Open Agriculture. 2018; 3: 644–651 DE GRUYTER

Research Article

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Effect of $ZnSO_4$ fertilizer on soil chemical properties, performance and proximate quality of sweet potato in a derived savanna ecology of Nigeria

https://doi.org/10.1515/opag-2018-0067
received May 28, 2018; accepted December 1, 2018

Abstract: Micro-nutrients especially zinc can not only increase the yield of sweet potato but can also improve the quality of tubers. Hence, experiments were carried out in 2015 and 2016 cropping seasons to determine the impact of various levels of $ZnSO_4$ fertilizer on soil chemical properties, foliage and storage root yields and proximate qualities of sweet potato (*Ipomoea batatas* L.). The experiments consisted of 5 levels (0, 5, 10, 15 and 20 kg ha^{-1}) of $ZnSO_4$ fertilizer. These were arranged in a randomized complete block design and replicated three times. $ZnSO_4$ increased (with the exception of P) soil chemical properties compared with the control. N, K, Ca, Mg and Zn were increased up to the 20 kg ha^{-1} $ZnSO_4$ level in both years. $ZnSO_4$ reduced P concentrations in soil as the level increased. For sweet potato performance, 5 kg ha^{-1} $ZnSO_4$ fertilizer had the highest values of foliage yield (vine length and vine weight) and storage root yield. Using the mean of the two years and compared with the control, $ZnSO_4$ fertilizer at 5 kg ha^{-1} increased storage root yield of sweet potato by 17.4%. On fitting the mean storage root yield data of the two years with a cubic equation, the optimum rate of Zn for sweet potato was found to be 3.9 kg ha^{-1} to achieve the maximum sweet potato yield. In this study, relative to the control, $ZnSO_4$ fertilizer increased moisture and decreased the fibre contents of sweet potato. There were no consistent patterns of variation between the 5, 10, 15 and 20 kg ha^{-1} $ZnSO_4$ treatments for proximate qualities except that the highest values of fat, protein, carbohydrate and ash was at 5 kg ha^{-1} $ZnSO_4$.

Keywords: Zn, *Ipomoea batatas*, soil, foliage yield, storage root yield, fat, carbohydrate

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1 Introduction

The agricultural lands in Nigeria, like other tropical countries, consist of fragile soils with a thin layer of coarse-textured top soils and dominance of low activity clays, as products of intensive weathering and leaching processes (Ahn 1993). For sustainable crop production, there is therefore the need to maintain its fertility by the addition of external inputs. However, soil fertility evaluation in tropical countries is often based in determination of organic matter and macronutrients (Tomori et al. 2006). Data are relatively few in case of micronutrients. Fageria et al. (2002) reported that intensive cropping practices, enhanced production of crops on marginal soils that contain low levels of essential micronutrients and adoption of high yielding cultivars which have high micronutrient demand have led to increase demand for micronutrient. Zinc is one of the most important micronutrients required for plant growth. According to the Food and Agriculture Organization (FAO), about 30% of the cultivable soils of the world contain low levels of plant available Zn (Sillanpaa 1990). It is an activator of several enzymes in plants and is directly involved in the biosynthesis of growth substances, such as auxin, which produces more plant cells and more dry matter (Marschner 1995). Zn deficiencies in human populations are a serious threat in sub Saharan Africa. Options of reducing this problem exist and one of them is the food based approach. This includes agronomic management of crops through fertilizer applications. The application of zinc into the soil not only enhances the fertility of the soil

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but also increases the storage root zinc content and cures zinc nutrient deficiency problems in human beings.

