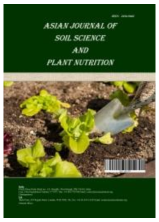

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Soil Chemical Properties Changes under Alley Cropping in Terrace Ecosystem of Bangladesh

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Authors' contributions

This work was carried out in collaboration among all authors. Author ASMJA designed the study, conducted research and analyzed soil samples, performed the statistical analysis, and prepared the first draft of the manuscript. Authors SRS, MGM, MMR, and MRI supervised the student in planning and designing the experiment, and editing the manuscript. Authors AKD helped ASMJA to analyze soil samples in the laboratory. All authors read and approved the final manuscript.

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ABSTRACT

Soil health needs to be improved for the sustenance of a productive agriculture and sound environment where alley cropping system might play a vital role. The study was composed of two factors viz. three alley widths of *Gliricidia sepium* (3.0, 4.5 and 6.0 m), and five nitrogen levels (0, 25, 50, 75 and 100% of the recommended dose) along with pruned materials in a split-plot design with three replications. The soil chemical properties were examined in alleys of *Gliricidia sepium* tree over two consecutive seasons. Results displayed that pruned materials (PM) of *G. sepium* increased the soil pH, organic carbon (OC), total nitrogen (N), available phosphorus (P) and sulfur (S), exchangeable calcium (Ca), magnesium (Mg), potassium (K), and cation exchange capacity (CEC) of soil in different alley widths compared to the control. However, alley width 3.0 m and

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100% N along with PM displayed the maximum OC (0.94%), total N (0.21%), available P (16.26 ppm), exchangeable Ca (2.54 meq/100 g) and Mg (0.90 meq/100 g), while maximum exchangeable K and CEC were noted in alley width 4.5 m and 100% N along with PM. The above results explicated that the improvement of the soil chemical properties by using pruned materials of *G. sepium* in alleys can be a promising option for uplifting the soil health condition as well as sustainable agricultural practices.

Keywords: Open field; soil temperature; soil moisture; total nitrogen; soil organic matter.

1. INTRODUCTION

Sustainable crop cultivation depends on good health of soil. Appropriate and well-adjusted nutrient availability influence the suitable crop growth and production. In Bangladesh, the fertility status of soil has been declining gradually. The soil under intensive cultivation is seriously degraded and appeared as a threat to sustainable agriculture [1]. Practically all upland soils of Bangladesh have inadequate nitrogen with low organic matter content. Organic matter content in the 60% of the arable land of Bangladesh is only 1% [2], while N, P and K contents are inadequate [3]. Around the world, from the last several decades' soil health has been threatened and nonetheless there has been a renewed interest in defending and enhancing this most vital resource for the generations to come [4]. Therefore, it is an utmost task to keep soil alive and maintain its productive capacity. Environment friendly, demand oriented and climate smart agricultural technologies are to be adopted for sustainable crop production [5]. Fortunately, agroforestry practices offer a great opportunity to rebuild the soil fertility for sustainable crop production. It has multifunctional land use practices that generated considerable interest in recent years in response to its potentiality to diminish poverty level, ensure food security, alleviate climate change and decrease land degradation. However, agroforestry is known as a diversified land use system that improves soil health and greatly recognized as a climate smart agriculture practice since its inception [6,7,8]. Both poplar and guava-based agroforestry systems increased SOC than under the sole crop system [9]. Tree species growing on farmlands may help improve soil physical conditions and chemical properties [10].

