plant height, decreased stem lodging (weak lower stems), and increased the yield of marketable tubers in drought conditions (soil Ψ =-0.05 MPa)[4]. Under drought stress application of silicon fertilizers in increased different agronomic and morphological parameter like biological yield, economic yield and harvest index[20]. In case of wheat, it was observed that, the plant height increase tremendously in the presence of silicon compared to plants grown without silicon under normal soil[1]. In rice, it was observed panicle formation is directly related with the number of productive tillers, which resulted in higher number of panicles per unit area. Maximum numbers of tillers 11.38 $hill^{-1}$ were reported on the application of 37.5 kg ha^{-1} Silixol Granules with 100 % recommended dose of fertilizers in rice plant as compare to other treatments [3]**.** Total dry matter of crops is positively related to various morphological characteristic such as plant height, leaf area and number of tillers and leaves in case of wheat, application of silicon can increased in wheat growth and produces more dry matter as compared with control[19]. It has been shown that silicon application influence the dry weight of rice plants in drought stress, rice growth decreased significantly during drought stress, while exogenously applied 1.5 mM silicon significantly increased plant dry matter[6]**.** In rice, by application of silicon fertilizers in aluminium, cadmium infected soil, increased root and shoot fresh weight by 14% and 18%, respectively as compared with untreated soils[18].

MATERIALS AND METHODS

The field experiment was conducted at Dr Norman E. Borlaug Crop Research Centre, G. B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand), during kharif season of 2015. According to geographical parameter Pantnagar lies in Tarai belt about 30 km southwards of hills of shivalik range of Himalayas at 28.970 N 79.410E longitude and at an altitude of 243.8 meter above mean sea level. The purpose of study was to find the positive influence of silicon on growth, yields attributes in different rice genotypes (*Oryza sativa* L.). Different rice genotypes namely PA-6129, PA-6201, PA-6444, PHB-71, US-312 and BPT-5204 were obtained from the Indian institute of Rice Research, Rajendranagar, Hyderabad. The field experiment was carried out in three separate independent split plot design with

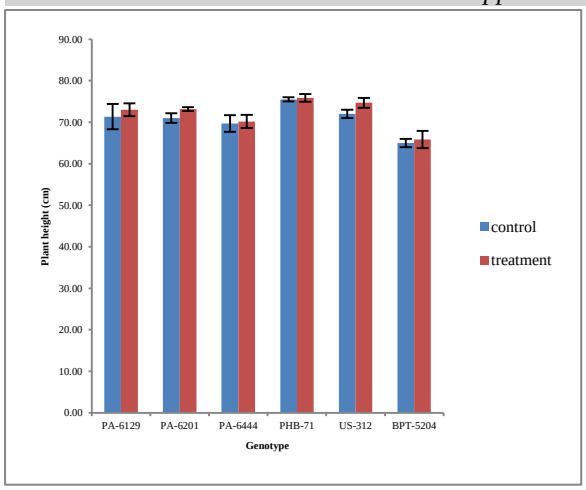
three replications. The gross plot size was 38.2 x 19.6 m^2 and sub plot size was 1 x1m. Different types of chemical fertilizers were applied during crop growing period. Nitrogen, phosphorus and potassium were applied in the form of urea, single super phosphate (SSP) and muriate of potash (MOP) respectively. MOP and SSP applied as basal dozes and urea was applied in three different stages and different quantity.Solid silicon treatment in the form of silicon solubilizer was given at three stages Dose : 10 gm solid dissolved in 2 litre water and make to 10 litre Sprayed it at different growing stage mainly in, maximum tillering, Panicle initiation, 50% flowering and milky grain stages. Plant height is expressed in centimetre. Final height was recorded by taking average height of three randomly selected plants. At three different stages maximum tillering, panicle initiation, and 50% flowering stages. After emerging, primary tiller gives rise to the secondary tiller and it takes around 30 days from date of transplanting. Three sample of hill were taken from each plot.All the leaves of each hill were collected and than leaf area was calculated with help of leaf area meter as well as manually with the help of scale (width cm*length cm*correction factor) and observed the leaf area in cm^2 and leaf area index calculated with the help of given formula-Leaf area index (LAI) = leaf area/land area. Total dry matter was recorded at three growth phases including maximum tillering, 50% flowering and maturity. One thousand well developed dried grains were randomly selected from each replication and weighed. Test Weight (Thousand grain weight) was recorded in grams upto two decimal place. Biological yield refers to the total yield of the plant material. Replicate of all genotypes from all subplots was uprooted from the ground level at the time of maturity and the weight of the whole plant before thrashing was recorded as biological yield. Economic yield is the grain yield of the crop and it was recorded from each plot after harvesting. The term "harvest index" is defined as the yield of a crop species versus the total amount of biomass that has been produced.

