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Research Paper

NUTRIENT SOURCES AND ITS EFFECT ON NUTRIENT UPTAKE BY SOYBEAN AND SOIL FERTILITY STATUS UNDER MID HILL CONDITION OF NEPAL

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Abstract

An experiment was conducted to study the effect of inorganic, organic and biological sources of nutrient on nutrient uptake by soybean (Glycine max L.) and its effect on residual soil nitrogen, available phosphorus and potassium, pH and organic matter content on soil at farm of Agronomy Division, Khumaltar, Lalitpur,Nepal. The experiment was laid out in a Randomized Complete Block Design (RCBD) with eight treatments consisting of T_1 *(30: 60: 30 N* P_2O_5 K_2O *kg* ha^{-1}*-recommended dose -control),* T_2 *(30: 80: 30 N* P_2O_5 K_2O *kg* ha^{-1}*),* T_3 *(50: 60: 30 N* P_2O_5 K_2O *kg* ha^{-1}*),* T_4 *(50: 80: 30 N* P_2O_5 K_2O *kg* ha^{-1}*),* T_5*(*T_1 *+ compost 10 t* ha^{-1}*) ,*T_6 *(*T_1 *+ Rhizobium inoculation),* T_7 *(*T_1 *+ Biochar 2 t* ha^{-1} *),* T_8 *(Compost 20 t* ha^{-1}*) with four replication. The result showed that Application of 2 ton* ha^{-1} *biochar with recommended dose of inorganic fertilizer and compost 20 ton* ha^{-1} *had significantly higher total nitrogen, phosphorus and potassium uptake (365.2 kg* ha^{-1}*and 299.3 kg* ha^{-1}*, 50.5 kg* ha^{-1} *and 46.8 kg* ha^{-1}*, 79.1 kg* ha^{-1} *and 85.1 kg* ha^{-1} *respectively). Soil total nitrogen, available phosphorus and potassium, soil pH and soil organic matters were increased with application of compost. Significantly higher available phosphorus (40.84 mg* kg^{-1}*) and potassium (90.78 mg* kg^{-1}*) contents in soil were recorded in* T_8*. Thus, integration of organic sources of nutrient with recommended dose of inorganic fertilizer showed the positive impact on residual soil nutrient and nutrient uptake*.

Key words: Inorganic, organic, biological sources, residual, soil properties.

INTRODUCTION

Soybean (*Glycine max* L. Merril) is one of the important legumes in Nepal. It is a good source of protein (45 to 50%), oil (20%), and is rich in Vitamin B, C, E and mineral so used as good supplemental food with cereals in underdeveloped country like Nepal [1].

It is cultivated in 23446 ha of land with the national production of 28917 mt but the productivity is substantially low with national average of 1201 kg ha^{-1}[2]. Land is the major non –renewable resource and faces the biggest threat of degradation. The long term use of inorganic fertilizer without organic supplements damages the soil physical, chemical and biological properties and causes the environmental pollution. Similarly, imbalanced use of fertilizers has adverse effect on agricultural productivity and caused soil degradation. Organic manures act not only as a source of nutrients but also increase biodiversity and activity of the microbial population in soil, influence nutrients get turnover and improve soil physical and chemical properties of soil [3]. Application of cow dung and poultry litter increased the soil pH, organic matter, N, available P, exchangeable K, Ca and Mg relative to control [4]. According to [5], the total nitrogen, available phosphorus and potassium status of soil and N, P, K uptake by soybean increased significantly with the integration of organic fertilizer with inorganic fertilizer. [6] reported that application of 100% NPK + farm yard manure 10 ton ha^{-1} in maize – wheat cropping system increased the NPK uptake significantly.

Although several field studies have been conducted on nutrient management of soybean in the various parts of the world, very few information is available under Nepalese soil conditions. Selecting the superior sources of nutrient and optimizing the nutrient requirements for sustainable soybean production is utmost necessity. Therefore this study was carried out to determine the effect of different sources of nutrient on nutrient uptake by soybean and residual nutrient status on soil.

