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Effect of Organic and Inorganic Fertilizer on the Soil Chemical Properties of the Rhizosphere in Kiambu County, Kenya

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Authors' contributions

This work was carried out in collaboration between all authors. Author KT designed the study, performed the statistical analysis, wrote the protocal and wrote the first draft of the manuscript. Authors TW and PGOJ managed the analysis of the study. Author PGOJ managed the literature searches. All authors read and approved the final draft.

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ABSTRACT

The experiment was carried out at Kenyatta university farm using 2×3×3 factorial plan in a randomized complete block design. The experiment was carried out for two seasons. Pre cropping soil analsyis was carried out before and after the study to assess soil pH, macro and micro nutrients in the soil. Pre cropping analyses showed that the study site soil pH was 5.2, slightly acidic, Calcium amount was 1.7 me%, nitrogen was 0.07% and phosphorous was 6 ppm, iron recorded 59.3 ppm and magnesium 0.73 me%. The soil was low in macro and micro nutrients. The organic quail manure used was also analysed and showed that it was high in phosphorus that recorded 9.748 ppm, magnesium was 0.29%, calcium of 3.2 me%, total nitrogen was 4.5% and Zn was 9.00 ppm and pH was 6.4. Two Amaranth species (*A. cruentus* and *A. tricolor*) were used in the investigation. To determine significant differences among treatments, analysis of variance (ANOVA) was done using SAS computer software and least significant difference (LSD) at 5% was used for mean separation. Chemical properties of the soil were significantly ($P \leq 0.05$) influenced during the second season. The result after the experiment showed that macro nutrients increased except for phosphorus. Nitrogen increased in the soil from 0.07% to 2.17%, potassium from 0.9% to 1.34%,

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the pH increased from 5.2 to 6.2, iron increased from 59.3 ppm to 167 ppm when 250 kg/ha of NPK + 8.45 t/ha, at 500 kg/h+16.9t/h calcium increased from 1.7 to 3.97 me% and manganese from 0.16 me% to 2.61 me%. Sole NPK which is inorganic fertilizer slightly increased magnesium from 0.73 me% to 1.49 me% in the first season to 1.52 me% in the second season, manganese was raised from 0.16 me% to 0.37 me% in the first season and to 0.46m% in the second season. Intergration of poultly manure and NPK was more effective in increasing soil nutrients than sole application of fertilizer materials.

Keywords: Rhizosphere; quail manure; NPK; macronutrients and micronutrients.

1. INTRODUCTION

Macronutrients are the most limiting nutrients affecting interaction of soil, water, nutrients and plant roots in the rhizosphere. Studies reviewed have attributed this to continuous cropping, hence leading to increased use of inorganic fertilizers [1]. This limitation requires quick intervention because high quality and quantitative yield of crops can be obtained by incorporating organic manure. It is important to note that most researchers have explored the influence of fertilizers on crop productivity; however, this study found it necessary to examine the changes in chemical properties of soil before and after addition of organic (quail manure), inorganic fertilizers (NPK) and while the two are combined. This was important especially because soil properties affect absorption of nutrients by the plant roots.

Kenya has diverse types of soils found in different terrains, The soils are, Andosols which are young volcanic soils that are porous, have high water holding capacity with low pH of 4.5 to 5.0. Nitisols have good soil moisture storage capacity, they are acidic with pH of 5 to 5.5. Acrisols, Alisols, lixisols and luvisols are not porous and have low water holding capacity, Acrisols and Alisols have low pH of 3-4.5, have low levels of nutrients with aluminium and manganese toxicities. Ferrasols are very old soils, with low cation exchange capacity, they are deficient in phosphorous and Nitrogen and are rich in Aluminium and iron, generally they are poorly fertile soils. Planosols and Vertisols are found on flat topography, they have high clay content and are poorly drained [2].

Rhizosphere is a section of the soil that is directly adjacent to plant roots. The region is also the most affected by interactions of plant roots, water, nutrients also microorganisms. It is for this reason that rhizosphere becomes the most important region of soil in agriculture [3]. It is also important to note that Macronutrients are the most limiting nutrients affecting this interaction, especially due to continuous cropping, hence leading to increased use of inorganic fertilizer [4]. This limitation requires quick intervention because high quality and quantitative yield of crops can be obtained by incorporating organic manure [5]. However, inorganic chemicals have also been incorporated due to increased nutrients deficiency in the soil. As a result, agricultural practises and landscape changes have had adverse effects on nutrient leaching, pesticide contamination, species extinction, and evolution of pesticide resistance because of continuous use of pesticides [6]. Animal manures have been used for plant production effectively for centuries. Chicken manure has long been recognized as perhaps the most desirable of these natural fertilizers because of its high nitrogen content [7]. In addition, manures supply other nutrients and serve as soil amendments by adding organic matter [8]. Organic matter persistence in soil varies with temperature, drainage, rainfall and other environmental factors. Organic matter in soil improves moisture and nutrient retention and soil physical properties [9]. In this study, the researcher compared the changes in chemical properties of rhizosphere attributed to use of organic fertilizer (quail manure) and inorganic fertilizer (NPK). Most soils in Kenya are of low pH with low cation exchange capacity. This study through educating the farmers will improve the soil pH and the organic manure which has high cation exchange sites will increase the macro and micro nutrients to be absorbed by the plants.