Alley cropping is a type of agroforestry system which is considered as an ideal technology for sustainable crop production. In this system, agricultural crops are grown in the inter spaces between rows of planted shrubs and or tree species, preferably legumes, which are periodically pruned to minimize tree-crop competition for growth resources such as water, nutrient and light [11]. Pruned material is applied to the soil which upon decomposition releases nutrients and improves soil health. Increased nutrient supply and improved soil health ultimately contribute to the growth and development of associated crops [12]. Alley cropping enhances soil carbon (C) sequestration and helps to mitigate global warming [13,14,15]. In addition, fast growing leguminous tree/shrubs species are grown because they usually recycle nutrients, contribute to biological nitrogen fixation [16]. Soil organic matter could increase by 4-7% in alley-cropping systems with red alder (*Alnus rubra*) and maize in comparison with maize monoculture following 4 years of cropping [17]. Addition of pruned materials significantly increased enzyme activity and microbial diversity in agroforestry alley cropping systems as compared with monocrop agriculture [18,19,20]. *Gliricidia sepium* tree is known as a fertilizer tree that has greater capacity to improve and rejuvenate soil health, and sustain agricultural production [21]. In view of the current national and international interest in organic farming for safe environment, it is necessary to assess the suitability of alley cropping as organic farming. For proper management of hedges and increased production of cauliflower, a study was undertaken and executed over two consecutive seasons to examine the changes in soil chemical properties in alleys of *G. sepium* tree.

2. MATERIALS AND METHODS

2.1 Description of the Study Site

The experiment was conducted at the alley cropping field (24°09´ N latitude and 90°26´ E longitude with an elevation of 8.5 meters from Sea level) of the Department of Agroforestry and Environment, BSMRAU, Bangladesh from October to February during 2016-2017 and 2017-2018 in winter seasons. The land of the experimental field was characterized by terrace landscape. The soil of the experimental site belongs to the agro-ecological zone 28 (Madhupur Tract) and is classified as shallow red brown terrace under the Salna series [22]. The texture of the soil has been changed to loamy by manual deposits of alluvial soils [23]. However, the available phosphorus content of the soil was low and other elements were almost at satisfactory level [24].

The experimental area has subtropical climate characterized by three distinct seasons, the monsoon or rainy season (May to October), the winter or dry season (November to February) and the pre monsoon or hot season (March to April). Heavy rainfall occurred during the months from May to September and scanty rainfall during rest of the year. The detailed meteorological data during experimentation periods of cauliflower in both the seasons has been envisaged in Table 1 and Table 2.

2.2 Experimental Design and Treatments

The experiment was laid out in a Split-plot design with three replications. The two factors were (Factor A); three different alley widths of *Gliricidia sepium* viz. 3.0 m, 4.5 m and 6.0 m which were designated as $W_{3.0}$, $W_{4.5}$ and $W_{6.0}$, respectively, along with control (CC). Factor B comprised of five different nitrogen levels along with pruned materials (PM) namely; N_0+PM, N_{25}+PM, N_{50}+PM, N_{75}+PM and N_{100}+PM and there were twenty different treatment combinations in the present study. For the control treatment, the crop was grown in an open field without incorporation of *Gliricidia sepium* pruned materials.

2.3 Experimental Details

To evaluate the changes in soil properties in alley cropping system where *Gliricidia sepium* was used as the hedgerow crop; a hybrid cauliflower variety (Snow White) was grown in different alleys of the alley cropping with different levels of nitrogen fertilizer and the PM were added to the soil and left to decompose properly before planting the crop in both seasons. The seedling was transplanted in the field on 14 October in 2016-2017 and 20 October in 2017-2018 growing seasons following 60 × 60 cm spacing. The crop was fertilized by following the fertilizer recommendation guide (FRG, 2012). There were different doses of nitrogen namely N_0 (no nitrogen), N_{25} (25% of the recomme nded dose), N_{50} (50% of the recommended dose),

Table 1. Meteorological data during experimentation period of cauliflower in alley cropping system from October, 2016 to February 2017

Month	Temperature (°C)			Relative Humidity (%)			Rainfall (mm)
	Max.	Min.	Avg.	Max.	Min.	Avg.	
October 2016	32.4	24.2	28.3	96.61	64.19	80.40	1.03
November 2016	29.5	18.1	23.8	97.58	53.61	75.60	0.03
December 2016	27.6	14.6	21.1	97.38	48.94	73.17	0.00
January 2017	25.9	12.8	19.4	94.90	44.13	69.52	0.00
February 2017	28.3	15.8	22.1	95.69	41.45	68.57	0.00