Every plant has the potentiality of yielding its maximum, but the maximum may not be achieved if the nutritional and fertilizer application is not proper. However, the amount that should be used to achieve the maximum yield varies with the nature of fertilizer, crop and soil. For $ZnSO_4$ fertilizer in sweet potato and Alfisol, of a derived savanna ecology, this rate has not been determined. Several workers stated that the application of zinc, in addition to essential major elements, can play a good role in increasing the yield of potato (Islam et al. 1986; Mondal 1993). Nutrient elements, especially zinc, not only increases the yield of potato but could also improve the quality of storage roots. Experiments conducted by Laxminarayana and John (2014) emphasized that the application of 20 kg ha^{-1} of $ZnSO_4$, along with the optimum doses of NPK and farm yard manure, produced sustainable sweet potato yields with good quality storage roots and maintained the soil fertility. Whereas Ahmad et al. (1989) could not establish a linkage between application of 5 or 10 kg Zinc ha^{-1} sprouting, growth and tuber yield of potato cv. Cardinal. Studies on the relative effects of $ZnSO_4$ fertilizer application on soil chemical properties, sweet potato yield and quality is very scarce in Nigeria. It was hypothesized that soil chemical properties and sweet potato yield and quality will react differently to different rates of $ZnSO_4$ fertilizer. Therefore the objective of this study was to evaluate the effects of $ZnSO_4$ fertilizer on soil chemical properties, foliage and storage root yields and qualities of sweet potato in a derived savanna ecology.

2 Materials and Methods

2.1 Site description and treatments

Field experiments were carried out at the Teaching and Research Farm, Landmark University, Omu-Aran, Kwara state, Nigeria in the 2015 and 2016 cropping seasons. The experiments were designed to determine the various levels of $ZnSO_4$ fertilizer on soil chemical properties, foliage and storage root yields and proximate quality of sweet potato. Landmark University lies between Lat 8° 9'N and Long 5° 61'E and is located in the derived savanna ecological zone of Nigeria. The soil at Landmark University is an Alfisol classified as Oxic Haplustalf or Luvisol. There are two rainy seasons, one from March to July and the other from mid-August to November. The mean annual rainfall in the area is about 1300 mm and mean annual temperature is 32°C. The experimental site for 2015 was under maize cultivation for two years and left to fallow for one year and 2016 was left to fallow for two years before cultivation to sweet potato. The site for 2015 experiment was just adjacent to that of 2016.

The experiment each year consisted of 5 levels (0, 5, 10, 15 and 20 kg ha^{-1}) of $ZnSO_4$ fertilizer. The five treatments were arranged in a randomized complete block design and replicated three times. The size of the experimental field each year was 187 m^2. Each block comprised of 5 plots, each of which measured 3 x 3 m. Blocks were 1 m apart and the plots were 0.5 m apart.

2.2 Planting of sweet potato and application of $ZnSO_4$ fertilizer

Each year, conventional tillage that involved ploughing, harrowing and ridging was done before planting. Three ridges were maintained per plot. Planting of sweet potato (Omu – Aran local variety) vines of about 25-30 cm long was done in April at each year on ridges at a distance of 1 m x 0.5m to give a plant population of 20,000 plants per ha. $ZnSO_4$ fertilizer was applied at the rates 0, 5, 10, 15 and 20 kg ha^{-1} three weeks after planting at 10 cm away from the planted cuttings by banding. Also, at this stage, 200 kg ha^{-1} NPK 15-15-15 fertilizer was applied as a basal application to boost the growth of the potato as the site was deficient in these nutrients.

2.3 Determination of soil properties

Before the start of the experiments in 2015 and 2016, surface soil (0–15 cm) samples were randomly collected from 10 different points from each experimental site. Soil samples were also collected randomly from the centre of each plot on ridges at five sites per plot at harvest of sweet potato each year. The soil samples were bulked, air-dried and sieved using a 2-mm sieve for routine chemical analysis, as described by Carter (1993). Particle-size analysis was carried out for textural class using the hydrometer method (Sheldrick and Hand Wang 1993). Soil pH was determined in a soil/water (1: 2) suspension using a digital electronic pH meter. Soil organic carbon was determined by the Walkley and Black procedure by wet oxidation using chromic acid digestion (Nelson and Sommers 1996). Total N was determined using micro-Kjeldahl digestion and distillation techniques (Bremner 1996), and available P was determined by Bray-1 extraction followed by molybdenum blue colorimetry (Frank et al. 1998). Exchangeable K, Ca and Mg were extracted with a

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1 M NH4OAc, pH 7 solution. Thereafter, K was analysed with a flame photometer and Ca and Mg were determined with an atomic absorption spectrophotometer (Okelabo et al. 2002). Zn was extracted with HCl and read on atomic absorption spectrophotometer.