2. METHODS

The study was carried out at Kenyatta university main campus Department of Agricultural Science and Technology farm. The campus is 20 Km by road from Nairobi the largest city in Kenya along the Nairobi and Thika superhighway. The type of soil in the area was dark reddish brown to dark brown loam. A 2×3×3 factorial plan was adopted for experiment in a randomized complete block design (RCBD) with three replications as shown in Table 1. Two fertilizers (one organic and one inorganic) were used for the experiment: quail manure and NPK fertilizer respectively. The quail manure levels were 0, 8.45 t/ha and 16.9 t/ha. The NPK (17-17-17) levels were 0, 250 kg/ha and 500 kg/ha.

The fertilizers were two, organic quail manure and organic NPK (17-17-17) each was applied at three levels. The organic manure levels were 0,8.45 t/h, and 16.9 t/h whereas the inorganic manure rates were 0,250 kg/h and 500 kg/h. Each level of organic manure was combined with each level of inorganic mineral fertilizer.

Table 1. Treatment combination between the NPK and quail manure

Levels of NPK				
	500 kg/ha	0, 500	8.45, 500	16.9, 500
	250 kg/ha	0, 250	8.45, 250	16.9, 250
	0 kg/ha	0, 0	8.45 , 0	16.9, 0
		0 t/ha	8.45 t/ha	16.9t/ha
	Levels of Quail Manure			

Experimental area had dimensions of 16 m by 27.5 m (440 m^2) while each block measured 4 m by 27.5 m (110 m^2). Individual plots measured 4mx1m (4 m^2), individual blocks were spaced 1m apart while the plots in within the blocks were separated by 0.5 m. Well decomposed quail manure was applied at recommended dry weight at three rates, 0, 8.45 t/ha and 16.9 t/ha [10]. NPK (17-17-17) was applied based on the recommended rate of 500 kg/ha at three levels 0, 250 kg/ha and 500 kg/ha. The organic manure used was analysed and had Total Nitrogen of 4.5%, Total organic Carbon recorded 5.3. Phosphorous was 9.74 ppm, Pottasium 1.3 me%, Calcium 3.2 me%, Mg was 0.29 me%, Mn 0.08 me%, Cu was 20 ppm, Iron was 460 ppm, Zn 900 ppm, Na 0.08 me% and pH of the quail manure was 6.4. The chemical properties of the soil at the experimental site was also carried out and Total Nitrogen of 0.07%, Total organic Carbon recorded 0.74. Phosphorous was 9 ppm, Pottasium 0.9 me%, Calcium 1.7me%, Mg was 0.73 me%, Mn 0.16 me%, Cu was15.98 ppm, Iron was 59.3 ppm, Zn9.02 ppm, Na 0.16 me% and pH of the soil was 5.2.

Land preparation was cleared and cultivation done one month before sowing of Amaranth seedlings (*A. cruentus* and *A. tricolor)*. The land was mechanically ploughed and leveled to create a suitable tilth. The plot units were slightly raised about 25-30 cm high. Inter plot spacing was maintained throughout the growing season. By use of zigzag method the spots were identified where soil was to be collected for analysis. Ten random samples were identified. Using soil auger, soil samples at a depth of 20 cm was taken. Unusual areas were avoided like around the paths and under fences. All the composite samples from the identified spots were mixed and dried. The sub samples were weighed to 100 grams for laboratory analyses and put it in a clean container [11]. After harvesting in the second season, soil samples were collected from a depth of 20 cm from each sub-plot in different spots from each block in order to evaluate the changes of the soil chemical.

Solid manure was collected from fifteen points in a zigzag manner from the coop, samples around watering troughs and feeders were also collected, they were thoroughly mixed in a clean bucket and were spread on a clean concrete surface and further mixed, a sub-sample from the mixed composite sample was taken for analyses as the representative sample in a dry and clean container [12]. Organic carbon was determined by Walkey and Black method [13]. One gram of dried soil was ground to pass 0.5mm, was weighed out and introduced in an Erlemeyer flask of 250 ml then 2 ml of water was added then 10 ml of 5 aqueous potassium dichromate of $K_2CR_2O_7$ was also added in order to completely wet the soil. A standard was prepared using a pipette, 2 ml of each working standard was transferred into dry labeled digestion tubes. The digestion tubes contained 0 mg, 5 mg, 10 mg, 15 mg, 20 mg and 25 mg carbon. 0.5 ml of concentrated sulphuric acid was added in the mixture and digested at 150 degrees Celsius for 30 minutes then cooled, After, 100 ml of water was added and mixed. Solution was brought to 100 ml by adding water it was allowed to cool overnight. Concentration of standard and sample was read at 600 nm of the spectrometer. The content of the total organic Carbon in the air dry soil was calculated and expressed in percentage by using the formula indicate below

Total soil organic carbon (%)=

$$\frac{CCS(mgC) - CCB(mgC)}{DW(g)} \times 100$$

Where,

CCS = carbon content of the sample
CCB = carbon content of the blank
DW = dry weight of the soil sample

Soil pH was measured in 1:2.5 (soil: water) ratio where a total of 10 g of dried soil of each soil sample was weighed and 25 ml of distilled water was added, and mixture was stirred for 15 minutes and allowed to settle for 40 seconds before using a calibrated pH meter to read the pH. The pH meter was immersed in the solution and pH was recorded for each sample [14]. K, Ca, Mg and Na were determined using atomic absorption spectrophotometer [14]. where five grams of air dried soil of less than 2 mm was weighed into a clean plastic flask with a stopper and 100 ml of 1M (NH_4OAc) ammonium acetate solution (pH 7) was added, an internal standard and a repeat sample within each batch of test soils was also added. The content was shaken for 30 minutes and filtered through no 42 Whatman filter paper. The concentration was then calculated using the following formula