Source: Meteorological Station of the Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur-1706, Bangladesh

Table 2. Meteorological data during experimentation period of cauliflower in alley cropping system from October, 2017 to February 2018

Month	Temperature (0°)			Relative Humidity (%)			Rainfall (mm)
	Max	Min	Avg.	Max	Min	Avg.	
October 2016	31.5	24.1	27.8	96.94	68.52	82.73	11.00
November 2016	29.9	18.4	24.1	97.13	53.39	75.26	0.83
December 2016	26.8	15.9	21.3	98.45	57.06	77.76	1.10
January 2017	22.8	10.8	16.8	93.26	51.81	72.54	0.00
February 2017	27.3	16.0	21.6	95.90	48.23	72.07	0.36

Source: Meteorological Station of the Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur-1706, Bangladesh

N_{75} (75% of the recommended dose) and N_{100} (100% of the recommended dose). No blanching was needed as the variety was a self-blanched one. Weeding was done properly to control the degree of competition between the crop and weeds for nutrient and light absorption. Irrigation along with other inter cultural operations was done as and when needed. No plant protection measures were taken as it was not essential. The crop was harvested when the curd size became suitable for consumption.

2.4 Collection of Soil Samples and Analysis of Soil Chemical Properties

In each of the growing seasons, both before and after the experimentation soil samples were collected from 0-15 cm depth from each of the plots where the treatments were allocated. Soil samples were collected to determine soil pH, soil organic carbon, total nitrogen, available phosphorus and sulphur, exchangeable calcium, magnesium, potassium and cation exchange capacity (CEC). Soil pH was measured by Glass Electrode pH meter by maintaining soil water ratio of 1:2:5 [25]. Organic carbon (%) in soil sample was determined by wet oxidation method [26]. Total nitrogen content (%) of soil was determined following the Micro-Kjeldahl method [27]. Available phosphorus was estimated following the methods of Olsen and Page [28,27]. Available Sulphur was quantified as per method of Chesin and Yien [29]. Exchangeable calcium and magnesium were determined following the method of Hesse [30], whereas exchangeable potassium was estimated as per the method described by Page [27].

2.5 Statistical Analysis

All the data were analyzed by analysis of variance (ANOVA) using Statistix 10 software. Different alphabetical letters represent significant differences among the treatments at $P < 0.05$ following a least significant difference (LSD) test.

3. RESULTS AND DISCUSSION

3.1 Effects of Pruned Materials Application on Soil Chemical Properties

The effects of different treatments on soil chemical properties after harvesting of cauliflower are presented and discussed under the following sub-headings.

3.1.1 Soil pH

The soil pH varied from 5.13 (CC+N_0) to 5.93 ($W_{6.0}N_{75}$+PM) among the treatments (Table 3). However, incorporation of the pruned materials of *G. sepium* slightly increased the pH of soil in different alley widths compared to the control where no pruned materials were added. The average pH of *G. sepium* pruned material added in plot $W_{3.0}$ was 5.82 while the values were 5.79 and 5.67 in $W_{4.5}$ and $W_{6.0}$ respectively. The control plot had pH value of 5.34 (Fig. 1a). Compared to control, the average increment of soil pH under different alley widths were 8.95%, 8.39% and 6.22% higher against $W_{3.0}$, $W_{4.5}$and $W_{6.0}$ treatments respectively.

The soil of the field where the study was conducted was slightly acidic and increment in soil pH of acidic soil is a good indication for better utilization of nutrients especially phosphorus. Acidic soil contains a high amount of Fe, Mn and Al, and these elements can react with phosphorus and ultimately phosphorus becomes insoluble. Thus, phosphorus either inherent or added through inorganic fertilizers becomes unavailable for plant uptake. The soil pH of PM added plots were found slightly higher over control treatment which indicated that due to application of PM, soil pH tends to increase. The increment in soil pH in *G. sepium* PM added plots in different alley widths may be due to the faster decomposition of PM and subsequent release of Ca into the soil. Similar increase in soil pH under *G. sepium* was observed by other researchers [12,31,32,33,34,35].

