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Original Research Paper

EFFECT OF BIOCHAR AND SILICON WITH DIFFERENT PHOSPHORUS LEVELS ON MAIZE YIELD AND SOIL CHEMICAL PROPERTIES

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Abstract: Silicon fertilizer combine with biochar improved the utilization of Phosphorus fertilization application. The experiment was carried out with eight treatment combination with varying proportions of rice husk biochar, silicon, and phosphorus in a by completely randomized design with 75-days of growth in the greenhouse. To identify the optimum rate of phosphorus combining with rice husk biochar and Si for maximizing maize yield and soil chemical properties. This experiment showed that the application of biochar combine with silicon has a potential to reduce the amount of phosphorus fertilizer requirement. The application of 5 t ha-1 RHB + 100% Si + 25% TSP showed the highest pH compared to other treatment. While application of 2.5 t ha-1 RHB + 100% Si + 100% TSP showed the highest exchangeable K, Ca & Mg. Moreover, application of 5 t ha-1 RHB + 100% Si + 100% TSP recorded the highest dry biomass compared to other treatment. Lastly, the application of 5 t ha-1 RHB + 100% Si + 50% TSP Showed the highest cob length(cm), cob weight(g), no of grain per cob and grain yield (t/ha) compared to other treatment. The combined application of biochar and silicon, along with 50% phosphorus, is recommended for improving maize yield and soil health in greenhouse conditions.

Key Words	Phosphorus; biochar; silicon; fertilizer; productivity
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1. INTRODUCTION

Maize is one kind of important crop that being use in daily life and start to increase it demand all around the world (He,Y et al., 2023). The cultivation of this crop has to face many problems in today world that cause it production to be reduce and failed to fulfill the demand (Ali et al., 2023). The available soil mostly being affected by a few factors such as alkalinity, acidity, imbalance nutrient toxicity and water stress (Msimbira & Smith, 2020).

This suffering by crop in soil because the acidic soil high in hydrogen ion with the high concentration of Al content (Neina, 2019). Adding cation (Mg, K & Ca) by application of chemical fertilizer can be one of the solutions to reduce the soil acidity (Shankara et al., 2022). Other than that, adding silicon would be also practical to reduce the effect of aluminium and manganese at the same time handling P deficiency problem in acidic soil (Pontingo et al., 2015). Thus, as an alternative to single silicon, biochar should be applied together to improve its function (Sattar et al., 2022). Moreover, apply biochar together with the fertilizer would promote N retention and C stability together with improving N uptake by and minimized the loss N (Peng et al., 2019). The biochar would also improve phytoremediation and lower down health risk caused by fertilizer (Ibrahim et al., 2016). Different type of biochar would have different content of elemental composition (i.e., wood mixture biochar has higher content of H, O, N and S than biochar from maize and meadow grass) (Ullah et al., 2018).

To solve the problem regarding acidity in soil focus need to be given on the functional group (carboxylic and phenolic) that need to be neutral (Mosharrof et al., 2022). Unfortunately, freshly prepared biochar having low carboxylic and phenolic group that give less effect to the neutralization (Mia et al., 2017). Most of the researcher agree that biochar combine with other compound would give beneficial effect to lower down the acidity effect and rise up the pH (Islam et al., 2021;Haque et al., 2021; Mosharrof et al., 2022), soil carbon removal(Zheng et al., 2020), promote rapidly growth, (Brennan et al., 2014), adjust soil structure together with improvement nutrient uptake(Peng et al., 2019) and some type of biochar also seemed to be practical to remove few type of pollutant(i.e., blue, tetracycline, pesticide and phosphate)(Li, X., et al., 2020). Biochar is also applicable to reduce the effect of Al & Fe concentration that give effect to increasing in Ph (Shetty & Prakash., 2020).

These suggest that biochar could help to reduce the acidity effect and improve the production. The effects of biochar with silicon should be further enhanced because both has same function to control the acidity of soil through alkaline and cation properties. The combining of both of this material should give more impact on the soil quality (Pontigo et al., 2015; Abukari., 2014). Moreover, previous studies showed that the silicon application would give benefit to increase the pH (De Sousa et al., 2019), boost up the photosynthesis rate (Pitann et al., 2021) and support the plant development (Zhiming et al., 2014). To get optimal outcome the rate of biochar and silicon need to be justified. Other than that, low pH value is can be highly caused by phosphorus deficiency and high potential for N2O emissions (Xie et al., 2020). While Mensah & Frimpong (2018), report that in sub-Saharan African (SSA), soil also face problem through continuous cultivation and rapid organic matter mineralization that will affect the properties of soil. However, these studies were conducted in various rate of biochar and silicon without the reducing of any supply on NPK fertilizer.

