



# Influence of Silicon and Phosphorus on Yield and Nutrient Content of Wheat in Loamy Sand Soils of Sardarkrushinagar, Banaskantha, Gujarat, India

K. Sureka<sup>a#\*</sup>, P. Kamalakannan<sup>a†</sup> and J. K. Malav<sup>bt</sup>

<sup>a</sup> Department of Soil Science and Agricultural Chemistry, Faculty of Agriculture, Annamalai University, Annamalai Nagar-608002, India.

<sup>b</sup> Department of Soil Science and Agricultural Chemistry, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar-385506, India.

## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

## Article Information

DOI: 10.9734/IJPSS/2023/v35i62847

## Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/96866>

Original Research Article

Received: 01/01/2023

Accepted: 02/03/2023

Published: 21/03/2023

## ABSTRACT

To investigate the influence of silicon and phosphorus application on yield and nutrient content of wheat, a field experiment was carried out at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during Rabi season of 2020-2021. Experimental soil was loamy sand in texture with pH 7.01 and electrical conductivity 0.19 dSm<sup>-1</sup>. The soil was low in organic carbon (0.39%) and medium in

# PhD Scholar;

† Assistant Professor;

\*Corresponding author: E-mail: surekasureka73@gmail.com;

available phosphorus ( $38.10 \text{ kg ha}^{-1}$ ) and potassium ( $191.25 \text{ kg ha}^{-1}$ ). Available silicon in soils was  $60.75 \text{ mg kg}^{-1}$ . The experiment was dispersed as four levels of phosphorus (0, 30, 60 and  $90 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ ) and four levels of silicon (0, 100, 200 and  $300 \text{ kg Si ha}^{-1}$ ) laid in randomized block design with factorial concept and replicated thrice. All the plots received a uniform recommended dose of nitrogen at  $120 \text{ kg ha}^{-1}$ . Yield and nutrient content viz., nitrogen, phosphorus, potassium and silicon of grain and straw were noted. The results of experiment clearly indicated that the individual application of  $60 \text{ kg ha}^{-1}$  phosphorus and  $100 \text{ kg ha}^{-1}$  silicon recorded the significantly highest grain yield of  $3808$  and  $3619 \text{ kg ha}^{-1}$ , respectively. With respect to phosphorus and silicon content in grain (0.36 and 1.64%) and straw (0.32 and 1.67%), individual application 60 and  $90 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$  and  $100 \text{ kg Si ha}^{-1}$  and  $300 \text{ kg Si ha}^{-1}$  recorded maximum, respectively. As of interaction effect, significantly highest grain yield ( $4304 \text{ kg ha}^{-1}$ ), and phosphorus content in grain (0.39%) was found with interaction effect of  $60 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$  with Si level at  $100 \text{ kg ha}^{-1}$ . Whereas the significantly highest straw yield ( $6201 \text{ kg ha}^{-1}$ ), silicon content in grain (1.82%) and straw (4.21%) was found with interaction of  $90 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$  with Si level at  $100 \text{ kg ha}^{-1}$  and  $90 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$  with Si level at  $200 \text{ kg ha}^{-1}$ . From the results of experimentation, it is clear that application of  $60 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$  along with  $100 \text{ kg Si ha}^{-1}$  could be better for increasing yield and nutrient content in wheat in loamy sand soils under North Gujarat Agro-climatic conditions.

**Keywords:** *Wheat; phosphorus; silicon; nutrient content; yield.*

## 1. INTRODUCTION

“Wheat is an edible grain, one in every of oldest and most significant of the cereal crops. It's been cultivated for over 10,000 years in all probability, originates with the Fertile Crescent. India occupies second position next to China within the world with regard to area 30.15 million hectares and production 107 million tonnes with average productivity of  $31.77 \text{ q ha}^{-1}$  of wheat. It's a very important winter cereal contributing about 32.04 % of the total food grain production in India. In India, main wheat growing states are UP, Punjab, M.P., Haryana, Rajasthan and Bihar. In Gujarat, wheat has an area of 10.18 lakh hectare with the production of 3332.4 thousand tonnes. The average productivity of wheat in the state is  $30.0 \text{ q ha}^{-1}$  [1].