3.1.2 Soil organic carbon

Soil organic carbon varied from 0.42% (CC+$N_{75)}$ to 0.94% ($W_{3.0}N_{100}$+PM) among the treatments (Table 3). Incorporation of the pruned materials of *G. sepium* slightly increased the organic carbon of soil in different alley widths compared to the control. The average organic carbon in *G. sepium* PM added plot was 0.82% in $W_{3.0}$, while the values were 0.66% and 0.61% in $_{W4.5}$ and $W_{6.0}$ treatments while it was 0.44% in control plot. The organic carbon in soil of $W_{3.0,}$ $W_{4.5}$ and $W_{6.0}$ was found 40.83% higher over control plots respectively (Fig. 1a). Soil organic carbon content increased due to the incorporation of tree leaves and decreased slightly in control plots. Many researchers observed higher organic carbon content in soil under alley cropping system compared to the non-alley cropping system [36,37,35]. Attah-Krah and Sumberg found 1.59% organic carbon in *G. sepium* added soil compared to 1.13% in the control soil [31]. Organic matter is known as a life of soil that governs all physical, chemical and biological characteristics. According to Fertilizer Recommendation Guide (FRG), the present level of soil organic carbon content in the study area is very low to medium [38]. Therefore, a regular supply of organic matter using different sources needs to be ensured for sustainable agriculture. Alley cropping might contribute to increase soil organic carbon and thus improve soil health. Furthermore, alley cropping fetches multiple benefits to make the production system economically viable and ecologically sustainable.

3.1.3 Total nitrogen

The total nitrogen content in soils under different treatments in pruned material added plots was found to increase over the control (Fig. 1a). The average increment of total nitrogen in *G. sepium* pruned material added plots were 113.57% and 108.29% in $W_{3.0}$ and $W_{4.5}$ alley widths respectively. But at $W_{6.0}$ treatment, it was found 103.77% over control. The average total nitrogen in *G. sepium* pruned material added plot was 0.08%, 0.17% in both $W_{4.5}$ and $W_{6.0}$ alley widths while it was 0.16% in $W_{6.0}$ alley width. Among the treatment's highest total nitrogen content (0.209%) was recorded in $W_{3.0}N_{100}$+PM followed by 0.201% in $W_{4.5}N_{100}$+PM treatments. While the lowest value (0.027%) was recorded in control treatments (Table 3). Results revealed that addition of *G. sepium* PM increased N content in soils and thereby increased soil fertility. Nitrogen loss from the soil environment is very high through different pathways like denitrification, ammonia volatilization, nitrate leaching etc. Therefore, enrichment of soil with nitrogen and store it for a long time is not possible. Nitrogen is one of the most limiting plant nutrients in the tropical and sub-tropical production environment and therefore, judicious and balanced application of nitrogen as per crop requirements is always advisable for better utilization of nitrogen in crop production. Leguminous crops can fix atmospheric nitrogen and increase soil fertility. The increment of soil nitrogen in the present study might be the contribution of alley cropping. Alley cropping along with inorganic fertilizer application and alley cropping alone have the potential to increase 70-100% soil nitrogen compared to the zero-input control [39].

3.1.4 Available P

Available phosphorus means the portion of the total soil phosphorus which can be utilized by plants and that can be extracted by dilute acid solution. In the present study, the available P varied remarkably among the treatments (Table 3). However, incorporation of the pruned materials of *G. sepium* increased the available P in soil compared to the control treatments (Fig. 1b). The average available P in *G. sepium* pruned material added plot was 13.97 ppm in both $W_{3.0}$ and$W_{4.5}$ alley widths while it was found 13.13 ppm in $W_{6.0}$ alley width. On the other hand, control plot had 7.68 ppm P in soil. The average increment of available P in $W_{3.0}$, $W_{4.5}$ and $W_{6.0}$ alley widths was 81.97 ppm, 81.87 ppm and 70.91 ppm respectively over control. Among the treatments, the highest available P was recorded in $W_{3.0}N_{100}$+PM (16.261 ppm) treatment, while the lowest value was recorded in CC + N_{75} (7.606 ppm) treatment. Inherent phosphorus content of agricultural soil is low and moreover, the applied P undergoes a rapid fixation either with calcium and magnesium in calcareous soil or with iron, aluminum and manganese in acidic soil. However, the adoption of different soil and crop management practices may improve phosphorus supply capacity of soils Addition of higher phosphorus in soil from *G. sepium* was also observed in alley cropping system by other scientists [40,35].