Application of biochar and silicon fertilizer helps to reduce the phosphorus fertilizer application, improve the maize growth and soil properties. Hence, the main objective of the study was to examine the performance of maize after the application of biochar with silicon fertilizer and with variable rates of P fertilizer.

2. MATERIALS AND METHODS

2.1.1 Experimental Site

A pot experiment was conducted for 75 days (October to December, 2022) in the greenhouse UPM at 2°98′36.6″ N (north) latitude and 101°73′81.9″ E (east) longitudes with an elevation of 56.8 m from sea level at the west coast of Peninsular Malaysia.

2.1.2 Experimental design and Treatments

The pot experiment was laid out in a completely randomized (CRD) with three replications having a pot size 38cm(height) and 32cm(diameter). The Bungor (Typic Paleudult; Order: Ultisol) soil series was collected in depth from 0–20 cm from Taman Pertanian, UPM, Puchong, Selangor (2°58′59.7″ N latitude; 101°38′47.5″ E longitude). It was air-dried, sieved through a 2 mm before chemical analyzing. For the green house experiment, the soil was sieved to 4mm and applied in all of the pots at a rate 20 kg of soil pot^{-1}. The biochar treatment was applied to the soil base on the dose required with recommend rate 10t/ha and mixed well and left for about one week before add with silicon 150kg/ha recommend as optimal amount for maize by (Xie et al., 2014). Additional N & K based on MARDI recommendation fertilizer: 120 kg N/Ha in the form of urea and 100 kg Potassium in the form of Muriate of potash 45 (MOP) was applied. Two recommended treatment from previous studies (Bakar et al.,2024). It was (50% RHB+ 100%Silicon) and (25% RHB+ 100%Silicon) and continue to implement together with various rate (0%,50%,75% & 100%) of Triple Superphosphate (TSP) for this research. In this experiment, F1 Hybrid Sweet Corn variety was collected from a local market as a test crop and it also a common variety use by Malaysian farmers. The maize seedling was put and being watered regularly to maintain a soil moisture content of 60-70% of water holding capacity during the growth period, and being destructively harvested 75 days after planting. Table 1 shows the treatment combination:

Table 1: Treatments for Conducting the Experiment

	Treatment
1.	(50% RHB) + (100% Si) + (0%P)
2.	(50% RHB) + (100% Si) + (25%P)
3.	(50% RHB) + (100% Si) + (50%P)
4.	(50% RHB) + (100% Si) + (100%P)
5.	(25% RHB) + (100% Si) + (0%P)
6.	(25% RHB) + (100% Si) + (25%P)
7.	(25% RHB) + (100% Si) + (50%P)
8.	(25% RHB) + (100% Si) + (100%P)

Table 1.1: Equivalent amount in the experiment setu

Element	Application	Recommended rate (kg/Ha)	Experiment setup rate (g/20kg soil)
Biochar	Rice Husk	10000	700
Silicon	Silicon (SiO :40%)	150	1
Nitrogen	Urea	120	0.8
Phosphorus	Triple Superphosphate (TSP)	60	0.4
Potassium	Muriate of Potash (MOP)	90	0.6

2.1.3 Post-harvest soil analysis

2.1.3.1 4.2.3.1 Acidity (pH)

Soil Ph was determined in water at a soil to solution ratio of 1:10(TAN, 1995). 1g oven-dried soil sample was placed into a vial and 10Ml Distilled water was added to it. It was shaken thoroughly for 5minutes and allowed to stand for 2 hours and the ph of the suspension was then measured using a pH meter for soil samples respectively.