MATERIALS AND METHODS

The experiment was conducted from June 2016 to December 2016 at the experimental site of Agronomy Division, Khumaltar of Nepal Agricultural Research Council. The experimental site is geographically situated at 85˚ 10' East longitudes and 27 ˚ 39' North latitude at an altitude of 1360 masl. The soil of the experimental site was medium (0.10 g kg^{-1}) in nitrogen, high in available phosphorus (81.92 mg kg^{-1}), high in available potassium content (160.9 mg kg^{-1}), low in organic matter content (2.15%) and moderately acidic (5.43) in pH. The highest monthly average maximum temperature (28.6°C) was recorded during crop growing period in June and the crop received 844.9

mm rainfall during the experimental period. Crop received maximum rainfall (414mm) in July. The weather condition of the area for the study period is presented in Figure (1). The experiment was conducted by using Randomized Complete Block Design (RCBD) with eight treatments and each treatment was replicated four times. The eight treatments consisting of T_1 (30: 60: 30 N P_2O_5 K_2O kg ha^{-1}-recommended dose - control), T_2 (30: 80: 30 N P_2O_5 K_2O kg ha^{-1}), T_3 (50: 60: 30 N P_2O_5 K_2O kg ha^{-1}), T_4 (50: 80: 30 N P_2O_5 K_2O kg ha^{-1}), T_5(T_1 + compost 10 t ha^{-1}) ,T_6 (T_1 + Rhizobium inoculation), T_7 (T_1 + Biochar 2 t ha^{-1}), T_8 (Compost 20 t ha^{-1}). Crop was maintained in uniform rows of 50 cm and plant to plant distance of 10 cm. The area of each plot was 15 m^2 (3m x 5m). There were six rows of soybean in each plot with 5m long. There was 75 cm space between the plot and blocks were separated by 1 m space.

Soybean variety Tarkari Bhatamas – 1 was selected in the experiment and crop was sown on 8 June 2016 (26 Jestha 2073). It is short duration soybean variety and recommended for upland or bariland of Kathmandu valley and similar environmental area of mid hill (800-1500 m amsl) which has seed production capacity of 2287 kg ha^{-1} and pods 10.85 ton ha^{-1} [7]. Compost (1.50% N, 0.51% P_2O_5, 1.51% K_2O and C: N ratio 10:1) prepared in compost pit were applied according to the treatment and incorporated in to the soil. Rhizobium 1 kg ha^{-1} was mixed in soil according to treatment before seeding. Full dose of N, P_2O_5 and K_2O were applied as per treatment at the time of seed sowing. Biochar was also placed in deep furrows according to treatment and covered by soil before seed sowing. The urea (46% N), Di-Ammonium Phosphate (18% N and 46% P_2O_5) and Muriate of potash (60% K_2O) were used as a source of N, P_2O_5 and K_2O respectively. Normal intercultural operations like weeding, earthing up etc. were done as per needed. Manual weeding was done at 20 days after seeding and earthing-up was carried out at 45 days after seeding (DAS). Drainage facility was provided surrounding the experimental plot. Ten plants were selected randomly from inner two row of each plot at harvest to measure the plant height, number of branch per plant, pods per plant and seeds per pod. Total number of branch and pods of each plant were counted and their averaged values were used for analysis. Seed yield and straw yield of ten plants were taken from each plot at harvesting. The harvested plants were dried on threshing floor and threshed, sun dried, cleaned and final weight of seed was taken. Digital Moisture Meter was used to record the moisture percentage of the grain. Finally grain yield was adjusted at 12% moisture using the following formula

$$\text{Gain yield (kg ha}^{-1}\text{) at 12\% moisture} = \frac{(100\text{-MC}) \times \text{Plot yield (kg)}}{(100\text{-}12) \times \text{Net plot area (m}^2\text{)}} \times 10000 \text{ (m}^2\text{)}$$

Where, MC is the moisture content in percentage of the grains.

Soil samples were collected diagonally from three spots of each plot at a depth of 0-20 cm using augur and prepared one composite sample of each plot to determine the pH, soil texture, total nitrogen, available phosphorus, available potassium, and organic matter. The samples were air-dried, ground and sieved through 2 mm sieve for analysis.

Plant samples (shoot and grain) were collected at harvest from each plot to analyze the nitrogen, phosphorus and potassium. Stem, leaf and pod wall of each plot were mixed together to make the composite sample and grains from inner two rows were taken randomly. The samples were oven dried at 65^0C for 72 hours and ground to pass 1mm sieve for analysis.

Methods used for physical and chemical analysis of soil samples are given in Table 1.