“World demand for wheat is increasing because of the distinctive viscoelastic and adhesive properties of gluten proteins. It is an important source of carbohydrates and leading source of vegetable protein in human food, having a protein content of about 13%. When eaten as the whole grain, wheat is a source of multiple nutrients and dietary fibre. It is used in the production of bread, biscuits, feeds, confectionary, etc” [2].

“Next to nitrogen, phosphorus is that the most important nutrient needed by a wheat crop from seedling to maturity. It acts behind the scenes assisting with photosynthesis, energy storage and cellular division. Wheat uptakes P about 0.5-0.6 pounds of  $\text{P}_2\text{O}_5$  per bushel. Without enough

available P within the soil, plants will suffer from deficiencies like stunted growth, purple discoloration of stem and leaves, reduced root system and poor tillering” [3]. Jat et al. [4] application of P @  $60 \text{ kg ha}^{-1}$  improved phosphorus content in grain and straw at all the growth stages over control. Jat et al. [5] also reported that “phosphorus application at  $60 \text{ kg ha}^{-1}$  has given higher grain and straw yield”.

“Silicon is one of the primary components of virtually all soils. In fact, next to oxygen, Si is that the most prevalent element within the earth and varieties of Si such as quartz and aluminosilicates often contribute as much as 75-95% of the inorganic fraction of mass” [6]. “Each kilogram of soil usually contains Si ranging from 50 to 400 grams. Silicon dioxide ( $\text{SiO}_2$ ) is the common form of Si in soil. Vermiculite, smectite, kaolin (rich minerals in soils), orthoclase, feldspars, plagioclase (silicates in the form of crystal), amorphous silica, and quartz are the main Si containing components in most soil structures. However, not all Si in soil is available to plants; most of it is locked up in recalcitrant silicate minerals and only a much smaller fraction is available for plants. The soluble fraction of Si is redox and pH dependent” [7].

Plants belonging to Graminae family can take silicon as equivalent to maconutrient. High concentration of silicon in plants increase the mechanical strength and prevents lodging, besides it also protect the plants from abiotic and biotic stress. Deficiency of silicon reported to increase the susceptibility of plants to stress and

lodging [8]. Alam et al. [9] reported that application of silicon to wheat which is grown under different salinity stress has increased the nutrient uptake. "Mesoporous Si nanoparticles formed within wheat plant cells were shown to increase wheat seedling growth, seedling photosynthetic activity, and total protein content of seedlings" [10].

The interaction between Si and P is not direct, but indirect. The effectiveness of P fertilizer use and crop yields are decreased in some P deficient low pH soils due to high soil sorption of phosphorus (P). Plants are able to directly absorb phosphates (P) when the concentration of monosilicic acid in the soil solution is increased. Sun [10] revealed that application of silicon with nutrient medium in wheat crop has increased the content of S, Mg, Ca, B, Fe, P, and Mn and decreased the N, Cu, Zn and K content.

As wheat is one the important cereal crop which provides more than seventy percent of population's calorie intake, this research was carried to use of silicon and phosphorus to enhance the productivity and nutrient content in wheat plant. Thus the main objective of this study is to investigate the influence of silicon and phosphorus on yield and nutrient content as well as their interaction on nutritional status of wheat in loamy sand soils of Sardarkrushinagar.

## 2. MATERIALS AND METHODS

The experiment was conducted at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Banaskantha, Gujarat during *Rabi*, 2020-21. Geographically, this place is located at 72°19' East longitude and 24°19' North latitude at 154.52 meters above the mean sea level and situated in North Gujarat agro climatic zone of Gujarat state. Soil of the experimental plot was loamy sand in texture, neutral in reaction, low in organic carbon, medium in available  $P_2O_5$  and  $K_2O$ . The experiment comprises of four levels of phosphorus (0, 30, 60, 90 kg  $P_2O_5$  ha<sup>-1</sup>) and four levels of silicon (0, 100, 200, 300 kg Si ha<sup>-1</sup>) and total sixteen treatment combinations were laid out in Randomized Block Design (Factorial) with three replications. The variety GW- 451 was used with seed rate of 120 kg ha<sup>-1</sup>.