2.1.3.2 Soil Available P

0.5M sodium bicarbonate, $NaHCO_3$, was prepared (21g of sodium bicarbonate was dissolved in about 450ml distilled water and was adjust to 8.5 pH with 1N NaOH and mark up to volume).1 g of soil sample was weighed into the plastic vial, 20 ml of the 0.5M sodium bicarbonate was added. It was shaking for 30 minutes, filtered by filter paper no.2 and send to ICP for phosphorus analysis (Olsen et al.,1954)

2.1.3.3 Exchangeable Cation(Magnesium, Potassium & Calcium)

Exchangeable cation was extracted using 100ml of 1N ammonium acetate((Schollengberger & Simon.,1945). Ashless cotton was put down at the hole of leaching tube to avoid the soil from pass through the tube and covered with filter paper with small size before put the 10g soil sample. Another filter paper was put on the soil sample to avoid the soil from being inverted when the solution was poured. The leaching valve was adjusted to make sure that the ammonium acetate flowing through the soil sample slowly with the speed one drop to another drop around 6 to

8 second. The concentration of K, Ca & Mg in the solutions were determined by the inductively coupled plasma-atomic emission spectrometry (ICP).

2.1.3.4 Soil Exchangeable Aluminium

1N KCL solution was prepared. Then weighed 5g of soil in plastic vial, added with 50 ml KCL solution, the cap was closed and the solution was shake for 30 minutes. After that the supernatant was slowly passing through whatman no 42 filters paper and send to ICP for aluminium analysis.

2.2.4 Plant material analysis

2.2.4.1 Leave number and plant Height analysis

The leave number of open leave was count at (75 DAS) and the plant height was determined using a measuring tape at harvest (75 DAS) from the base to the tip of the longest leaf (Lai,L.,2019).

2.2.4.2 Leave Photosynthesis rate(µmolCO2m-2s-1) and conductance (mol H20 m-2s-1)

The leaf chlorophyll content was measured using a portable chlorophyll meter (SPAD-502 Konica Minolta, Inc., Tokyo, Japan). The Chlorophyll reading was taken from the middle part of the largest leave of each plant using meter (SPAD--502, Konica Minolta, Osaka, Japan) (Alarefee ER AL.,2021) and the conductance reading was recorded at the same time.

2.2.4.3 Plant Fresh weight and biomass(g)

After harvest, the shoot (stem and leaves) were washed and dammed with tissue paper before dried in an oven at 60 °C for 72 h and weighed again for the biomass with consistence weight (Mosharrof et al.,2021)

2.2.4.4 Shoot nutrient Uptake (ppm)

The dried shoot than was blender and again dry in crucible in oven then put in glass desiccator before 0.25g was take to be extract the macro element of the shoot by using drying ashing method (Yuan et al.,2016) The concentration of P, K Ca and Mg were determined using inductively coupled plasma-atomic emission spectrometry (ICP). The result then convert into (ppm) by this formula:

$$Nutrient\ concentration(ppm) = Mean(mg/L) \times \left(\frac{mark\ up\ volume(50ml)}{weight(0.25g)}\right)$$

The maize nutrient uptake was later being calculated by multiplying with the respective dry weight oven-dry weight of the plant part with the nutrient content (Alarefee ER AL.,2021)

$$Nutrient\ Uptake = Nutrient\ Content(ppm) \times Biomass(g)$$

2.2.5 Cob yield component

2.2.5.1 Cob length, weight, grain per cob and grain yield

The cob length was measure before destructive the plant. While the cob weight(g) was measured using weight balance after harvest. Then total grain weight and 100 grain weight per cob was measure to calculated the grain per cob. Lastly the grain yield was recorded as stated in formula below:

$$\text{grain yield}\frac{\text{t}}{\text{ha}} = \left(\frac{\text{Total grain weight per cob } \times (3x10^6 KgSoil\ per\ Ha}{20KgSoil}\right)$$

2.2.6 Statistical Analysis

Analysis of Variance (ANOVA) procedure was used to analyze all of the data, and Tukey's Honestly Significant Difference (HSD) test was used to separate the means. Repeated measures analyses were performed on all parameters using John's Macintosh Project (JMP) Analysis Software , ($p \leq 0.05$).

3.1 Result and discussion

3.1.1 Effect of RHB, Silicon fertilizer, and Varying Doses of Phosphorus on the post-harvest soil properties

It was noticed that pH from post-harvest soil were significantly affected by biochar and silicon with varied phosphorus fertilizer application ($p<0.05$) (Table 4.3). The available pH was higher in T2(6.70) followed by T1, T3 & T7(6.47). This finding was similar to Mosharrof et al. (2021b), which observe 6.14 pH with the application of recommended RHB and phosphorus. The acidity also reduce with the low dose of phosphorus may cause by the effectiveness applies after reducing the Al and Fe stress reduced, make the pH increase and would improve the plant development (Xiong et al.,2024; Bakar et al.,2024; Ahmad et al.,2018). The available P was significantly affected by the application of different rate of biochar, silicon and phosphorus fertilizer. The highest P was recorded by T7(10.75) followed by T8(8.85) while T6(2.3) recorded the lowest P. Biochar application would increase the phosphorus availability (Seleiman et al., 2020). Thus, the low dose of phosphorus with application of biochar still show high result (Glaser, B., & Lehr, 2019). The combining of silicon and fertilizer would become an agent to make a binding that will make the fertilizer embedded in soil that would reduce the leaching of it and remain the available in soil (Nguyen, 2021).