3.1.5 Available S

The available S varied slightly among the treatments (Table 3). However, incorporation of the pruned materials of *G. sepium* slightly increased the available S of soil compared to the control. The average available S in *G. sepium* pruned material added plots were 14.85 ppm, 14.84 ppm and 14.00 ppm in $W_{3.0,}$ $W_{4.5}$ and $W_{6.0}$ alley widths respectively whereas, the control plot showed 7.71 ppm S in soil. The average increment of S was 92.65% in $W_{3.0}$ while the average increments were 92.54% and 81.63% in $W_{4.5}$ and $W_{.6.0}$ over the control. Among the treatments, the highest available S was recorded in $W_{6.0}N_{100}$+PM (16.266 ppm) treatment and the lowest was recorded CC+N_{75} (7.650 ppm). Sulphur (S) is required for the formation of proteins, enzymes, vitamins, and chlorophyll in plants. It is essential for legume nodule development and efficient nitrogen fixation. However, alley cropping can be a good options for increasing organic matter content of soil as most of the available S comes from organic matter. The Pertinent result was found in alley cropping plots when *G. sepium* and *L. leucocephala* were added as pruned materials [41].

3.1.6 Exchangeable Ca

The exchangeable Ca contents of soil showed an increasing trend in all the treatments except control (Table 3). Incorporation of the pruned materials of *G. sepium* increased the soil exchangeable Ca in all the alley widths compared to the control. The average exchangeable Ca in *G. sepium* pruned material added plot was 2.49 meq/100g soil in $WE_{3.0}$ alley width whereas, 2.25 and 2.27 meq/100g soil of Ca were found in $W_{4.5}$ and $W_{6.0}$ alley widths and the control plot had 1.09 meq/100g soil of exchangeable Ca. The average increment of exchangeable Ca was maximum in $W_{3.0}$ alley width (128.26%) whereas 106.61% and 108.07% of Ca were found in $W_{4.5}$ and $W_{6.0}$ treatments of alley widths over control. Among the treatments, the highest exchangeable Ca was recorded in $W_{3.0}N_{100}$+PM (2.54 meq/100g soil) and the lowest was recorded in CC+N_{25} (1.05 meq/100g soil) treatment (Table 3). The high availability of calcium in soil neutralizes soil acidity and thereby helps in increasing the solubility of phosphorus as well as improve the soil aggregate stability. Findings regarding the increase of soil Ca in alley-cropping system had been reported in different investigations [42,32,43].

3.1.7 Exchangeable Mg

The available Mg did not vary remarkably among the treatments (Table 3). But control treatments showed comparatively lesser quantities of exchangeable Mg. Incorporation of the pruned materials of *G. sepium* slightly increased the soil exchangeable Mg as compared to the control. The average exchangeable Mg in *G. sepium* pruned material added plot was 0.76 meq/100g soil in $W_{3.0}$ alley width while the average values were 0.70 and 0.66 meq/100g soil for $W_{4.5}$ and $W_{6.0}$ alley widths respectively. The average increment of exchangeable Mg was 82.88% in $W_{3.0}$ while the average increments were only 69.82% and 60.22% in the higher alley widths of $W_{4.5}$ and $W_{6.0}$ over the control respectively (Fig. 1b). Among the treatments, the highest exchangeable Mg was recorded in $W_{3.0}N_{100}$+PM (0.899 meq/100g soil) and the lowest was found in CC+N_{100} (0.390 meq/100g soil) treatment (Table 3). The addition of plant materials plays an important role in increasing soil Mg content. An increase of the concentration of available basic cations after the burn of plant litters. Another reason may be due to the accumulation of ashes rich in oxides and carbonates of basic ions [44] renders the higher Mg content in soil in alley cropping system.