All the plots are fertilized with recommended dose of nitrogen at 120 kg ha<sup>-1</sup>. The half dose of nitrogen and full of phosphorus and silicon were

applied basal. Remaining half dose of nitrogen was applied at 30 days after sowing. The source of fertilizers was nitrogen (urea 46%), phosphorus (Diammonium Phosphate 18% N, 46% P) and Silicon (calcium silicate 18%).

The straw and grain yield were recorded individually after harvest of crop. Grain and straw samples were collected separately from each plot after harvest, dried in hot air oven at 65°C, powdered and used for analysis of nutrient content. The Chemical analysis of grain and straw samples were done by following the method of Micro-Kjeldahl's method [11] for nitrogen, Vanadomolybdo phosphoric acid yellow colour method [12] for phosphorus, Flame photometric method [12] for potassium and Colorimetric method [13] for silicon.

Data recorded during the investigation regarding the yield and nutrient content were statistically analyzed using the factorial randomized block design as represented by [14]. The summery tables for effect of treatments had been worked out using standard error of difference and critical difference (C.D.) at 5 % level of probability and are noted in the respective table.

## 3. RESULTS AND DISCUSSION

### 3.1 Grain Yield (kg ha<sup>-1</sup>)

The results presented in data illustrate that wheat grain yield was significantly influenced by phosphorus and silicon application. The most grain (3808 kg ha<sup>-1</sup>) yield was recorded thanks to application of 60 kg  $P_2O_5$  ha<sup>-1</sup> (Table 1). "The most reason for increase in grain yield with different levels of phosphatic fertilizer may be because of more practical tillers per plant which may well be the result of higher rate of photosynthesis and better crop health which ultimately increased the ultimate grain yield. Plants showed normal growth with the appliance of phosphorus and resulted in improved agronomic traits which lead toward improved grain yield" [15]. Similar findings were reported with [16] and [17].

The significantly higher grain (3619 kg ha<sup>-1</sup>) yield was recorded thanks to silicon application at 100 kg ha<sup>-1</sup>; while the bottom grain (2981 kg ha<sup>-1</sup>) yield was recorded under  $Si_0$  (Table 1). The improvement in leaf erectness brought about by reducing mutual shading of leaves, lodging, pathogen incidence, and preventing manganese and iron toxicity, or even both, may have

contributed to the increase in yield brought about by Si application. The increased water use efficiency brought on by Si application may be explained by the prevention of excessive transpiration. Just in case of interaction effect, combination of phosphorus level *i.e.* 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> with Si level at 100 kg ha<sup>-1</sup> showed significantly highest grain yield (4304 kg ha<sup>-1</sup>). Very cheap grain yield (2565 kg ha<sup>-1</sup>) was observed in P<sub>0</sub>Si<sub>0</sub> (Table 2). [18] stated that “silicon addition significantly increases phosphorus mobilization by mobilizing Fe (II)-P phases from mineral surfaces”.

### 3.2 Straw Yield (kg ha<sup>-1</sup>)

Application of various levels of silicon and phosphorus has exhibited a major influence on straw yield of wheat. All-time low straw (4853 kg ha<sup>-1</sup>) yield was observed under P<sub>0</sub>. The most straw (5729 kg ha<sup>-1</sup>) yield was recorded thanks to

application of 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (Table 4). Early tiller development is critical to plant health and, ultimately, yield potential. The plant's initial tillers have a higher yield potential than late or delayed tillers. When sufficient phosphorus is provided in the soil, the resulting tillers are healthier and more productive. The findings are consistent with those of [4] and [17].