MgKg-1 K, Ca, Na, and Mg in soil = ((a-b)×v×f×1000)÷(1000×w)

where a =concentration of K, Ca, Na, and Mg in the sample extract;

b=concentration of the element in the blank extract; v= volume of the extract solution; w=weight of the soil sample; f=dilution factor. To determine soil phosphorous 2.5 g of air dried soil of 2 mm was weighed into 250 ml plastic bottle and 50 ml of extracting solution (a reagent grade s Anti-nutrient is any compound that reduces the ability to absorb or use essential nutrients like vitamins ammonium fluoride (NH_4F) was mixed with distilled water, 250 ml of previously standardized (1MHcl) was added. After which the solution was shaken for a period of five minutes. Extracts were filtered through Whatmans paper No. 42. Phosphorous was the measured by colorimetry using a blank prepared in the Bray P-1 extracting solution [15]. The calculation was made using the following formula,

PmgKg-1=(a-b)×v×f× 1000÷1000×w

where a=Concentration of Pmg1^{-1} in exrtact solution, b= Concentration of Pmg1-1 in blank sample, c=extract volume, w= weight of air dried sample and f =additional dilution factor, to determine soil nitrogen 1 g of dried soil of 0.5 mm was weighed and introduced into a Kjeldahl digestion tube and then one gram of selenium powder to act as catalyst was added. After, 10 ml of concentrated H2SO4 was added, The mixture was digested at 300℃ for two hours until a green colour appeared. The solution was cooled and tranversed into a volumetric flask of 100 mland filled to 100 mark with distilled water. The blank was also prepared, after which 10 ml of aliquot of the digest was taken and put into a distillation tube which also received 10 mls of distilled water, To the mixture, a 1o ml of NaoH 50% was added and distillation commenced. The distillate was distilled and collected in an Erlenmeyer flask of 250 ml containing 5 ml of boric acid 2% (H3BO3) Approximatel 100 ml of distillate was collected. The solution obtained was titrated with 0.005MH2SO4 untill a pink colour appeared, titration continued to the point where the whole solution turned pink. The volume of 0.005M H2SO4 used was noted and the percentage of N calculated using the following formula,

%N=(T-L)×0.2×FC×FD×100×1000

Where bl =blank fc =corrective factor fd=dilution factor(=10) was and minerals the most common anti-nutrients in vegetables are phyto-oestrogens, lignin, phenolic compounds, and phytic acid and which in Amaranth, oxalates and nitrates are common. Soluble and total oxalates concentration was determined by titrimetric method of [16]. To determine significant differences among treatments, analysis of variance (ANOVA) was done using SAS computer software and least significant difference (LSD) at 5% was used for mean separation.

3. RESULTS AND DISCUSSION

The chemical properties of the soil were significantly ($P \leq 0.05$) influenced during the second season and it was clear that inorganic fertilizer rate influenced most of the chemical properties. inorganic fertilizer rates 8.45t/h and 16.9 t/ha showed an increase in the nitrogen content from 0.18%, 0.23% in season one to 0.38% and 0.24%in season two, potassium amount also increased from 1.42me% when 250 kg of quail manure was added to 1.62me%, at 500 kg/hac, the potassium level also increased from 1.11me% to 1.41%, phosphorous content when NPK was applied at 250 kg/ha decreased from 13.67 ppm to 12.67 ppm.

NPK at 500 kg/ha slightly increased manganese from 0.26me% in the first season to 0.46me% in the second season.

Organic fertilizer significantly influenced, phosphorous, potassium, calcium magnesium, iron and zinc content of the soil Table 4: phosphorous, recorded 6.45 ppm, 10 ppm, 11.57 ppm when applied at 0t/h, 8.45t/h, 16.9t/h respectively in season one in comparison in season two that recorded 7.45 ppm, 11 ppm, 11.57 ppm when applied at 0 t/h, 8.45 t/h, 16.9 t/h respectively, phosphorous was recorded at 0.8me%, 1.2me% and 1.56me% in comparison with the second season that was highly increased to 1.4me% and 1.66me% at when quail manure was applied at 8.45t/h, 16.9t/h respectively Table 5, nitrogen amount also increased from 0.02%, 0.13%, 0.17% when applied at 0t/h, 8.45t/h, 16.9t/h respectively in season one to 0.03%, 0.33%, 0.44% when organic fertilizer was applied at at 0t/h, 8.45 t/h, 16.9t/h respectively in season two. Calcium in the soil also increased highly from 2.93me% in the first season to 3.93me% in the second season when the organic rate was at 16.9t/h, poultry manure has high calcium carbonate which aid in raising soil pH [17]. The highest quail manure rate and the 250 kg/ha NPK rate showed significantly ($P<0.05$) the highest nitrogen content in the amaranth plant tissues with 2.93% on the *A. tricolor* variety during the first season and 2.98% during the second season. For both seasons, the lowest nitrogen content in the plant tissues were observed in the controls with as low as 1.21% on the *A. cruentus* variety and 1.82% on the *A. tricolor* variety. The Nitrogen and phosphorus content of soil that received the two highest application rates (8.45t/ha and 16.9 t/ha) were significantly ($P\leq0.05$) higher than those that did not received any organic fertilizer, Calcium and Potassium content were significantly higher in all three application rates compared to the control. Organic fertilizer application rate of 16.9 t/ha significantly ($P\leq0.05$) increased the copper content if compared to the other application rates. The highest amount of Calcium 3.43% was recorded in the organic fertilized soils at the rate of 8.45 t/ha followed by the quail manure at the rate of 16.9 t/ha the unfertilized soil had the least amount in the organic fertilized soils the highest amount of Calcium was recorded at 500 kg/ha.