3.1.8 Exchangeable K

The exchangeable K content in soil showed an irregular fashion. However, K was lower in control treatments as compared to alley cropping treatments (Table 3). Incorporation of the pruned materials of *G. sepium* slightly increased the soil exchangeable K as compared to the control. The average exchangeable K in *G. sepium* pruned material added plot was 0.09 meq/100g soil, while the average values were 0.16 and 0.15 meq/100g soil for $W_{4.5}$ and $W_{6.0}$ alley widths respectively. The average increment of exchangeable K was 86.36% in $_{W3.0}$ alley width while the average increments were only 81.82% and 75.00% in the higher alley widths of $W_{4.5}$ and $W_{6.0}$ respectively over the control (Fig. 1b). Among the treatments, the highest exchangeable K was recorded in $W_{4.5}N_{100}$+PM (0.19 meq/100 g soil) and the lowest was found in both CC+N_o and CC+N_{25} (0.08 meq/100 g soil) treatments (Table 3). Crop removal and losses through runoff may be attributed to the lowest exchangeable K in the control plot, whereas, the increase in exchangeable K in plots under the three different alley widths might be due to the return of K via tree pruning and leaf litterfall to the soil surface [42] and an increased exchangeable K was observed under *G. sepium* [24].

3.1.9 Cation exchange capacity (CEC)

The cation exchange capacity (CEC) of soil varied among the treatments but the incorporation of the pruned materials of *G. sepium* slightly increased the soil CEC compared to the control (Table 3). The average CEC of *G. sepium* pruned material added plot was 14.67 meq/100g soil in $W_{3.0}$ treatment while the average values were 15.64 and 14.26 meq/100g soil were found in $W_{4.5}$ and $W_{6.0}$ treatments respectively. The average increment of CEC was 12.34% in $W_{3.0}$ whereas, the values were observed 19.77% and 9.22% in $W_{4.5}$ and $W_{6.0}$ treatments respectively over the control (Fig. 1b). Among the treatments, the highest CEC of soil was recorded in $W_{4.5}N_{100}$+PM (15.99 meq/100g soil) and the lowest was recorded in CC+$N_{7.5}$ (12.74 meq/100g soil) treated plots (Table 3).

CEC of soil indicates the fertility status of soil and higher CEC indicates the more fertile condition of soil. The improvement of CEC was recorded due to the addition of pruned materials in alleys of alley cropping system at BSMRAU alley cropping field when cabbage was grown under five different nitrogen levels [41].

Table 3. Change in soil properties in alley cropping system as influenced by tree pruned materials of *Gliricidia sepium* along with different N doses after harvesting of Cauliflower (Average of two seasons)