2.4 Foliage and storage root yields and quality of sweet potato measurements

Ten plants were selected per plot for the determination of foliage yield (vine length and vine weight) and storage root yield (storage root weight) parameters at 150 days after planting. Vine length was determined by measuring with a meter rule while the vine weight and storage root weight were determined by weighing on a top loading balance after washing and cleaning to remove any traces of sand from the storage root. One kg of sweet potato storage root from each plot was taken for proximate analysis. The ash, moisture, crude fibre, crude protein, crude fat and carbohydrate contents of the sweet potato were determined using standard chemical methods described by Association of Analytical chemists (AOAC 2003). The moisture content was determined by drying 200 g of each sample at 105^{o}C till constant weight is achieved,

$$\% \text{ moisture content} = \frac{\text{weight of moisture}}{\text{Weight of sample}} \times 100$$

The ash content was determined by incineration of 2 g of each sample in a muffle furnace at 500^{o}C for 2 h. Soxhlet extraction technique using petroleum ether (40-50^{o}C) was used to evaluate the fat content of the samples. The Kjedahl method was used to determine the crude protein content of the samples, as described by AOAC (2003). The carbohydrate content of the sample was estimated by using Muller and Tobin (1980). The total carbohydrate was estimated as the balance after accounting for ash, crude fibre, protein and fat. % carbohydrate = 100% - sum of percentage moisture, ash, crude fat, crude fibre and crude protein contents.

2.5 Statistical Analysis

Data collected were subjected to statistical analysis of variance (ANOVA) using IBM SPSS Statistics 21 and the Microsoft Excel 2013. The treatment means were compared using the Duncan's multiple range test (DMRT) at p = 0.05 probability level.

Ethical approval: The conducted research is not related to either human or animal use.

3 Results

3.1 Initial soil fertility status of the experimental site

Table 1 shows the results of the soil physical and chemical properties of the two sites before planting to sweet potato. The soils were sandy loam in texture, slightly acidic, low in organic matter (OM), N, P, K, Ca, Mg and Zn but adequate in Mg in 2015 when considering the critical levels of 3.0% OM, 0.20% N, 10.0 mg kg^{1} available P, 0.16–0.20 cmol kg^{1} exchangeable K, 2.0 cmol kg^{1} exchangeable Ca, 0.40 cmol kg^{1} exchangeable Mg and 5 mg kg^{1} Zn recommended for crop production in ecological zones of Nigeria (Akinride and Obigbesan 2000; Chude et al. 2011), thus indicating poor soil fertility, but the site used in 2016 had slightly higher pH, OM, N and Ca compared with the 2015 site. Hence, it is expected that the soils will respond to application of $ZnSO_4$ fertilizer and therefore sweet potato performance.

Table 1: Initial soil physical and chemical properties of the site before experimentation

Soil property	2015	2016
Sand (%)	69.0	69.0
Silt (%)	13.1	13.6
Clay (%)	17.9	17.4
Textural class	Sandy loam	Sandy loam
pH (water)	5.62	5.68
Organic matter (%)	1.27	1.60
Total N (%)	0.14	0.16
Available P (mg kg^{-1})	9.8	8.9
Exchangeable K (cmol kg^{-1})	0.15	0.14
Exchangeable Ca (cmol kg^{-1})	1.72	1.80
Exchangeable Mg (cmol kg^{-1})	0.41	0.39
Zn (mg kg^{-1})	3.35	2.51

3.2 Effect of $ZnSO_4$ fertilizer on soil chemical properties

The results of various levels of $ZnSO_4$ fertilizer on soil chemical properties in 2015 and 2016 are presented in Table 2. Application of $ZnSO_4$ fertilizer increased (with the exception of P) soil chemical properties compared with the control. N, K, Ca, Mg and Zn were increased with

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Table 2: Effect of $ZnSO_4$ fertilizer on soil chemical properties