The application of Silicon, biochar and phosphorus fertilizer significantly affected the Al content in soil. The highest total Al in soil was observed from T_2(0.031) followed by T1(0.023/kg) and the lowest was record by T6(0.001Cmol/kg). One finding show that the application of rice husk with high silicon would reduce the phytotoxicity (Wang et al.,2019). The less dose of phosphorus seemed to be still effective to reduce the Al may cause by the adding of silicon with the presence of its silicate surface would absorb and reduce the Al effect (Pontigo et al., 2015; Haynes, 2014).

The application of different rate of phosphorus with biochar and silicon fertilizer was significantly affected the exchangeable cation of the soil (Ca, K and Mg). The highest Exchangeable Ca, K & Mg recorded by T8(2.96, 2.09 & 1.94) cmol/kg and lowest K & Ca recorded by T2(1.52 & 0.67) cmol/kg. While the lowest exchangeable Mg recorded by T5(0.42cmol/kg). This cation may increase through the high consumption of H+ promote by biochar (Mosharrof et al., 2021b) and applying biochar and silicon together seemed to be as then medium to change the property of hydrophilic into hydrophobic. That would delay nutrient release from the soil (Weeks & Hettiarachchi, 2019)

Table 4.3: Post-harvest soil properties

Treatment	pH	P(Mg/kg)	EXC Ca	EXC K	EXC Mg	Al (Cmol/kg)
T1	6.47ab±0.07	7.75ab±0.49	2.54b±0.04	1.08bc±0.02	0.96b±0.02	0.023ab±0.004
T2	6.7a±0.06	8.1ab±1.91	1.52c±0.04	0.67e±0.02	0.43f±0.01	0.031a±0.001
T3	6.47ab±0.07	5.9ab±0.29	2.63ab±0.04	1.04bc±0.02	0.67cd±0.01	0.005c±0.001
T4	6.33ab±0.07	3b±1.50	2.60ab±0.20	1.10b±0.04	0.71c±0.01	0.012bc±0.004
T5	5.2d±0.00	8.53ab±0.18	1.54c±0.06	0.88d±0.01	0.42f±0.003	0.012bc±0.001
T6	6.27bc±0.07	2.3b±0.12	1.83c±0.02	0.76e±0.01	0.49e±0.01	0.001c±0
T7	6.47ab±0.07	10.75a±0.38	2.43b±0.04	0.97cd±0.01	0.65d±0.004	0.006c±0.002
T8	5.87c±0.18	8.85ab±3.15	2.96a±0.02	2.09a±0.03	1.94a±0.02	0.007c±0.002

Means within the same column followed by the different letters are significantly different at $p \leq 0.05$; (Tukey's HSD test). The column represents the mean values ± standard error. T1 = (50% RHB) + (100% Si) + (0%P), T2=(50% RHB) + (100% Si) + (25%P), T3= (50% RHB) + (100% Si) + (50%P), T4= (50% RHB) + (100% Si) + (100%P), T5= (25% RHB) + (100% Si) + (0%P), T6= (25% RHB) + (100% Si) + (25%P), T7= (25% RHB) + (100% Si) + (50%P), T8= (25% RHB) + (100% Si) + (100%P).

3.1.2 Effect of RHB, Silicon fertilizer, and Varying Doses of Phosphorus on plant height, leaf number, conductance, photosynthesis rate and dry biomass of maize plant

Different availability of phosphorus significantly together with silicon and biochar application affected (Appendix F1) on the plant height(cm) of the maize measure at 65 DAS. T5 showed the shortest height(119.63cm) compare to other treatments. All the remaining treatment result higher height ranging from154.27cm to 180.23cm in 65 day. It was noticed that Biomass of maize were significantly affected by the availability of biochar with biochar and silicon application ($p<0.05$) (Table 4.4). The highest biomass recorded by T4(81.47) Followed by T5(76.74) while the lowest biomass recorded by

T1(52.13). One research recorded that the maize treat with Silicon 40 kg ha-1 and 80 kg ha-1 showed result of shoot height 130.4cm and 133.5 cm while 128.5cm for control (Younas et al., 2021). While Peter Asbon. (2017), stated that high rate of phosphorus would give more impact on the Plant height after 6 weeks. The application of biochar and silicon increase the development of plant by promoting rise in solubilizing organic phosphate, mineralizing inorganic phosphate and nutrient uptake (Raza et al., 2021).