$$\text{Harvest index} = \frac{\text{Economical Yield}}{\text{Biological yield}} \times 100$$

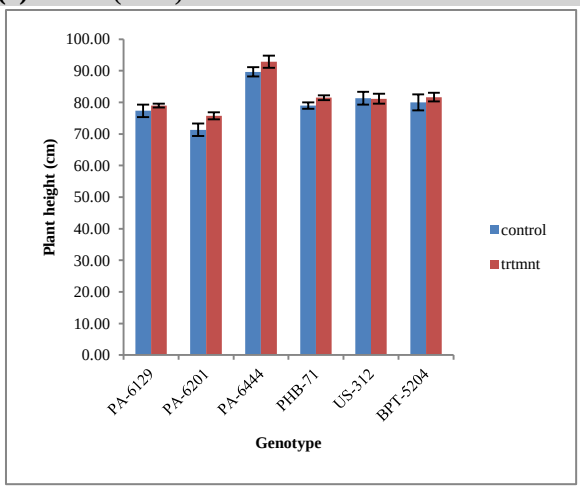
RESULT AND DISCUSSION

Plant height (cm) at maximum tillering, panicle initiation and 50% flowering stage

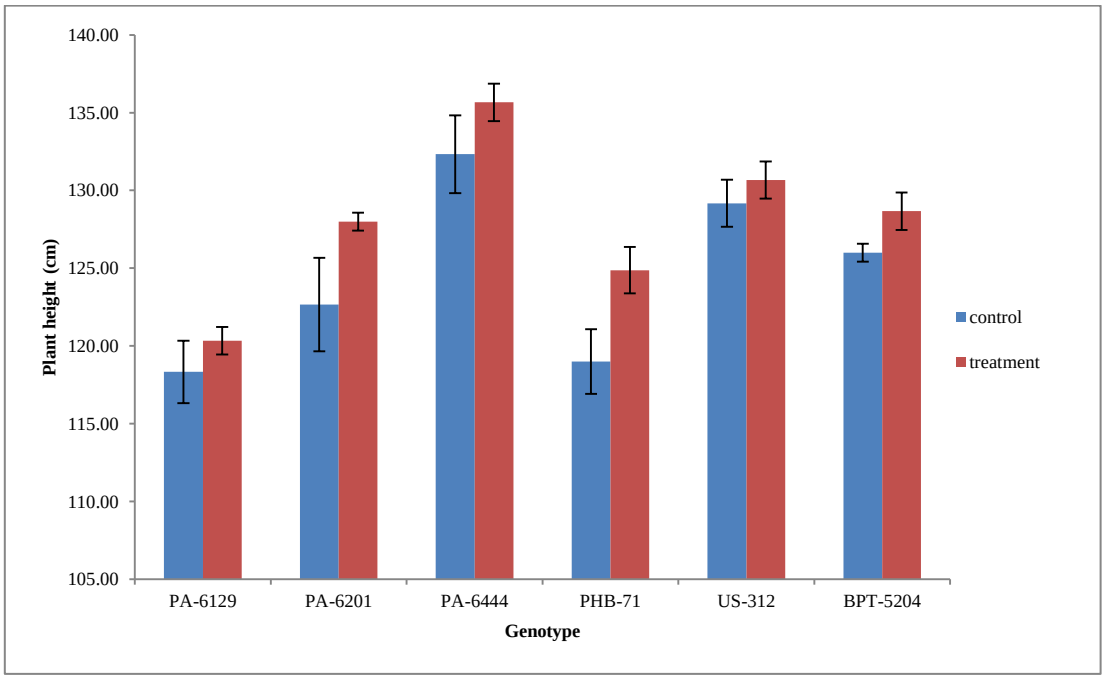
Plant height at maximum tillering was maximum in PHB-71 (75.50cm) and the minimum in BPT-5204 (65.00cm). Similarly, in silicon solubilizer PHB-71 (75.83cm) showed the maximum and BPT-5204 (65.83cm) attained minimum plant height. As compared to control (70.75cm) the overall mean of all genotypes showed increase plant height (72.11cm) under silicon treatment. Among all the rice genotypes and silicon treatment the plant height of PHB-71 had a significant difference from all other genotypes at maximum tillering. In panicle initiation Similarly in silicon solubilizer treatment maximum plant height was found in PA-6444 (92.86cm) and minimum in PA-6201 (75.75cm). The plant height at 50% flowering in silicon solubilizer PA-6444 (135.66cm) showed the maximum plant height and PA-6129 (120.33cm) attained minimum. In silicon solubilizer showed 0.44 to 3.7% increment of plant height as compare to control at maximum tillering, 0.40 to 6.19% at panicle initiation and 1.16 to 4.92% at 50% flowering stage respectively .Increasing plant height under silicon application because leaves and stem become more erect thus decreases self-shading and improving photosynthetic rate especially under conditions of high population densities and higher dose of nitrogen **.** In case of wheat, there was a significant increase in the plants height with the application of calcium silicate along with urea (87 cm) over control (78 cm)[8]. Similarly in drought condition silicon solubilizer significant increase in plant height (77.39), where compared to plant grown on normal watering condition (70.29)[1]. Similar observation were recorded in rice where the application of calcium silicate along with nitrogenous fertilizers increased plant height significantly as compared with non treated plants[21].