3.1 The Interaction Effects of the Variety, Npk Fertilizer and Quail Manure on the Soil Chemical Properties

Pre cropping soil analysis at the study site showed that the soils was low in total organic carbon of 0.74%, copper was 15.98, iron recorded 59.3 ppm, zinc was 9.02 ppm. The soil was also acidic and less suitable for amaranth growth for which 5.5-7.5pH is recommended interval, the soil was also low in Ca and Mg hence its low pH. Soil chemical properties were was significantly affected at $P\leq0.05$, the highest potassium was 14 ppm at treatment 250 kg/h+16.9 t/h, the control had the lowest of 5 ppm in season one but in season two and at the same treatment of 250 kg/h+16.9 t/h the highest potassium was 15 ppm but the control had the lowest of 4.6 ppm.

Table 4. indicates that soil available nitrogen was significantly affected at $p\leq 0.05$, *A. cruentus* rhizosphere recorded the following amount of nitrogen in season one 0.05%, 0.092% 0.14%, 0.092%, 0.15%, 0.17%, 0.11%, 0.18%, 0.15% whereas *A. tricolor* rhizosphere nitrogen amount was 0.05%, 0.11%.0.13%, 0.1%,0.14%,0.15%, 0.2%, 0.15%, 0.16% in season one at the application of the following rates respectively.

0 kg/h+0 t/ha, 0kg+8.45 t/h, 0 kg/h+16.9 t/ha, 250 kg/hac+0 t/h, 250 kg/h+8.45 t/h, 250 kg/h +16.9 t/h, 500 kg/h+0t/h, 500 kg/h+8.45 t/h, 500 kg/h+16.9 t/h. As opposed to use of NPK fertilizers alone combined use of organic and inorganic manure ensures more availability of soil micro and macro elements ensuring a balanced nutrition [18]. All the treatments increased Cu, Me, Mg, K, N, k, P, Na, Ca and Zn above the control treatments, soil organic matter form chelate with micronutrients forming cation exchange sites [19] 500 kg/h+8.45 t/hac had the highest Cu of 30.16 ppm, Fe of 72.5 ppm and Mn of 0.45me% in *A. cruentus* variety rhizosphere. Application of 500 kg/ha+16.9 t/h recorded the highest Ca of 3.98% and K of 14 ppm in *A. tricolor* rhizosphere in season one. Poultry manure residual increases soil organic matter, Cu, Fe, Mg, Mn, K, P, N, Ca and Zn [19]. In very acid soils there is abundance of Fe, Mn, Zn and Cu [20]. NPK application over a long period lowers soil pH [9]. The effects of fertilizers at the second cropping showed that inorganic fertilizers showed better results than in control but organic fertilizers showed much better results than inorganic fertilizers. All the micro and macro elements increased above the control treatment. in *A. tricolor* rhizosphere the highest Ca, Mg, K, Na and Nitrogen of 3.97%, 73.5 ppm, 2.61%, 15%, 0.46% and 0.17% was recorded at 500 kg/h+16.9 t/ha respectively. In *A. cruentus* rhizosphere, application of 500 kg/ha+16.9 t/h recorded the highest Cu of 29.99 ppm, Mn of 0.61% and Zn of 13.64 ppm. The Nitrogen amount in the soil in the second season reduced in comparison with season one in the two varieties rhizosphere. 60% of Nitrogen is lost through volatilization or is leached becoming

ground water pollutant [18]. Sole application of NPK fertilizer recorded low levels of macro and micro nutrients in the rhizosphere of the two varieties, in season one, at 250 kg/ha, Ca was 1.97%, Cu was 22.3 ppm, Fe was 62.3 ppm, Mg was 0.88%, Mn was 0.21 % K was 8 ppm, Phosphorous was 0.85%, Nitrogen was 0.09% and Zn was 9.9% but the levels increased once organic manure was intergrated at 8.45 t/h, so at 250 kg/ha+8.45 t/h, Ca was 2.41% from 1.97%, Cu increased to 26.1 ppm, Fe recorded 69.2 from 62.3 ppm, Mg increased to 0.25%.K recorded 10 ppm, Phosphorous increased from 0.85% to 0.96%, Nitrogen increased to 0.15% from 0.09% and eventually Zn from 9,9 ppm to 12.4 ppm.

3.1.1 Calcium

Both quail manure and NPK application rates significantly ($P \leq 0.05$) influenced the Calcium content in the soil (Table 6 and 7). The highest rate of the organic fertilizer led to the greatest increase in the calcium content in the soil in both varieties. As the organic fertilizer rate increased the Calcium content significantly increased, irrespective of the application rate when compared to soil that did not received any organic fertilizer. Soils treated with quail manure contained significantly higher calcium than soils treated with NPK. Contrary to the above results, some studies found high Calcium levels in inorganic grown products than organic grown ones [21].