Significantly highest straw (5584 kg ha<sup>-1</sup>) yield was recorded thanks to silicon application at 100 kg ha<sup>-1</sup>; while lowest straw yield (4828 kg ha<sup>-1</sup>) was recorded under Si<sub>0</sub> (Table 4). “The rise in yield with Si application can be thanks to the improving leaf erectness, reduction in lodging and decreasing susceptibility to plant pathogens and pests and preventing manganese and iron toxicity or both. Application of Si, increased water use efficiency probably may be because of prevention of excessive transpiration” [19].

**Table 1. Effect of phosphorus and silicon on yield and nutrient content of wheat grain**

Treatments	Grain yield (kg ha <sup>-1</sup> )	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Silicon (%)
<b>Phosphorus levels</b>					
P <sub>0</sub> -0 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup>	2789	0.24	0.83	1.42	0.24
P <sub>1</sub> - 30 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup>	3049	0.28	0.85	1.50	0.28
P <sub>2</sub> - 60 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup>	3808	0.36	0.89	1.64	0.36
P <sub>3</sub> - 90 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup>	3766	0.31	0.86	1.62	0.31
S.Em.±	77.00	0.01	0.03	0.03	0.01
C.D. (P=0.05)	222.40	0.03	NS	0.10	0.03
<b>Silicon levels</b>					
Si <sub>0</sub> -0 kg Si ha <sup>-1</sup>	2981	1.67	0.28	0.85	1.32
Si <sub>1</sub> -100 kg Si ha <sup>-1</sup>	3619	1.74	0.32	0.87	1.58
Si <sub>2</sub> -200 kg Si ha <sup>-1</sup>	3459	1.79	0.30	0.86	1.61
Si <sub>3</sub> -300 kg Si ha <sup>-1</sup>	3354	1.69	0.28	0.85	1.67
S.Em.±	77.00	0.05	0.01	0.03	0.03
C.D. (P=0.05)	222.40	NS	0.03	NS	0.10
<b>Interaction</b>					
P x Si	Sig.	NS	Sig.	NS	Sig.
C.V. (%)	7.96	10.49	10.25	11.25	7.68

Sig. – significant, NS- Non- Significant

**Table 2. Interaction effect of phosphorus and silicon on grain and straw yield of wheat**

Treatments	Grain yield (kg ha <sup>-1</sup> )				Straw yield (kg ha <sup>-1</sup> )			
	Phosphorus levels (kg ha <sup>-1</sup> )							
Silicon levels (kg ha <sup>-1</sup> )	P <sub>0</sub>	P <sub>1</sub>	P <sub>2</sub>	P <sub>3</sub>	P <sub>0</sub>	P <sub>1</sub>	P <sub>2</sub>	P <sub>3</sub>
Si <sub>0</sub>	2568	2579	3123	3653	3739	5087	5450	5036
Si <sub>1</sub>	2721	3503	4304	3946	5162	4800	6172	6201
Si <sub>2</sub>	3034	3007	3939	3855	5262	4819	6094	5494
Si <sub>3</sub>	2832	3109	3866	3610	5249	5441	5201	5292
S.Em. ±	154.00							
C.D. (P=0.05)	444.80							
C.V. (%)	7.96							

In case of interaction effect, the best straw yield of wheat crop was observed because of combined application of 90 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> and 100 kg Si ha<sup>-1</sup> (6201 kg ha<sup>-1</sup>) over the remainder of the combinations (Table 2). [20] described that “in water culture, when P is low Si causes a decrease in Fe and Mn uptake and thus promotes P availability within the plant. From these findings, it’s clear that Si application alleviated the phosphorus uptakes which resulted within the increase in biomass of wheat crop”.

### 3.3 Nitrogen Content in Grain (%)

Data presented in Table 1 indicates that individual application of different levels of phosphorous and silicon did not exert significant effect on nitrogen content in grain. The maximum nitrogen content was reported with 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (1.78%) and 200 kg Si ha<sup>-1</sup> (11.79%) and minimum nitrogen content of 1.65% and 1.67% was observed with control respectively. The interaction effect was found to non- significant in all levels of treatments.