$ZnSO_4$ (kg ha^{-1})	N (%)		P (mg kg^{-1})		K (cmol kg^{-1})		Ca (cmol kg^{-1})		Mg (cmol kg^{-1})		Zn (mg kg^{-1})	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
0.0	0.13e	0.15e	9.3a	8.6a	0.15e	0.14e	1.54d	1.60e	0.37e	0.35e	3.03e	2.42e
5.0	0.14de	0.16de	8.1b	8.1b	0.17d	0.16d	1.69c	1.72d	0.45d	0.41d	4.20d	3.54d
10.0	0.16cd	0.18bc	7.4c	6.9c	0.18cd	0.18c	1.75c	1.80c	0.67c	0.47c	4.55c	4.65c
15.0	0.17bc	0.19ab	6.7d	6.1d	0.19bc	0.19bc	1.80bc	1.91b	0.75ab	0.55b	5.42b	5.06b
20.0	0.18ab	0.20a	5.7e	5.4e	0.21a	0.22a	1.96a	2.08a	0.80a	0.62a	6.50a	6.65a

Values followed by similar letters under the same column are not significantly different at p=0.05 according to Duncan's multiple range test

increasing $ZnSO_4$ level in both years, up to the 20 kg ha^{-1} treatment. $ZnSO_4$ fertilizer reduced P concentrations in soil as the level increases.

3.3 Effect of $ZnSO_4$ fertilizer on foliage and storage root yields of sweet potato

The results of the various $ZnSO_4$ levels on foliage and storage root yields of sweet potato are presented in Table 3. The treatment with 5 kg ha^{-1} $ZnSO_4$ had significantly higher foliage yield (t ha^{-1}) and total storage root yield (t ha^{-1}) than the control treatment (0 kg ha^{-1} $ZnSO_4$) over the two years. There were foliage and storage root yield reductions from 10 kg ha^{-1} application of $ZnSO_4$. Using the mean of the two years and compared with the control and 20 kg ha^{-1} application, $ZnSO_4$ fertilizer at 5 kg ha^{-1} increased storage root yield of sweet potato by 17.4% and 40.3%, respectively. Figure 1 shows that the relationship between mean storage root yield of sweet potato and $ZnSO_4$ fertilizer was described by a cubic model with an r^2 = 0.935. The optimum $ZnSO_4$ fertilizer for maximum sweet potato yield was obtained at 3.9 kg ha^{-1} $ZnSO_4$ fertilizer.

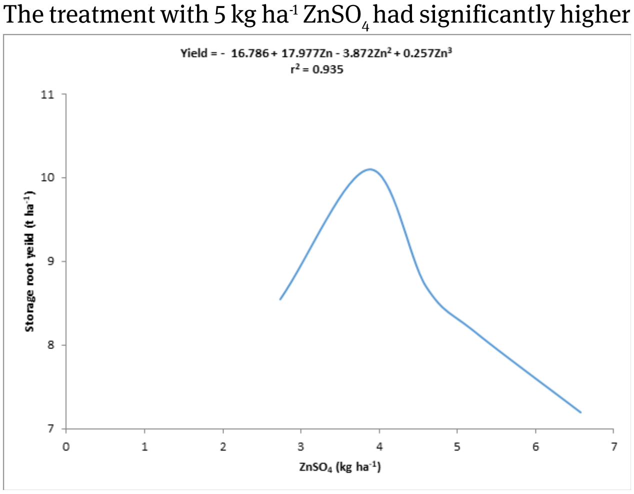

Figure 1: Yield response of sweet potato to applied Zn fertilizer

3.4 Effect of $ZnSO_4$ fertilizer on the proximate quality of storage root yield of sweet potato

The results of the mean values from years 2015 and 2016 of $ZnSO_4$ fertilizer on tuber qualities of sweet potato are presented in Table 4. Application of $ZnSO_4$ fertilizer at 5 kg ha^{-1} increased the qualities (moisture, protein, fat, carbohydrate and ash) compared with the control. The optimum values of carbohydrate, ash, protein and fat were obtained at 5 kg ha^{-1} $ZnSO_4$ fertilizer after which there was a decrease. Application of $ZnSO_4$ fertilizer increased

Table 3: Effect of $ZnSO_4$ fertilizer on the foliage and storage root yield parameters of sweet potato