3.1.2 Magnesium

As shown in Table 6 and 7, quail manure rate significantly influenced the magnesium content of soil. The soils rhizosphere in both varieties, at the highest rates of organic and NPK led to the highest increase of magnesium in the soil. Soils that received organic fertilizer at 8.45 t/ha had significantly ($P \leq 0.05$) lower magnesium than all the other quail manure levels including the control. In this study, the inorganic treated soils contained higher magnesium levels than soils that not receive any fertilizer and at a higher range than the organic treated soils. Magnesium content of potatoes soil rhizosphere that received fresh and composted farmyard manure plus slurry for three years was lower than inorganic fertilized soils [22]. Organic fertilizer rate 2 significantly decreased the magnesium content in *A. cruentus* compared to soils that did not received any fertilizer. In the present study, soil that received NPK contained more manganese than those that received organic fertilizer.

which was in contrary to Warman and Havard who obtained higher manganese levels in carrots treated with compost (170 kg N ha"[1]) over a period of 3 years compared to inorganic fertilized carrots [23].

3.1.3 Iron

The quail manure and NPK treated plots showed no significant differences in two seasons, in the two amaranth varieties. Iron content of soils that received quail manure was significantly ($P \leq 0.05$) higher than the one that received NPK.

3.1.4 Total carbon

The controls on both varieties showed the lowest amount of total organic carbon in the soil as shown on Table 6 and 7. The carbon content of soils that received 16.9 t/ha quail manure was significantly ($P \leq 0.05$) higher than all the other treatments except where no quail manure was applied. The total carbon content of soils was not significantly influence by NPK [24]. Higher carbon in vegetables treated with co-compost (sludge and municipal organic waste).

3.1.5 Phosphorous

The phosphorus content of soil was also significantly ($P \leq 0.05$) influenced by the organic fertilizer rate (Table 6 and 7). The highest rates of organic and NPK showed the highest phosphorus content while the controls had the lowest under both varieties though the NPK showed higher amount of phosphorous compared to the organic poultry manure. According to Lairon et al. [25] the phosphorus content of potatoes and carrots treated with organic fertilizer for two seasons was higher than those treated with sole NPK.

The interactions between organic fertilizer and application rate was only significant for total nitrogen and carbon content of the soil. NPK significantly influenced the calcium and iron content.

Table 2. The interaction effects of the variety, NPK fertilizer and quail manure rates on the soil chemical properties during the first season

Variety	Nitrogen rate	Quail manure	Ca %	Cu ppm	Fe ppm	Mg %	Mn %	K ppm	P %	Na %	N %	Organic C%	Zn ppm
A. cruentus	0 kg/ha	0 t/ha	1.8d	16.15c	60b	0.74d	0.18f	6e	0.73c	0.16f	0.05e	0.91c	9.2c
		8.45 t/ha	1.99d	23.14b	64.2a	0.97d	0.21d	10b	0.94c	0.25c	0.092d	0.98b	10.31b
		16.9 t/ha	2.3c	24.12b	66.59a	1.23c	0.29c	10b	1.04b	0.29c	0.14b	1.22a	9.c
	250 kg/ha	0 t/ha	1.97d	22.31b	62.3a	0.88d	0.21d	8c	0.85c	0.21d	0.09 1d	0.96b	9.9c
		8.45 t/ha	2.41c	26.1a	69.2a	1.35c	0.25c	10b	0.96c	0.26c	0.15b	1.13a	12.4b
		16.9 t/ha	3.1b	29.31a	69.4a	1.89b	0.28c	12a	1.14b	0.38b	0.17a	1.21a	11.65b
	500 kg/ha	0 t/ha	2.12c	24.13b	66.5a	1.02c	0.23d	9c	0.86c	0.22d	0.11c	1.01b	11.02b
		8.45 t/ha	2.6b	25.31b	68.5a	1.51b	0.31a	11b	1.05b	0.31b	0.18a	1.25a	12.2a
		16.9 t/ha	3.8a	30.16a	72.5a	2.14a	0.41a	13a	1.19b	0.36b	0.15a	1.6a	14.64a
A. tricolor	0 kg/ha	0 t/ha	1.81d	16.3c	60.2b	0.74d	0.17f	5e	0.78d	0.16f	0.05e	0.85c	9.35c
		8.45 t/ha	2.24c	21.23b	61.23ab	1.08c	0.24d	9c	1.01b	0.24d	0.11c	1.12b	10.06b
		16.9 t/ha	2.61b	21.35b	65.58a	1.75b	0.27c	11b	0.98c	0.26c	0.13b	1.35a	10.25b
	250 kg/ha	0 t/ha	2.1c	23.15b	63.11a	0.99a	0.2d	10b	0.85c	0.25c	0.1c	1.01b	9.56c
		8.45 t/ha	2.6b	24.36b	68.41a	1.85b	0.27c	12a	1.08b	0.31c	0.14a	1.16b	10.57b
		16.9 t/ha	2.97b	26.35a	69.56a	2.42a	0.29c	14a	1.14b	0.37b	0.15a	1.38a	10.25b
	500 kg/ha	0 t/ha	2.31c	22.54b	63.12a	1.13c	0.21d	10b	0.97c	0.24d	0.12b	1.11b	9.87c
		8.45 t/ha	2.76b	26.45a	69.31a	2.31a	0.33b	13a	1.06b	0.41a	0.15a	1.23a	10.95b
		16.9 t/ha	3.98a	29.43a	72.5a	2.51a	0.34b	14a	1.25a	0.45a	0.16a	1.46a	11.31b