### 3.4 Phosphorus Content in Grain (%)

Different levels of phosphorus and silicon significantly influenced the phosphorus content in wheat grain. Application of 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> has recorded significantly highest phosphorus content (0.36%) which is at par with 90 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> and 30 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>. The lowest phosphorus content (0.24%) was observed with control (Table 1). Significant difference phosphorus content is mainly due to application of phosphorus as moderately supply of phosphorus is needed for growing period of wheat for

improving nutrient content in grain. The results are in close agreement with those reported by [21].

In case of silicon application, highest phosphorus content (0.32%) was found with 100 kg Si ha<sup>-1</sup>; however it is at par with 200 kg Si ha<sup>-1</sup> and 100 kg Si ha<sup>-1</sup>. The lowest phosphorus content (0.28%) was observed with control (Table 1). It is mainly due to application of silicon which increased the root exudation of organic acids that mobilize the phosphorus in the rhizosphere region and unregulated the transport of phosphorous to root in wheat crops.

For interaction effect, combination of phosphorous *i.e.*, 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> with Si level at 100 kg ha<sup>-1</sup> and 200 kg ha<sup>-1</sup> showed significantly higher phosphorus content (0.39%); which was at par with P<sub>60</sub> x Si<sub>300</sub>, P<sub>90</sub> x Si<sub>0</sub>. The lowest phosphorus content (0.21%) is observed with control and P<sub>0</sub> x Si<sub>300</sub> (Table 3). Studies have indicated that Si fertilization enhances plant phosphorus (P) utilization by increasing both P content of rice and phosphate fertilizer efficiency. The results are similar with the findings of [22].

### 3.5 Potassium Content in Grain (%)

Data presented in Table 1 indicates that different levels of phosphorous and silicon application did not exert significant effect on potassium contents in wheat grain. The maximum potassium content 0.89% and 0.87% was recorded with 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> and 100 kg Si ha<sup>-1</sup> respectively. Interaction between phosphorus and silicon application was found to be non-significant with respect to potassium content in grain.

**Table 3. Interaction effect of phosphorus and silicon on phosphorus and silicon content in wheat grain**

Treatments	Phosphorus (%)				Silicon (%)			
	Phosphorus levels (kg ha <sup>-1</sup> )							
Silicon levels (kg ha <sup>-1</sup> )	P <sub>0</sub>	P <sub>1</sub>	P <sub>2</sub>	P <sub>3</sub>	P <sub>0</sub>	P <sub>1</sub>	P <sub>2</sub>	P <sub>3</sub>
Si <sub>0</sub>	0.21	0.26	0.31	0.34	1.43	1.34	1.32	1.17
Si <sub>1</sub>	0.28	0.30	0.39	0.32	1.30	1.46	1.75	1.82
Si <sub>2</sub>	0.25	0.27	0.39	0.31	1.36	1.54	1.76	1.79
Si <sub>3</sub>	0.21	0.29	0.35	0.25	1.58	1.67	1.72	1.71
<b>S.Em. ±</b>	0.02				0.07			
<b>C.D. (P=0.05)</b>	0.05				0.20			
<b>C.V. (%)</b>	10.25				7.68			