On the basis of nutrient concentration of seeds and straw, the total nutrient uptake by crop was calculated using the following formula:

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (\%) x Yield (kg ha}^{-1}\text{)}}{100}$$

The data was statistically analyzed by using computer software MSTAT-C. The mean separation was done by using Duncan's Multiple Range Test (DMRT) at 5% level of significance.

RESULTS

Effect of nutrient sources on nutrients uptake by soybean

Nutrient sources had significant effect on nitrogen uptake by soybean (Table 2). Highest nitrogen uptake (365.2 kg ha-^{1}) was recorded from the plot treated with recommended dose of chemical fertilizer with biochar followed by plot treated with compost 20 ton ha-

^{1} (299.3 kg ha^{-1}). Increasing in nitrogen level from 30 kg N ha^{-1} to 50 kg N ha^{-1} and P level from 60 kg ha^{-1} to 80 kg ha^{-1} had not significant effect on nitrogen uptake by crop. Integration of compost with chemical fertilizer increased nitrogen uptake by 13.9% compared to chemical fertilizer alone. Similarly rhizobium inoculation with chemical fertilizer increased Nitrogen uptake by 4.99% compared to chemical fertilizer alone. Lowest nitrogen uptake (203 kg ha^{-1}) from the plot treated with 50 kg N, 60 kg P_2O_5 and 30 kg K_2O ha^{-1}.

Phosphorus uptake by crop was affected by various sources of nutrient which was presented on Table 2. Highest phosphorus uptake (50.5 kg ha^{-1}) was recorded from the plot treated with recommended dose of chemical fertilizer with biochar which was significantly different ($P<0.05$) to the other treatments but statistically at par with T_8, T_2, and T_4. Increased phosphorus application from 60 kg ha^{-1} to 80 kg ha^{-1} increased 17.6 to 20.83% more phosphorus uptake. Lowest P uptake (33.6 kg ha^{-1}) was obtained from the plot treated with recommended dose of chemical fertilizer.

Various sources of nutrient affected significantly on potassium uptake by soybean. Highest uptake of potassium (85.1 kg ha^{-1}) was obtained from plot treated with compost 20 t ha^{-1} followed by plot treated with recommended dose of chemical fertilizer with biochar (79.1 kg ha^{-1}) and plot treated with RDF with compost 10 t ha^{-1} (71.6 kg ha^{-1}) which was statistically superior to others. Lowest uptake of potassium (45.4 kg ha^{-1}) was recorded from T_1 (RDF). Increased in N and P doses from recommended increased 20.26 to 30.83% potassium uptake, respectively (Table 2).

Effect of nutrient sources on soil fertility status

Nitrogen content in soil at crop harvest was not differed significantly with nutrient sources (Table 3). However application of 20 t ha^{-1} compost increased 4.35% more nitrogen compared to plot received inorganic fertilizer alone.

Nutrient sources had significant effect on available P_2O_5 and available K_2O content in soil at harvest (Table 3). The highest available P_2O_5 (40.84 mg kg^{-1}) and K_2O (90.78 mg kg-^{1}) was observed in plot treated with compost 20 t ha^{-1}. In this experiment, available phosphorus and potassium status in soil was not affected significantly with integration of biochar with chemical fertilizer (Table 3).

Effect of nutrient sources on soil pH and organic matter was presented on Figure 2. Data revealed that soil organic matter content was statistically similar with nutrient sources. However application of compost 20 t ha^{-1} increased organic matter by 6.52% compared to T_1. Soil pH was affected by nutrient sources significantly. The highest soil pH 5.60 was recorded from plot treated with chemical fertilizer with compost 10 t ha^{-1}. Increment in soil pH was followed by integration of biochar with chemical fertilizer (5.50) which is shown in Figure (2).

Table 1. Methods of soil and plant analysis

Parameters	Analysis methods
Soil pH	Glass- electrode pH meter [8]
Soil texture	Bouyoucos hydrometer method [9]
Soil organic matter	[10]
Soil total nitrogen	Kjeldahl distillation [11]
Nitrogen content in nodule	Kjeldahl distillation [11]
Plant total nitrogen content	Kjeldahl distillation [11]
Plant phosphorus content	Vandomolybdo-Phosphoric Yellow color method [12]
Available phosphorus in soil	Modified Olsen's bicarbonate method [13]
Available potassium in soil	Ammonium acetate method [12]