Plant height at maximum tillering



Plant height at panicle initiation



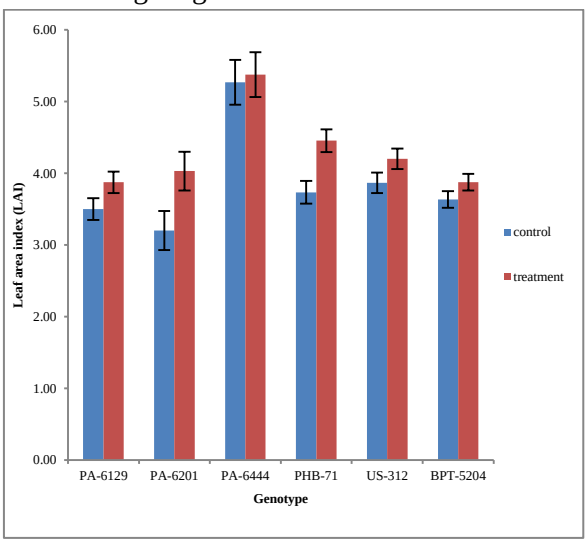
Plant height at flowering stages

Table 1: Effect of silicon application on plant height (cm) at maximum tillering, panicle initiation and 50% flowering in different rice genotypes

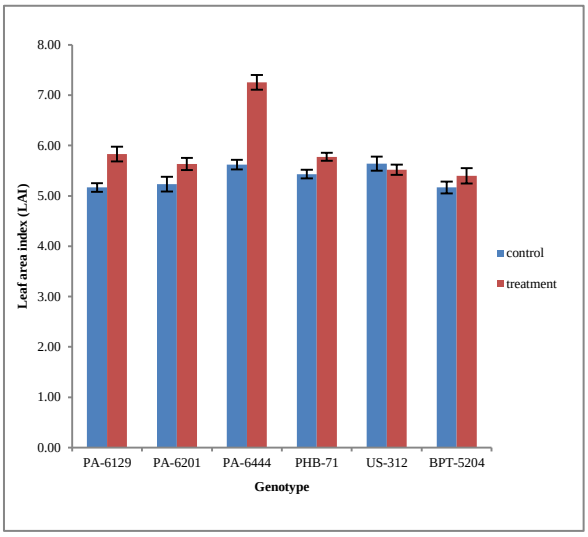
Name of the rice genotypes	Plant height (cm) at tillering				Plant height (cm) at panicle initiation				Plant height (cm) at 50% flowering			
	Control	Silicon solubilizer treatment	Mean	% increase	Control	Silicon solubilizer treatment	Mean	% increase	Control	Silicon solubilizer treatment	Mean	% increase
PA-6129	71.33±3.02	73.00±1.52	72.16	2.33	77.33±2.00	79.00±0.57	78.16	2.15	118.33±2.00	120.33±0.88	119.33	1.69
PA-6201	71.00±1.15	73.16±0.44	72.08	3.05	71.33±2.09	75.75±1.14	73.54	6.19	122.66±3.00	128.00±0.57	125.33	4.34
PA-6444	69.66±2.00	70.16±1.58	69.91	0.71	89.66±1.50	92.86±1.93	91.26	3.56	132.33±2.50	135.66±1.20	134.00	2.51
PHB-71	75.50±0.50	75.83±0.92	75.66	0.44	79.00±1.00	81.50±0.76	80.25	3.16	119.00±2.08	124.86±1.48	121.93	4.92
US-312	72.00±1.00	74.66±1.20	73.33	3.70	81.33±2.00	81.66±1.58	81.25	0.40	129.16±1.57	130.66±1.20	129.91	1.16
BPT-5204	65.00±1.00	65.83±2.08	65.41	1.28	80.00±2.51	81.66±1.33	80.83	2.08	126.00±0.57	128.66±1.21	127.33	2.11
Mean	70.75	72.11			79.77	81.99			124.58	128.03		
	Genotype (G)	**Treatment (T)**	**TxV**		**Genotype (G)**	**Treatment (T)**	**TxV**		**Genotype (G)**	**Treatment (T)**	**TxV**	
S.Em. ±	0.46	.80	1.13		0.44	.76	1.07		0.48	0.84	1.19	
CD at 5%	1.35	2.35	3.32		1.29	2.23	3.16		1.42	2.46	3.49	