**Table 4. Effect of phosphorus and silicon on yield and nutrient content in wheat straw**

Treatments	Straw yield (kg ha <sup>-1</sup> )	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Silicon (%)
<b>Phosphorus levels</b>					
P <sub>0</sub> -0 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup>	4853	0.95	0.19	1.05	3.13
P <sub>1</sub> - 30 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup>	5037	0.96	0.22	1.09	3.56
P <sub>2</sub> - 60 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup>	5729	0.97	0.25	1.17	3.56
P <sub>3</sub> - 90 kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup>	5506	0.98	0.26	1.08	3.76
S.Em.±	118.66	0.02	0.01	0.03	0.09
C.D. (P=0.05)	342.72	NS	0.02	NS	0.25
<b>Silicon levels (kg ha<sup>-1</sup>)</b>					
Si <sub>0</sub> -0 kg Si ha <sup>-1</sup>	4828	0.96	0.20	1.07	3.15
Si <sub>1</sub> -100 kg Si ha <sup>-1</sup>	5584	0.99	0.24	1.12	3.52
Si <sub>2</sub> -200 kg Si ha <sup>-1</sup>	5417	0.95	0.24	1.13	3.64
Si <sub>3</sub> -300 kg Si ha <sup>-1</sup>	5296	0.96	0.25	1.08	3.71
S.Em.±	118.66	0.02	0.01	0.03	0.09
C.D. (P=0.05)	342.72	NS	0.02	NS	0.25
<b>Interaction</b>					
P x Si	Sig.	NS	Sig.	NS	Sig.
C.V.(%)	7.78	8.06	10.27	10.43	8.46

*Sig. – significant, NS- Non- Significant*

### 3.6 Silicon Content in Grain (%)

The different levels of phosphorus and silicon application to wheat significantly affected the silicon content in grains of wheat. The significantly highest silicon content (1.64%) was recorded with application of 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> and it was at par with 90 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>, while the lowest (1.42%) was recorded with control. The highest silicon content (1.67%) was recorded with 300 kg Si ha<sup>-1</sup> and lowest (1.32%) was recorded with control. But, it was at par with 200 kg Si ha<sup>-1</sup> and 100 kg Si ha<sup>-1</sup> (Table 1). The increase in silicon content in wheat grain is due to the mobilization of silicon which increases the availability of silicon for uptake. The results are line with the finds of [23].

The data on interaction of P x Si (Table 3) revealed that significantly highest silicon content (1.82%) was observed due to the combined effect of 90 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> and 100 kg Si ha<sup>-1</sup> over rest of the treatment combinations. However, it was at par with treatment combination with P<sub>60</sub> x Si<sub>100</sub>, P<sub>60</sub> x Si<sub>200</sub> and P<sub>90</sub> x Si<sub>200</sub>. The lowest silicon content (1.30%) was recorded with P<sub>0</sub> x Si<sub>100</sub>. The decrease in P adsorption in soil with increase in the availability of P in soil and plants result in increase in phosphorus content in crop.

### 3.7 Nitrogen Content in Straw (%)

The different level of phosphorus and silicon presented in the Table 4 clearly indicates that

there's no significant influence in nitrogen content in wheat straw. Maximum nitrogen content of 0.98% and 0.99% was recorded with application of 90 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> and 100 kg Si ha<sup>-1</sup> whereas minimum nitrogen content of 0.95% and 0.96% was observed with control. The interaction effect was found to be non-significant between the treatments.

### 3.8 Phosphorus Content in Straw (%)

The various levels of phosphorus and silicon application have a big effect on phosphorus content in wheat straw (Table 4). The highest phosphorus content (0.26%) was found with the appliance of 90 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>. However, it had been at par with 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>. The lowest phosphorus content (0.20%) was observed with control. Just in case of silicon application, application of 300 kg Si ha<sup>-1</sup> recorded the maximum utmost phosphorus content of 0.25% in straw. It is at par with 100 kg Si ha<sup>-1</sup> and 200 kg Si ha<sup>-1</sup>. The bottom phosphorus content (0.20%) was recorded with control (Table 4).