Treatment	pH	OC	TN	P	S	Ca	Mg	K	CEC
		(%)		(ppm)		(meq/100 g of soil)			
$W_{3.0} N_0$ + PM	5.79	0.71	0.140	12.40	13.28	2.42	0.62	0.14	14.02
$W_{3.0} N_{25}$ + PM	5.84	0.77	0.149	12.89	13.76	2.48	0.71	0.14	14.43
$W_{3.0} N_{50}$ + PM	5.84	0.82	0.166	13.81	14.68	2.51	0.76	0.16	14.72
$W_{3.0} N_{75}$ + PM	5.81	0.88	0.186	14.50	15.37	2.49	0.80	0.18	14.90
$W_{3.0} N_{100}$ + PM	5.80	0.94	0.209	16.26	17.13	2.54	0.89	0.20	15.28
$W_{4.5} N_0$ + PM	5.75	0.59	0.139	12.40	13.28	2.30	0.62	0.14	15.35
$W_{4.5} N_{25}$ + PM	5.69	0.63	0.147	12.88	13.76	2.38	0.69	0.14	15.38
$W_{4.5} N_{50}$ + PM	5.87	0.65	0.162	13.80	14.68	2.32	0.73	0.16	15.70
$W_{4.5} N_{75}$ + PM	5.90	0.68	0.180	14.49	15.36	2.08	0.74	0.17	15.78
$W_{4.5} N_{100}$ + PM	5.72	0.73	0.201	16.24	17.11	2.18	0.74	0.19	15.99
$W_{6.0} N_0$ + PM	5.75	0.56	0.139	11.52	12.40	2.13	0.61	0.14	13.83
$W_{6.0} N_{25}$ + PM	5.52	0.62	0.145	12.05	12.93	2.34	0.67	0.14	14.20
$W_{6.0} N_{50}$+ PM	5.80	0.60	0.159	12.94	13.82	2.18	0.69	0.15	14.30
$W_{6.0} N_{75}$ + PM	5.93	0.63	0.174	13.69	14.56	2.34	0.68	0.16	14.43
$W_{6.0} N_{100}$ + PM	5.35	0.66	0.194	15.40	16.26	2.35	0.66	0.18	14.55
CC + N_0	5.13	0.45	0.072	7.68	7.68	1.07	0.42	0.08	12.99
CC + N_{25}	5.39	0.44	0.081	7.65	7.66	1.05	0.43	0.08	13.14
CC + N_{50}	5.54	0.44	0.081	7.67	7.69	1.08	0.44	0.09	13.25
CC + N_{75}	5.47	0.42	0.081	7.60	7.65	1.08	0.39	0.09	12.74
CC + N_{100}	5.16	0.43	0.083	7.77	7.84	1.17	0.39	0.10	13.17
SE (±)	0.68	0.02	0.02	1.45	0.78	0.09	0.03	0.20	1.55
CV	2.06	3.54	3.10	0.60	0.66	1.52	1.06	0.14	1.57

GS: Gliricidia sepium; N_0 = 0%; N_{25} = 25%; N_{50} = 50%; N_{75} =75%
AW 3.0 = 3.0 m, AW 4.5= 4.5 m, AW 6.0 = 6.0 m

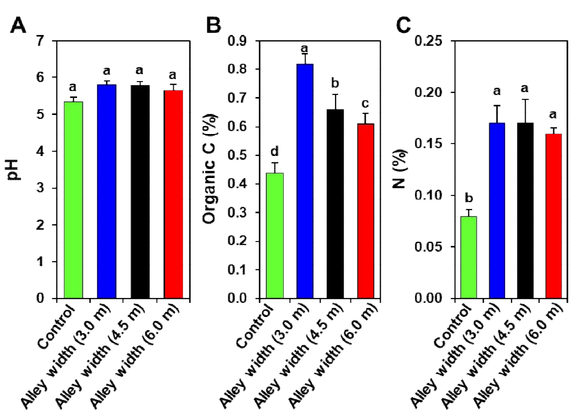

Fig. 1a. Performance of pruned materials application in three different alley widths when cauliflower was grown for improving soil fertility. Data presented are means and standard errors of three replications (*n* = 3). Different alphabetical letters above the error bars indicate significant differences among various treatments (*P* < 0.05, least significant difference test). Organic C, organic carbon; N, Nitrogen