Means in a same column followed by different letter (s) are significantly different at P≤0.05

Table 3. The interaction effects of the variety, NPK fertilizer and quail manure rates on the soil chemical properties during the second season

Variety	Nitrogen rate	Quail manure	Ca %	Cu ppm	Fe ppm	Mg %	Mn %	K ppm	P %	Na %	N %	Organic C %	Zn ppm
A. cruentus	0 kg/ha	0 t/ha	1.7d	16.15c	60.2b	0.74d	0.17f	6.2e	0.733c	0.17f	0.04e	0.81c	9.1c
		8.45 t/ha	1.89d	24.14b	64.82a	0.97d	0.22d	10.4b	0.94c	0.22c	0.09d	0.99b	10.01b
		16.9 t/ha	2.27c	25.12b	65.59a	1.23c	0.31c	11b	1.14b	0.26c	0.13b	1.21a	9.98c
	250 kg/ha	0 t/ha	1.87d	23.31b	61.3a	0.88d	0.31d	9c	0.95c	0.25d	0.09d	0.95b	9.8c
		8.45 t/ha	2.43c	27.1a	69.72a	1.35c	0.35c	9.1	0.86c	0.28c	0.13b	1.12a	11.4b
		16.9 t/ha	3.2b	28.31a	68.4a	1.89b	0.38c	11.9a	1.04b	0.37b	0.15a	1.19a	10.65b
	500 kg/ha	0 t/ha	2.21c	23.13b	66.5a	1.03c	0.33d	10c	0.89c	0.32d	0.1c	1.01b	10.02b
		8.45 t/ha	2.59b	25.31b	67.5a	1.61b	0.47a	12b	1.45a	0.31b	0.14b	1.25a	13.2a
		16.9 t/ha	3.78a	29.99a	72.5a	2.13a	0.61a	14a	1.29b	0.46b	0.16a	1.5a	13.64a
A. tricolor	0 kg/ha	0 t/ha	1.91d	16.4c	60.2b	0.75d	0.18f	4.6e	0.79d	0.17f	0.06e	0.95c	9.15c
		8.45 t/ha	2.34c	21.73b	62.23ab	1.09c	0.245d	10c	1.02b	0.24d	0.12c	1.22b	10.16b
		16.9 t/ha	2.71b	21.45b	65.68a	1.76b	0.29c	12b	0.97c	0.27c	0.14b	1.45a	10.35b
	250 kg/ha	0 t/ha	2.3c	23.23b	64.11a	0.98d	0.22d	11b	0.87c	0.25c	0.15c	1.11b	9.66c
		8.45 t/ha	2.69b	23.36b	68.71a	1.75b	0.29c	13a	1.09b	0.32c	0.1455a	1.26b	10.47b
		16.9 t/ha	2.98b	26.45a	69.66a	2.432a	0.28c	13a	1.15b	0.38b	0.14a	1.38a	10.35b
	500 kg/ha	0 t/ha	2.321c	22.56b	63.52a	1.23c	0.22d	11b	0.98c	0.23d	0.11b	1.11b	9.67c
		8.45 t/ha	2.66b	26.55a	69.41a	2.41a	0.34b	14a	1.07b	0.421a	0.16a	1.33a	11b
		16.9 t/ha	3.97a	29.53a	73.5a	2.61a	0.35b	15a	1.35b	0.46a	0.17a	1b	11.41b

Means in a same column followed by different letter (s) are significantly different at P ≤0.05

Table 4. The influence of quail manure rates on the soil chemical properties season 1

Quail rate	Calcium me%	Copper ppm	Iron ppm	Magnesium me%	Manganese me%	Phosphorus ppm	Potassium me%	Sodium me%	Total N%
0 t/ha	2.12c	20.28b	62.97b	1.07c	0.242a	6.45b	0.80b	0.24b	0.02c
8.45 t/ha	2.52b	26.26a	67a	1.58b	0.25b	10a	1.2a	0.33d	0.13a
16.9 t/ha	2.93a	26.34a	67.74a	1.67a	0.32a	11.57a	1.56a	0.24d	0.17a
LSD	0.31	2.34	2.36	0.06	0.17	2.69	0.16	0.28	0.04

Means in a same column followed by different letter (s) are significantly different at P≤0.05

Table 5. The influence of quail manure rates on the soil chemical properties season 2

Quail Rate	Calcium me%	Copper Ppm	Iron ppm	Magnesium me%	Manganese me%	Phosphoru ppm	Potassium me%	Sodium me%	Total N%
0 t/ha	2.02c	19.28c	62.97c	0.97c	0.142c	7.45b	0.67b	0.24b	0.03b
8.45 t/ha	2.82b	25.26b	68a	1.58b	0.25b	11a	1.4a	0.27a	0.33b
500 kg/ha	3.93a	27.34a	69.74a	1.67a	0.32a	11.57a	1.66a	0.26a	0.44a
LSD	0.61	1.14	2.46	0.02	0.21	2.89	0.21	0.17	0.04

Means in a same column followed by different letter (s) are significantly different at P≤0.05