Table 2. Effect of sources of nutrients on NPK uptake by plant

Treatments	Total N uptake (kg ha^{-1})	Total P uptake (kg ha^{-1})	Total K uptake (kg ha^{-1})
T_1 (N_{30} P_{60} K_{30})	212.1^{bc}	33.6^{c}	45.4^{c}
T_2 (N_{30} P_{80} K_{30})	264.7^{bc}	40.6^{ab}	59.4^{bc}
T_3 (N_{50} P_{60} K_{30})	203.7^{c}	34.8^{bc}	57.2^{bc}
T_4 (N_{50} P_{80} K_{30})	237.0^{bc}	39.5^{abc}	54.6^{bc}
T_5 (N_{30} P_{60} K_{30} C_{10})	241.6^{bc}	35.0^{bc}	71.6^{ab}
T_6 (N_{30} P_{60} K_{30} RI)	222.7^{bc}	36.7^{bc}	55.3^{bc}
T_7 (N_{30} P_{60} K_{30} BC_2)	365.2^{a}	50.5^{a}	79.1^{a}
T_8 (C_{20})	299.3^{ab}	46.8^{ab}	85.5^{a}
Grand mean	255.8	39.7	63.5
F- probability	<0.01	<0.05	<.001
SEm(±)	27.27	3.64	5.73
$LSD_{0.05}$	80.21	10.72	16.85
CV %	21.3	15.1	18.0

SEm= Standard Error of Mean, CV= Coefficient of Variation, Means followed by different letters are significantly different among each other based on DMRT at 5% level of significance

Table 3. Nutrient content of soil after the experiment under different treatment

Treatments	Total Nitrogen, g kg^{-1}	Available P_2O_5 in mg kg^{-1}	Available K_2O in mg kg^{-1}
T_1 (N_{30} P_{60} K_{30})	1.15	38.26^{ab}	71.84^{b}
T_2 (N_{30} P_{80} K_{30})	1.15	36.24^{b}	67.33^{b}
T_3 (N_{50} P_{60} K_{30})	1.18	36.84^{b}	65.86^{b}
T_4 (N_{50} P_{80} K_{30})	1.13	36.67^{b}	65.79^{b}
T_5 (N_{30} P_{60} K_{30} C_{10})	1.13	37.64^{b}	71.78^{b}
T_6 (N_{30} P_{60} K_{30} RI)	1.13	36.04^{b}	62.87^{b}
T_7 (N_{30} P_{60} K_{30} BC_2)	1.18	37.44^{b}	71.80^{b}
T_8 (C_{20})	1.20	40.84^{a}	90.78^{a}
Grand mean	1.153	37.50	71.0
F-probability	NS	<0.05	<0.01
SEm(±)	0.042	1.01	4.64
$LSD_{0.05}$	0.126	2.988	13.65
CV %	7.4	5.4	13.1

SEm= Standard Error of Mean, CV= Coefficient of Variation, Means followed by different letters are significantly different among each other based on DMRT at 5% level of significance