In this study, it was noticed that the silicon and biochar with different phosphorus availability significantly affected (Appendix F3) ($p<0.05$) the conductance (mol H20 $m^{-2}s^{-1}$) from maize leaf (Table 4.4). The conductance was higher in T5(0.274) followed by T2(0.0.268) while T3(0.136) recorded the lowest conductance. Phoshorus application on the soil would probably has the tendency to improve the stomata opening and increase the conductance (Zangani et al., 2021). Although, the dose of phosphorus in this research was not constant still outcome with not high range in the conductance may cause by the presence of silicon that cover the function of phosphorus to reduce chlorophyll synthesis and lower down the the leaf water potential (Rehman et al., 2021).

Table 4.4: Plant morphological and physiological parameter

Treatment	Plant height	Leaf no	Conductance (mol H20 $m^{-2}s^{-1}$)	Photosynthesis rate (μmolCO2$m^{-2}s^{-1}$)	Dry biomass
T1	174.07b±0.31	11a±0.25	0.206b±0.001	32.5a±0.31	52.13d±0.98
T2	157.37d±0.37	10b±0.00	0.268a±0.003	32.7a±0.95	64.86c±1.59
T3	166.40c±1.14	11a±0.00	0.136c±0.001	28.5b±0.49	54.22d±1.22
T4	154.27d±0.43	10b±0.00	0.146c±0.004	23.8c±0.78	81.47a±0.30
T5	119.63e±0.19	10b±0.00	0.274a±0.006	30.6ab±0.01	76.74b±0.43
T6	174.60ab±2.87	10ab±0.00	0.174bc±0.017	33.4a±1.18	67.97c±1.01
T7	180.23a±1.54	11a±0.47	0.208b±0.001	18.8d±0.00	69.05c±0.69
T8	168.87bc±1.10	11a±0.50	0.211b±0.023	24.4c±0.06	66.90c±0.58

Means within the same column followed by the different letters are significantly different at p≤ 0.05; (Tukey's HSD test). The column represents the mean values ± standard error. T1 = (50% RHB) + (100% Si) + (0%P), T2=(50% RHB) + (100% Si) + (25%P), T3= (50% RHB) + (100% Si) + (50%P), T4= (50% RHB) + (100% Si) + (100%P), T5= (25% RHB) + (100% Si) + (0%P), T6= (25% RHB) + (100% Si) + (25%P), T7= (25% RHB) + (100% Si) + (50%P), T8= (25% RHB) + (100% Si) + (100%P).

3.1.3 Effect of RHB, Silicon fertilizer, and Varying Doses of Phosphorus on cob length, cob weight, number of grain per cob and grain yield

Cob length, Cob weight, number of grains per cob and grain yield of maize were enhanced significantly (Appendix F6, F7, F8 & F9) by various treatments (Table 4.5). A longer but statistically similar cob length was observed in T3, T4, and T5 (up to 20.77g), while the lightest was observed in T5 (16.4g). The maximum cob weight, No of grain and yield grain were noted in T3 (160.56g, 417.08g and 14.6t/ha, respectively), while the lowest rate of biochar, silicon and phosphorus recorded the lowest T5(61.23g, 120.24g and 4.21t/ha). Application of biochar with NPK would produce high yield compare to sole biochar (Arif et al., 2012) and higher dose would produce higher yield (islam et al., 2018). Biochar improve the soil structure, root growth, nutrient uptake and promote high yield (Liu x et al., 2021). Although biochar has high content of phosphorus, TSP fertilizer still need to be imply as targeted for the high yield because biochar will act as slow-releasing phosphorus (P) fertilizers and will increase P use efficiency (Li H et al., 2020).