Leaf area index

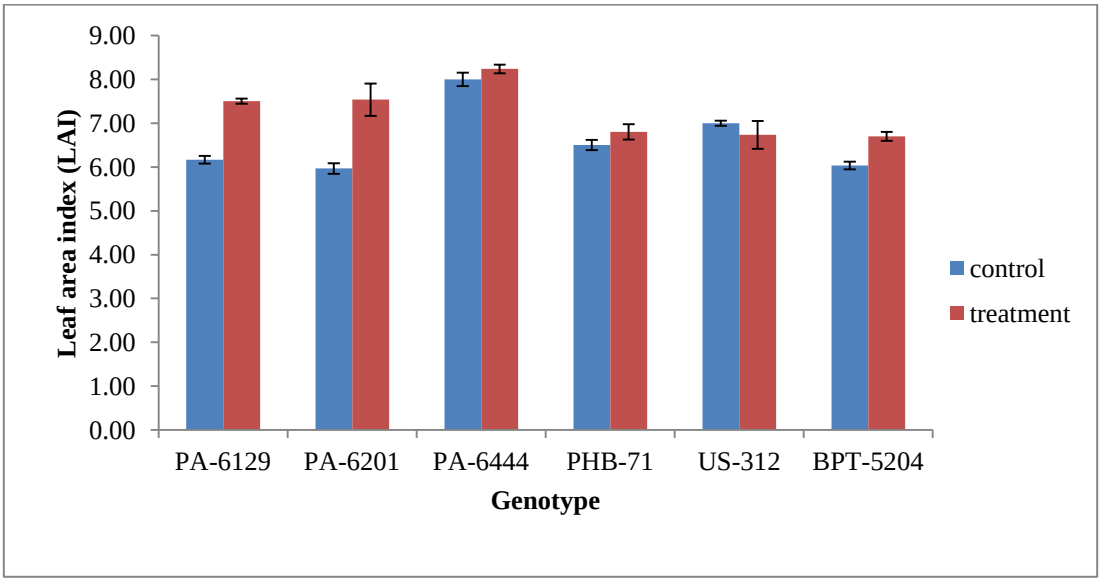
Leaf area index (LAI) was influenced by the application of silicon solubilizer treatment, at different developmental stages in plants like maximum tillering, panicle initiation, and 50% flowering. PA-6444 (5.37) showed maximum leaf area index (LAI) and the minimum in PA-6129 (3.86) under silicon solubilizer treatment at maximum tillering stage. The leaf area index (LAI) was recorded maximum in rice genotypes PA-6444 (7.25) and minimum in BPT-5204 (5.39) at silicon solubilizer treatment at panicle initiation stage. Similarly genotype PA-6444 (8.24) was recorded maximum LAI and minimum in BPT-5204 (6.70) at silicon solubilizer treatment at 50%flowering stage. The results revealed that silicon solubilizer treatments had a significant influence on leaf area index in rice genotypes at maximum tillering, panicle initiation, and 50% flowering. It was observed that silicon solubilizer treated genotypes showed increased leaf area index (LAI) as compared to control. 8 to 26% enhancement in leaf area index at maximum tillering, 2 to 30% at panicle initiation and 3 to 26% at 50% flowering stages as compare to control was observed in LAI of treated plants. Application of silicon solubilizer might be increase source and sink strength and provide resistant against disease by which leaf become more healthy and mature which increases leaf area, Similarly under water stress condition silicon can enhance leaf area index of rice as compared normal condition[10].