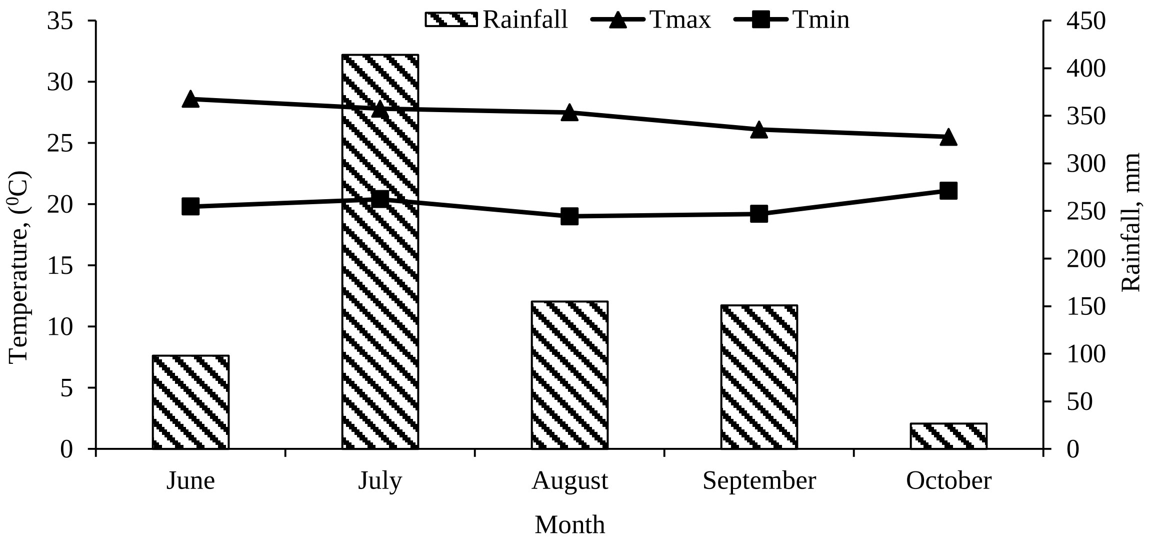

Figure 1. Weather conditions during the experimentation period at Khumaltar, Lalitpur, 2016

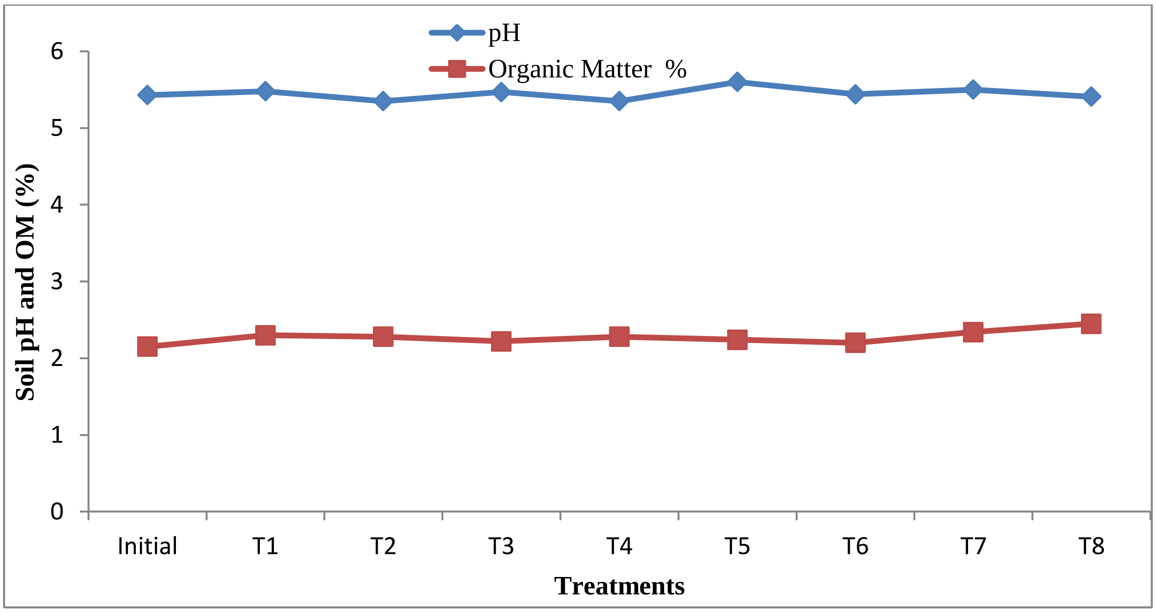

Figure 2. Soil pH and organic matter content before and after the experiment for different treatments

DISCUSSION

Nutrient uptake by soybean

Different sources of nutrient had significant effect on nitrogen, phosphorus and potassium uptake by crop. The highest nitrogen uptake was obtained from the plot treated with recommended dose of chemical fertilizers with biochar 2 ton ha^{-1}. This result was similar with result of [14] in which they reported that application of biochar significantly increased nitrogen uptake by plant. [15] and [16] also reported higher nitrogen uptake by raddish plants grown in biochar amended soils. The increase in nutrient uptake in biochar treated soil may be due to the increased microbial activity in the soil. [16] reported that biochar addition to the soil provided habitat for soil microorganisms which were involved in transformation of nitrogen and phosphorus.

Total N uptake from plot treated with compost fertilizer was at par with biochar treated plot. [17] observed that the uptake of N by the linseed increased significantly with the application of FYM over control. It might be due to the balanced supply of nutrient through the FYM and increased availability of this nutrient to the soil.