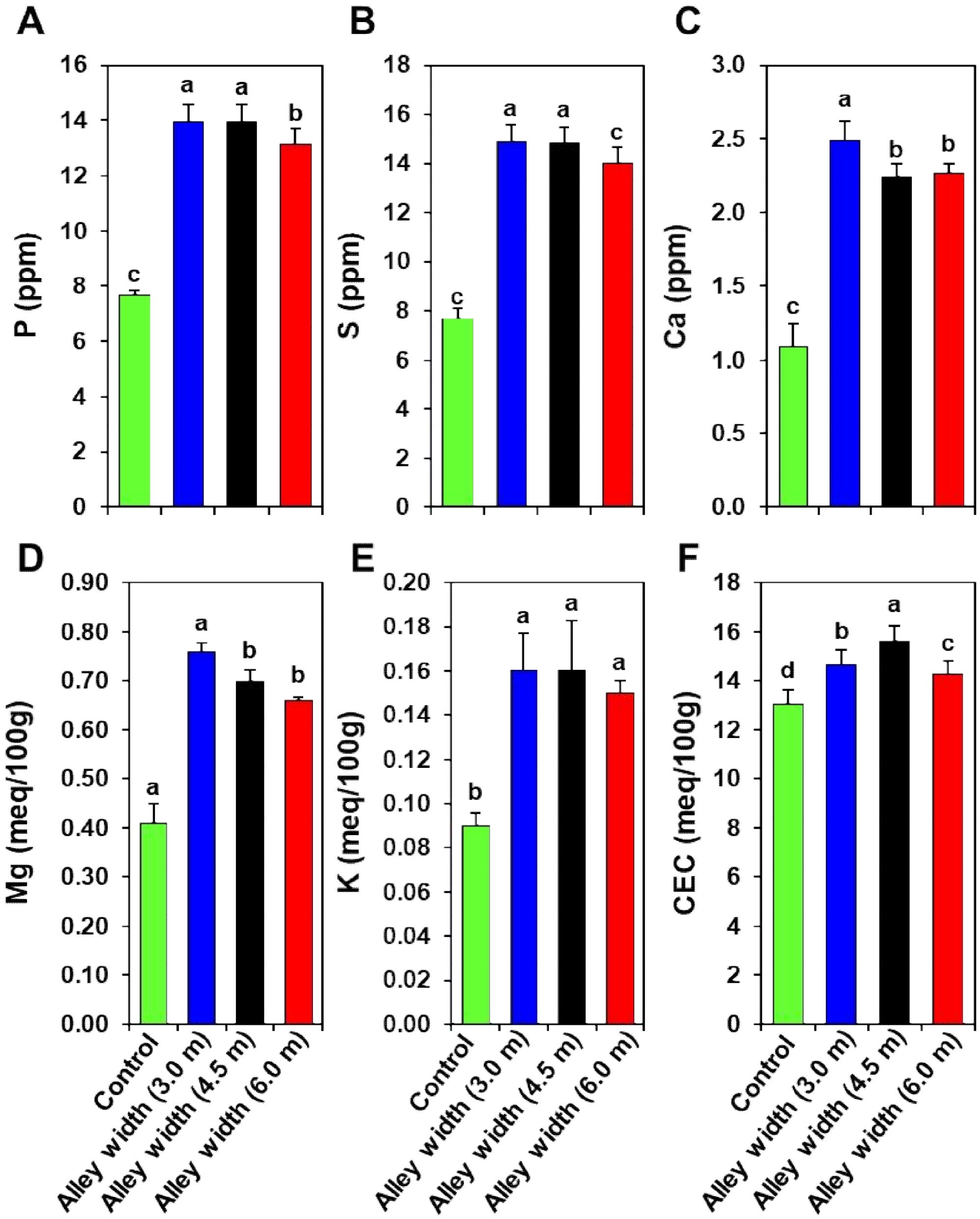

Fig. 1b. Performance of pruned materials application in three different alley widths when cauliflower was grown for improving soil fertility. Data presented are means and standard errors of three replications (*n* = 3). Different alphabetical letters above the error bars indicate significant differences among various treatments (*P* < 0.05, least significant difference test). P, phosphorus; S, sulphur; Ca, Calcium; Mg, magnesium; K, potassium; CEC, cation exchange capacity

4. CONCLUSIONS

The findings of the study revealed that *G. sepium* as a fertilizer tree in the alley cropping system potentially improved the soil chemical properties than the mono-cropping system. Our results indicated that *G. sepium* based alley cropping system could be a viable option in response to restore the soil health for noteworthy crop production.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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