As for the interaction effect between phosphorus and silicon, they're found be significantly influenced the phosphorus content in straw (Table 5). The highest phosphorus content (0.30%) was observed with combination of phosphorus *i.e.*, 90 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> with Si level at 300 kg ha<sup>-1</sup> but it was absolutely at par with P<sub>60</sub> x Si<sub>100</sub>, P<sub>90</sub> x Si<sub>100</sub>, P<sub>60</sub> x Si<sub>200</sub>, P<sub>90</sub> x Si<sub>200</sub>, P<sub>60</sub> x Si<sub>300</sub>. The lowest phosphorous content

**Table 5. Interaction effect of phosphorus and silicon on phosphorus content in wheat straw**

Treatments	Phosphorus (%)				Silicon (%)			
	Phosphorus levels (kg ha <sup>-1</sup> )				Phosphorus levels (kg ha <sup>-1</sup> )			
Silicon levels (kg ha <sup>-1</sup> )	P <sub>0</sub>	P <sub>1</sub>	P <sub>2</sub>	P <sub>3</sub>	P <sub>0</sub>	P <sub>1</sub>	P <sub>2</sub>	P <sub>3</sub>
Si <sub>0</sub>	0.19	0.21	0.21	0.20	3.45	3.31	2.93	2.93
Si <sub>1</sub>	0.22	0.22	0.25	0.27	3.28	3.36	3.60	3.83
Si <sub>2</sub>	0.17	0.23	0.28	0.26	2.89	3.82	3.68	4.21
Si <sub>3</sub>	0.19	0.24	0.26	0.30	2.93	3.76	4.09	4.07
<b>S.Em. ±</b>	0.01				0.17			
<b>C.D. (P=0.05)</b>	0.04				0.49			
<b>C.V. (%)</b>	10.27				8.46			

(0.19%) was observed with control and P<sub>0</sub> x Si<sub>300</sub>. Application of silicon together with phosphorus by which silicon solubilizes phosphorus and increase its use efficiency may be reason more phosphorus content in straw.

### 3.9 Potassium Content in Straw (%)

Data presented in Table 4 indicates that different levels of phosphorus and silicon application didn't exert significant effect on potassium contents in wheat straw. The utmost potassium content of 1.17% and 1.13% was reported with 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> and 200 kg Si ha<sup>-1</sup> application. The minimum potassium content of 1.05% 1.07% was noted under control of both treatments. In case interaction effect, there was no significant different between the treatments.

### 3.10 Silicon Content in Straw (%)

The results reported in Table 4 indicated that silicon content of wheat straw was significantly stricken by different levels of phosphorus and silicon application. For phosphorus levels, significantly the best silicon content (3.76%) was observed with 90 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> and therefore the lowest (3.13%) was recorded with control. However, it was at par with 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> and 30 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>. In case of silicon levels, the highest silicon content was observed with 300 kg Si ha<sup>-1</sup> (3.71%). However, it absolutely was at par with 100 kg Si ha<sup>-1</sup> and 200 kg Si ha<sup>-1</sup>. The rock bottom silicon content (3.15%) was noted under control.

Meanwhile, the interaction effect was found to be significant. The data on interaction of P and Si (Table 5) revealed that significantly the highest silicon content (4.21%) was observed due to the combined effect of 90 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> and 200 kg Si ha<sup>-1</sup> over rest of the treatment combinations. However, it had been at par with treatment combination with P<sub>90</sub>x Si<sub>100</sub>, P<sub>30</sub> x Si<sub>200</sub>, P<sub>30</sub> x

Si<sub>300</sub>, P<sub>60</sub> x Si<sub>300</sub> and P<sub>90</sub> x Si<sub>300</sub>. The lowest silicon content was recorded with P<sub>0</sub> x Si<sub>200</sub> (2.89%).

## 4. CONCLUSION

From the result, it could be clear that individual application of silicon at 100 kg Si ha<sup>-1</sup> and phosphorus 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> and their interaction in loamy sand soil had enhanced the yield and nutrient in both grain and straw of wheat. It can release phosphorus and silicon into soil solution by solubilizing the phosphorus and also through cationic exchange and making it readily available to the plant. So, this present study suggest that application of phosphorus at 60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> and silicon at 100 kg Si ha<sup>-1</sup> to wheat under loamy sand for obtaining high yield and nutrient content to Sadarkrushinagar, Banaskantha district farmers.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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