Phosphorus uptake was affected by nutrient sources significantly. The highest phosphorus uptake by plant was obtained from plot treated with biochar and chemical fertilizer, however, statistically similar with T_8, T_2, and T_4. Increased phosphorus application from 60 kg ha^{-1} to 80 kg ha^{-1} increased 17.6 to 20.83% more phosphorus uptake. This result was in line with the result of [18]. They found that maximum phosphorus uptake was obtained from 80 kg P_2O_5 ha^{-1}. The increased uptake of phosphorus was due to added supply of nutrients and well developed root system resulting in better absorption of water and nutrient [19] also reported that total phosphorus uptake by pigeon pea significantly increased with increasing phosphorus level due to higher amount of biomass production and subsequently greater phosphorus accumulation by the plant.

The nutrient sources had significant effect on potassium uptake by crop. The highest potassium uptake was obtained from application of compost 20 t ha^{-1} which was statistically at par with integration of biochar with chemical fertilizer and integration of compost 10 t ha^{-1} with chemical fertilizer. This result was similar with findings of [5] in which they found that potassium uptake by crop was increased with the combination of inorganic fertilizer with biological and organic fertilizer. [6] found a significant higher K_2O uptake by maize- wheat cropping system by the application of 100 % NPK + FYM 10 t ha^{-1}. This might be due to the beneficial effects of organic manures on direct addition of K_2O widening available K pool of soil.

[20] reported that addition of organic manure to the soil not only act as a source of nutrients but also increased the availability leading to higher uptake of nutrients.

Soil fertility status at harvest

Total nitrogen % in the soil at the time of soybean harvest was not affected by different sources of nutrients. This may be due to short-term experiment of one year. Changes in soil properties require long term experiment. However, compost 20 t ha^{-1} treated plot content 4.35 %

more nitrogen compared to control. [21] found that the total nitrogen in organic field after crop harvested was higher than field treated with chemical fertilizer alone. Regular application of FYM might significantly increase the available phosphorus, total nitrogen and carbon contents in the soil [22]. **S**imilar result was observed by [5]. They found that integrated nutrient management increased the nitrogen content in soil. This may be due to slow release of nutrient through organic manures and enriching the available pool of nitrogen [23]

Available phosphorus content in soil after experiment was affected significantly with the nutrient sources. The highest available phosphorus was observed from compost treated plot. [5] also found the buildup of available phosphorus was higher in the integration of 75% RDF as inorganic fertilizer with organic manure and PSB treated plots. This might be due to the release of organic acid during microbial decomposition of organic matter which helps in increasing solubility of native phosphates, thus increased available phosphorus pool in the soil [24].

Available K_2O content in soil was highly significant with nutrient sources. Application of compost 20 t ha^{-1} increased potassium content (90.78 ppm) which was highly significant compared to other treatment. Similar result was observed by [5] in which they reported that integration of inorganic fertilizer with organic fertilizer enriched the fertility status of soil in respect of available K content. But, available potassium status in soil was not affected significantly with integration of biochar with chemical fertilizer in our experiment. This result was similar with [25].

According to [19], the available N, P, and K in the post-harvest soil were higher in the treatment that received composted poultry manure either alone or with FYM.
All the organic manure included treatments registered higher available N, P and K than no manuring. Available phosphorus and available potassium was higher in the field with organic fertilizer only and with integrated nutrient management system was also reported by [20].

Soil organic matter was not different statistically with nutrient sources. However application of compost 20 t ha^{-1} increased organic matter by 6.52% compared to T_1. [26] also reported addition of 5 ton FYM ha^{-1} along with fertilizer N helped in maintaining the original organic matter status in soil. Soil pH was affected by nutrient sources significantly. The highest soil pH 5.60 was recorded from plot treated with chemical fertilizer with compost 10 t ha^{-1}. This result was in line with [5] in which they revealed that maximum increased in soil pH (5.60) was recorded from the integration of inorganic fertilizers with organic manures. Increment in soil pH was followed by integration of biochar with chemical fertilizer (5.50). Increased in soil pH by the application of biochar was also observed by other authors. The basicity of most biochars can be beneficial to acidic soils, acting as a liming agent to increase pH, and decrease exchangeable Al [27], [14].

CONCLUSIONS

The experiment revealed that nitrogen, phosphorus and potassium uptake by plants was significantly higher from integrated use of organic and inorganic sources. Similarly, integration of biochar with chemical fertilizer and compost with chemical fertilizer increased soil pH, soil organic matter, total nitrogen, available phosphorus and available potassium in soil. Thus it can be concluded that the fertility status and nutrient uptake by crop was found better with the application of organic manure than application of chemical fertilizers alone. It is very important for sustainable agriculture.

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