$ZnSO_4$ (kg ha^{-1})	Vine length (m)			Vine weight (kg)			Storage root weight/plant (kg)			Storage root yield (t ha^{-1})		
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean
0.0	1.82d	2.02c	1.92c	1.42d	2.10c	1.76c	1.60b	1.82b	1.71b	8.0b	9.1b	8.6b
5.0	2.05a	2.74a	2.40a	2.16a	2.67a	2.42a	1.96a	2.08a	2.02a	9.8a	10.4a	10.1a
10.0	1.88c	2.21b	2.05b	1.40e	2.45b	1.93b	1.56b	1.92b	1.74b	7.8b	9.6b	8.7b
15.0	1.98b	2.01c	2.00b	1.76c	2.07c	1.92b	1.44c	1.82b	1.64b	7.2c	9.1b	8.2b
20.0	1.88c	1.89d	1.89c	1.80b	1.78d	1.79c	1.16d	1.72c	1.44c	5.8d	8.6c	7.2c

Values followed by similar letters under the same column are not significantly different at p = 0.05 according to Duncan's multiple range test

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Table 4: Effect of $ZnSO_4$ fertilizer on the proximate quality of sweet potato (mean from 2015 and 2016)

$ZnSO_4$ (kg ha^{-1})	Fat (g kg^{-1})	Moisture (g kg^{-1})	Protein (g kg^{-1})	Fibre (g kg^{-1})	Ash (g kg^{-1})	Carbohydrate (g kg^{-1})
0.0	18.6b	537.4c	39.1b	33.7a	13.0b	358.2b
5.0	19.7a	542.1b	43.4a	18.2b	16.4a	360.2a
10.0	17.4b	612.2ab	43.1a	18.5b	12.2b	296.6cd
15.0	14.4c	622.2ab	41.2a	17.6c	12.2b	292.5cd
20.0	17.6b	632.2a	42.5a	17.7c	12.1b	277.7d

Values followed by similar letters under the same column are not significantly different at p = 0.05 according to Duncan's multiple range test

moisture content of sweet potato storage root yields from 0 – 20 kg ha^{-1}. There were no significant differences between 5, 10, 15 and 20 kg ha^{-1} $ZnSO_4$ for protein. Also, there were no significant differences between 5 and 10 kg ha^{-1} $ZnSO_4$ levels for fibre. Application of $ZnSO_4$ fertilizer significantly reduced fibre content of sweet potato compared with the control. There was also no consistent pattern of variation between 5, 10, 15 and 20 kg ha^{-1} $ZnSO_4$ except that the highest values of fat, protein, fibre, carbohydrate and ash was at 5 kg ha^{-1} $ZnSO_4$.

4 Discussion

The increase in Zn, as a result of application of $ZnSO_4$ fertilizer to the soil, shows that the soils are deficient in Zn. Chude et al. (2011) had earlier reported that the soils of the agroecological zone are low in Zn. Kiekens (1995) reported that the lowest Zn concentrations were always found in Spodosols (28 mg kg^{-1}) and Luvisols (35mg kg^{-1}). The sites as Luvisols are low in Zn. The available P was highest at lower doses of $ZnSO_4$ fertilizer application and decreased at higher rates which is due to antagonistic effect of P and Zn (Choudhry et al. 1992; Yaseen 1999). The increase in total N as level of $ZnSO_4$ increases could be due to the synergistic effect between N and Zn. It might also be due to the increased enzymatic activity and the organic recycling of the plant nutrients in response to available zinc supply to plants and showed the importance of zinc application for nitrogen availability and uptake by plants (Khan et al., 2002). The increase in K could be due to the positive interaction of K and Zn (Keram et al. 2012; Alloway, 2004).

The increase in foliage and storage root yield parameters of sweet potato in Zn plots compared with the control could be related to the soil chemical properties of the control plots. $ZnSO_4$ application plots have higher values of N, K, Ca, Mg and Zn and hence higher yields compared with the control. The basal fertilizer applied could have caused an increase in zinc availability through improved root growth and hence an increased volume of soil explored by roots in the more vigorously growing plant and therefore better yield. Islam et al. (1986) and Mondal (1993) also found that the yield of potato increased with the application of Zn fertilizer.