Leaf area index at maximum tillering stage



Leaf area index at panicle initiation



Leaf area index at flowering stage

Table 2: Effect of silicon application on leaf area index at maximum tillering, panicle initiation, and 50% flowering stages

Name of the rice genotypes	Leaf area index (LAI) at tillering				Leaf area index (LAI) at panicle initiation				Leaf area index (LAI) at 50% flowering			
	Control	Silicon solubilizer treatment	Mean	% increase	Control	Silicon solubilizer treatment	Mean	% increase	Control	Silicon solubilizer treatment	Mean	% increase
PA-6129	3.5±0.05	3.86±0.15	3.68	10.00	5.16±0.08	5.83±0.14	5.50	12.90	6.16±0.08	7.50±0.05	6.83	21.62
PA-6201	3.2±0.11	4.03±0.27	3.61	25.93	5.23±0.14	5.63±0.12	5.43	07.64	5.96±0.12	7.53±0.36	6.75	26.31
PA-6444	5.26±0.08	5.37±0.31	5.32	02.08	5.62±0.09	7.25±0.14	6.44	29.04	8.00±0.15	8.24±0.09	8.12	03.00
PHB-71	3.73±0.08	4.45±0.15	4.09	19.28	5.43±0.08	5.77±0.07	5.68	06.13	6.50±0.11	6.80±0.17	6.65	04.61
US-312	3.86±0.12	4.20±0.14	4.03	08.62	5.52±0.14	5.64±0.10	5.58	02.12	6.73±0.3	17.00±0.05	6.86	03.80
BPT-5204	3.63±0.06	3.87±0.11	3.75	06.60	5.17±0.12	5.39±0.15	5.28	04.45	6.03±0.08	6.70±0.10	6.36	11.04
Mean	3.86	4.30			5.37	5.90			6.61	7.25		
	Genotype (G)	**Treatment (T)**	**TxV**		**Genotype (G)**	**Treatment (T)**	**TxV**		**Genotype (G)**	**Treatment (T)**	**TxV**	
S.Em. ±	0.06	0.11	0.16		0.05	0.08	0.12		0.06	0.12	0.17	
CD at 5%	0.19	0.33	0.47		0.14	0.25	0.36		0.20	0.35	0.50	

Panicle weight and Test weight (gm)

PA-6444 (5.92) showed maximum Panicle weight and the minimum in PHB-71 (3.77) under silicon solubilizer.all genotypes are positively response at treatment of silicon solublizers. In silicon solubilizer 3.79 to 30.7% enhancement in Panicle weight was found when compared with control. Similar results observed in another study of rice, Soil application of silicon fertilizers increased panicle weight up to 10% as compared to control when silicon solubilizer was given. Silixol treatment 37.5kg ha^{-1} along with 100% recommended dose of fertilizers recorded maximum panicle weight in rice was recorded as compared with control [11]**.** PA-6444 (23.65) showed maximum Test weight and the minimum in BPT-5204 (17.34) under silicon solubilizer. However silicon solubilizer showed maximum increase (17.69%) in PA-6444. In silicon solubilizer total test weight increased up to 1.20 to 17.69% at maturity stages as compare to control.Among all the genotypes and treatments test weight of PA-6444, PA-6129 and PA6201 was found statistically significant with respect to all the genotypes at control and as well as solid treatment. The increment in test weight due to silicon application might be because of improved photosynthetic activity, synthesis of starch and accumulation of dry matter and different macro, micro elements in grain husk may increases test weight.

Table 3: Effect of silicon application on panicle weight (g) and test weight (1000 grain weight) in different rice genotypes

Name of the rice genotypes	Panicle weight (g) at flowering				Test weight (1000 grain weight) (g)			
	Control	Silicon solubilizer treatment	Mean	% increase	Control	Silicon solubilizer treatment	Mean	% increase
PA-6129	4.93±0.05	5.73±0.12	5.33	16.21	21.40±0.88	23.12±0.51	22.26	8.03
PA-6201	3.27±0.17	4.25±0.18	3.76	30.07	18.56±0.29	21.16±0.67	19.86	13.96
PA-6444	4.61±0.05	5.92±0.21	5.26	28.48	20.10±0.60	23.65±0.84	21.87	17.69
PHB-71	3.20±0.10	3.77±0.08	3.48	17.68	22.36±0.64	22.63±0.77	22.49	1.20
US-312	4.39±0.11	4.56±0.15	4.48	03.79	21.18±1.00	22.40±0.35	21.79	5.41
BPT-5204	4.17±0.09	4.38±0.06	4.27	04.86	17.34±0.50	17.98±0.67	17.66	3.55
Mean	4.09	4.77			20.51	21.47		
	Genotype (G)	**Treatment (T)**	**TxV**		**Genotype (G)**	**Treatment (T)**	**TxV**	
S.Em. ±	0.04	0.08	0.11		0.26	0.46	0.65	
CD at 5%	0.14	0.24	0.34		0.78	1.35	1.91	