Table 6. The influence of NPK fertilizer rates on the soil chemical properties season 1

NPK rate	Calcium me%	Copper Ppm	Iron ppm	Magnesium me%	Manganese me%	Phosphorus ppm	Potassium me%	Sodium me%	Total N%
0 t/ha	2.02c	20.18b	62.97b	0.82c	0.21c	7c	0.74c	0.21c	0.03c
250 t/ha	2.42b	26.26a	68a	1.48b	0.37a	13.67 a	1.42a	0.23b	0.18b
500 t/ha	2.23c	26.34a	69.74a	1.49b	0.26b	12.48b	1.11b	0.25a	0.23a
LSD	0.29	2.47	2.94	0.05	0.13	3.12	0.11	0.19	0.05

Means in a same column followed by different letter (s) are significantly different at P≤0.05

Table 7. The influence of NPK fertilizer rates on the soil chemical properties season 2

NPK rate	Calcium me%	Copper Ppm	Iron ppm	Magnesium me%	Manganese me%	Phosphorus ppm	Potassium me%	Sodium me%	Total N%
0 t/ha	2.12c	20.28c	61.97c	0.82c	0.11c	7c	0.67c	0.23c	0.023e
250 t/ha	2.42b	24.26b	69.7a	1.51b	0.37a	12.67 a	1.62a	0.35b	0.28c
500 t/ha	2.13c	21.34c	69.74a	1.52b	0.46b	12.48b	1.41b	0.27a	0.23d
LSD	0.76	0.99	3.16	0.03	0.27	2.46	0.18	0.15	0.05

Means in a same column followed by different letter (s) are significantly different at P≤0.05

3.1.6 Soil pH

The increase in the quail manure rates led to an increase in the soil pH for both seasons with a peak at 6.51 units while the lowest observed in the controls. Quail manure have cation exchange sites, so micronutrient organic matter is known to form chelate with micronutrients [26], increasing availability of micronutrients like Fe, Cu, Zn and Mn are due to reduced soil pH micro nutrients cations are soluble and available under acidic conditions [27]. The highest value of pH was due to effect of chicken manure which contains calcium carbonate [2]. Among the main treatments the organic treatment showed the highest pH value of 6.51 where sole 16.9 t/ha of quail manure was applied followed by where sole 9.45 t/ha of quail manure was applied.

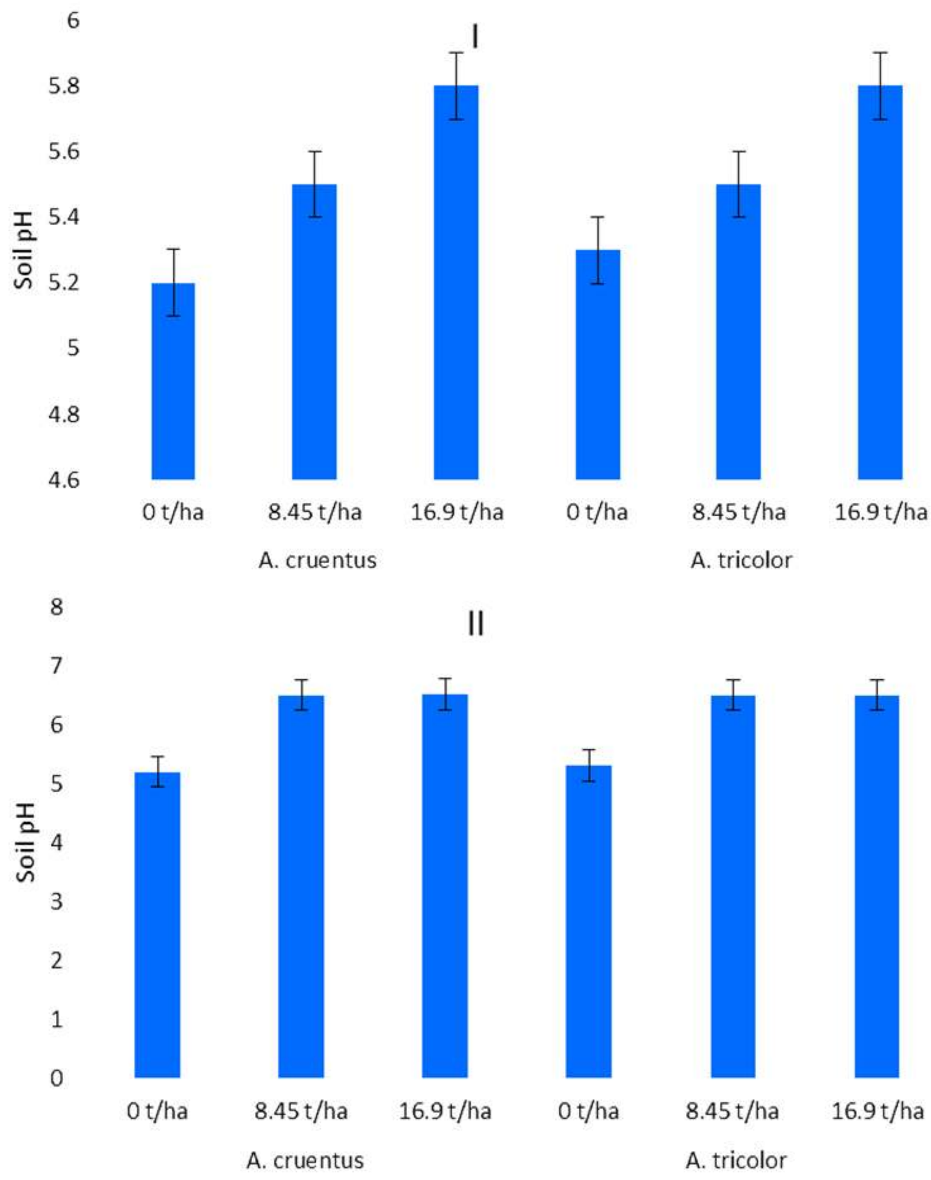

Fig. 1. The influence of the interaction between variety and quail manure rates on the soil pH content during the first season (I) and second season (II)