Table 4.5: Cob development and maize yield parameter

Treatment	Cob length (cm)	Cob weight (g)	No of grain per cob	grain yield (t/ha)
T1	19.4ab±1.15	112.21b±8.14	360.14a±7.89	12.60a±0.28
T2	19.13ab±0.91	135.76ab±14.41	180.11bc±24.99	6.30bc±0.87
T3	21.27a±0.52	160.56a±7.12	417.08a±11.84	14.60a±0.41
T4	20.77a±0.318	151.87ab±12.76	400.38a±15.24	14.01a±0.53
T5	16.4b±0.25	61.23c±7.95	120.24c±22.41	4.21c±0.78

T6	20.77a±0.63	125.96ab±7.61	218.8b±2.70	7.66b±0.09
T7	18.73b±1.07	119.22ab±10.32	337.36a±16	11.81a±0.56
T8	19.53ab±1.08	118.79ab±6.0	339.38a±19.25	11.88a±0.67

Means within the same column followed by the different letters are significantly different at p≤ 0.05; (Tukey's HSD test). The column represents the mean values ± standard error. T1 = (50% RHB) + (100% Si) + (0%P), T2=(50% RHB) + (100% Si) + (25%P), T3= (50% RHB) + (100% Si) + (50%P), T4= (50% RHB) + (100% Si) + (100%P), T5= (25% RHB) + (100% Si) + (0%P), T6= (25% RHB) + (100% Si) + (25%P), T7= (25% RHB) + (100% Si) + (50%P), T8= (25% RHB) + (100% Si) + (100%P).

3.1.4 Effect of RHB, Silicon fertilizer, and Varying Doses of Phosphorus on P, K, Ca & Mg uptake of maize plant

There was a significant difference in plant nutrient uptake of maize, represented in Tables 4.6. With T8 the total uptake of P(1143.62ppm/g) and Mg (1135.4 ppm/g) taken up by the maize plant were statistically higher than other treatment. The highest uptake of K (26980.9 ppm/g) and Ca (4273.6ppm/g) obtained from T4 (50% RHB + 100% Si + 100% TSP). The lowest Uptake of P recorded by T7(352.79ppm/g), lowest uptake of K showed by T3(17129.6ppm/g), lowest Ca and Mg recorded by T1(2138.24ppm/g & 578.76ppm/g). The high phosphorus & potassium uptake observe with application of biochar as the treatment (Ullah et al., 2018). According to Zaidun et al. (2019), the application of biochar would increase the exchangeable K together with the increasing of dose of biochar. The high uptake of K show that the good sign to help improve photosynthesis, carbohydrate metabolism, protein formation then affect the good development of yield (Mikkelsen, 2017).

Table 4.6: Nutrient uptake

Treatment	Uptake P(ppm/g)	Uptake K(ppm/g)	Uptake Ca(ppm/g)	Uptake Mg(ppm/g)
T1	378.59de+20	17337.2d+18.22	2138.24d+8.67	578.76f+14.71
T2	422.15de+15.4	20789.1b+28.5	3221.23b+7.33	984.65bc+13.2
T3	698.09b+7.09	17129.6d+38.1	2346.87cd+2.11	812.15e+8.88
T4	426.27d+8.81	26980.9a+31.2	4273.6a+18.63	1074.65ab+34.57
T5	510.1c+3.98	20713.9b+16.6	3270.59b+7.91	980.95bc+16.89
T6	363.46de+9.15	18525.3c+20.7	2672.78c+3.75	915.23cd+20.74
T7	352.79e+18.79	19286.9c+9.16	2618.04c+1.72	863.91de+9.2
T8	1143.62a+22.82	21050.1b+9.47	2543.41cd+1.1	1135.4a+32.1

Means within the same column followed by the different letters are significantly different at p ≤ 0.05; (Tukey's HSD test). The column represents the mean values ± standard error. T1 = (50% RHB) + (100% Si) + (0%P), T2=(50% RHB) + (100% Si) + (25%P), T3= (50% RHB) + (100% Si) + (50%P), T4= (50% RHB) + (100% Si) + (100%P), T5= (25% RHB) + (100% Si) + (0%P), T6= (25% RHB) + (100% Si) + (25%P), T7= (25% RHB) + (100% Si) + (50%P), T8= (25% RHB) + (100% Si) + (100%P).

4. Conclusion

To conclude, treatment 3 he combined application of biochar and silicon, along with 50% phosphorus, is recommended for enhancing the pH, K and Ca uptake, biomass and yield. This treatment is practically can be applied for further trial in field plot to get more stable result. This approach will help for conducive application, environmental benefits and gain more profit to farmers.

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