Biological yield, Economic yields and Harvest Index

Almost all the genotypes are showed positive response under silicon solublizers treatment.PA-6201 showed highest increment of biological yield compare to other genotypes under silicon treatment. In silicon solubilizer biological yield was increased in the range of 5 to 19% as compare to control. Similarly US-312 (848.33) showed maximum economic yield and the minimum in BPT-5204 (697.00) under silicon solubilizer. However silicon solubilizer showed maximum increase (19.54%) in US-312. In silicon solubilizer 4.70 to 19.54% increased in economic yield compare to control. The economic yield show positive relation with silicon solubilizer in all genotypes, it might be due to silicon enhanced carbohydrate translocation from vegetative part to grain or seeds.Harvest Index is significantly increase all genotypes, However PA-6444 and PA-6201 showed maximum harvest index under silicon treatment. In silicon solubilizer 17.35 to 19.25% increased in harvest index compare to control. Application of silicon solubilizer in soil it was reported that the harvest index increased up to 38.9% as compare to control 4.4% (when silicon was not applied)[17]**.**In wheat, under salinity salt tolerant variety showed higher harvest index compared to normal variety [1.]

Table 4: Effect of silicon application on biological yield (g m^{-2}), economic yield (g m^{-2}) and harvest index (%) in different rice genotypes

Name of the rice genotypes	Biological yield (g m^{-2})				Economic yield (g m^{-2})				Harvest index (%)			
	Control	Silicon solubilizer treatment	Mean	% increase	Control	Silicon solubilizer treatment	Mean	% increase	Control	Silicon solubilizer treatment	Mean	% increase
PA-6129	1655.00±27.53	1796.66±38.76	1725.83	08.55	751.50±04.16	786.33±26.59	768.66	04.70	43.75±0.89	43.93±0.93	43.84	3.64
PA-6201	1596.66±20.48	1915.00±24.66	1755.83	19.93	739.66±13.33	761.16±10.06	750.33	02.80	38.64±0.90	49.90±1.14	44.27	18.97
PA-6444	1885.00±12.58	1980.00±23.62	1932.50	05.03	807.66±31.24	936.33±1.383	872.00	13.74	40.82±1.87	49.19±0.45	45.00	17.80
PHB-71	1908.33±46.93	1988.33±46.49	1948.33	04.02	746.33.±60.66	831.33±32.50	788.83	10.22	39.01±2.23	45.73±2.31	42.37	6.89
US-312	1841.66±24.03	1850.00±90.87	1845.83	00.45	709.62±08.99	848.33±52.20	778.97	19.54	39.06±2.27	46.01±2.31	42.53	19.25
BPT-5204	2030.00±52.51	2033.33±52.94	2031.66	00.16	593.66±04.05	697.00±27.49	645.33	17.40	27.89±0.82	34.31±0.51	31.10	17.35
Mean	1834.72	1911.94			763.82	770.88			42.61	40.42		
	Genotype (G)	**Treatment (T)**	**TxV**		**Genotype (G)**	**Treatment (T)**	**TxV**		**Genotype (G)**	**Treatment (T)**	**TxV**	
S.Em. ±	18.28	31.67	44.78		12.38	21.45	30.33		0.48	.83	1.18	
CD at 5%	53.62	92.88	131.35		36.32	62.91	88.97		1.42	2.46	3.48	

CONCLUSION

In the overall conclusion, morpho-physiological parameters i.e. plant height, leaf area index, leaf weight, stem weight, Total dry matter, number of grains per panicle, panicle weight, biological yield, economic yield, harvest index, were significantly increased in all of the genotypes by the application of Silicon solublizers, This could be achieved by enhancing the plant physiological and agronomical efficiency of converting light energy into biomass and partioning greater part of it to grains and biomass. Different genes responsible for Silicon transport in plasmamembranes and vacuoler membranes (Tonoplast) could be further explored for its role in better growth and productivity to fulfilling the demand of overgrowing population in the up coming years.

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