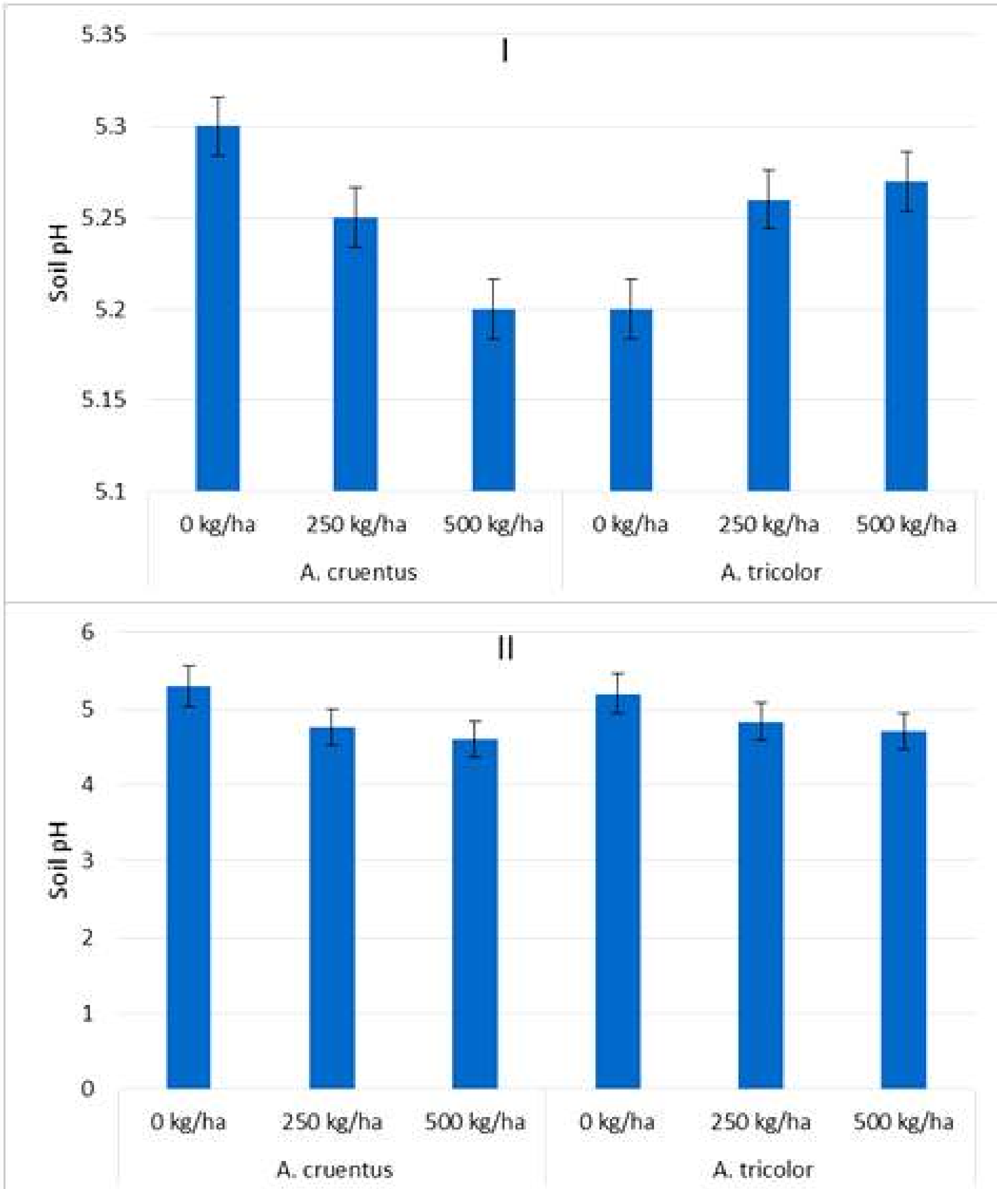

Fig. 2. The influence of the interaction between variety and NPK fertilizer rates on the soil pH content during the first season (I) and second season (II)

4. CONCLUSION

Farmers from this study are advised to apply 16.9 t/h of poultry (quail) manure intergrated with 250 kg/ ha NPK (17-17-17) from 500 kg/ha fertilizer. Poultry quail manure combined with reduced level of NPK fertilizer increased soil nutrients content than NPK fertilizer alone. This experiment shows that integrated application of poultry manure and NPK fertilizer was more effective in increasing soil nutrient available in the soil.

The trial demostrated that sole NPK induced rhizosphere acidification while sole organic quail manure treatment resulted to rise in rhizosphere pH, intergration of organic and inorganic fertiizers had better impact on the ultisol chemical properties.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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