The storage root yield of sweet potato at the two years showed highest response at 5 kg ha^{-1} of $ZnSO_4$ fertilizer application. The relationship between mean tuber yield and $ZnSO_4$ fertilizer rate was described by a cubic model with an r^2 = 0.935. From the curve, the optimum $ZnSO_4$ fertilizer rate for obtaining maximum storage root yield of sweet potato was best at 3.9 kg ha^{-1} $ZnSO_4$ fertilizer. Dwivedi et al. (2002) and Srinivasan et al. (2004) fixed the values of maize and ginger in a quadratic response to be 7.1 kg ha^{-1} and 6.0 kg ha^{-1}, respectively. On Alfisol in Odisha, India it was found that optimum storage root for sweet potato was achieved by the application of 20 kg ha^{-1} $ZnSO_4$ fertilizer (Laxminarayana and John 2014). There was a decrease in yield of sweet potato above 3.9 kg ha^{-1} $ZnSO_4$ fertilizer, which implies that nutrient supply was at the luxury level and contributed less to yield. As the concentration of soil Zn increased above threshold level it affects the yield by causing phytotoxicity and imbalance of nutrients (Srinivasan et al. 2004). The depressed yield as a result of Zn fertilizer application above the optimum level of 5 kg ha^{-1} could also be related to the inability of the sweet potato plant to photosynthesize (Stiborova et al. 1986; Prasad, 1999). Excess Zn can restrict the stomatal conductance (Singh and Bhati 2003; Khudsar et al. 2004; Di Baccio et al. 2005) and therefore CO_2 fixation (Van Assche et al. 1988; Khudsar et al. 2004) and consequently depressed foliage and storage root yields. Sahota (1985) had earlier reported that appropriate Zn level in the soil tended to increase large size storage root yield as these were more with 15 kg zinc ha^{-1} and low with 30 kg zinc ha^{-1} than without Zn.

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$ZnSO_4$ fertilizer treatments increased moisture, carbohydrate, protein, fat and ash contents of sweet potato storage root compared with the control. This might be as a result of increase in the nutrients in the soil due to application of $ZnSO_4$ fertilizer which consequently led to increased absorption of nutrients by the plants. This can also be because increase in $ZnSO_4$ fertilizer applied led to increased soil N and N absorbed by the potato plant and hence increased in the number of foliage and photosynthetic activities and enhancing physiological processes leading to the production of more assimilates which led to increase in chemical composition of the storage roots. Laxminarayana and John (2014) also found that zinc fertilizer improved the quality (starch, total sugar and dry matter) of orange-fleshed sweet potato in Alfisols of Odisha, India.

Studies about the kinetics of the uptake of Zn reported the occurrence of active and passive mechanism (Kochian 1993). Zinc is absorbed by plants as the divalent cation, Zn^{2+} only, since it is not affected by oxidation-reduction reaction in soil –plant system (Agbede 2009). It has generally been recognized that zinc is transported in the plant either as Zn^{2+} or bound to organic acids. Zinc accumulates in root tissues but is translocated to the shoot when needed. Zinc is partially translocated from old leaves to developing organs (Alloway 2008). Kochian (1993) proposed that the transport of zinc across the plasma membrane was towards a large negative electrical potential so that the process is thermodynamically passive. This negative electrical potential of the plasma membrane is the driving force for zinc by means of a divalent cation channel in dicotyledons and monocotyledons other than the Poaceae (Kochian 1993). It has also been reported (Brennan 2005; Broadley et al. 2007) that Zn translocation to roots' xylem occurs via symplast and apoplast, but high levels of Zn have also been detected in the phloem, denoting that this metal is translocated through both xylem and phloem tissues (Pearson et al. 1995; Haslett et al. 2001) as cited by Tsonev and Lidon, (2012).

Due to the metabolic role of Zn in synthesis of protein, enzymes activation and metabolism of carbohydrate, utilization of fertilizers containing these elements increases qualitative and quantitative performance of potato storage root (Parmar et al. 2016). Zinc may play a role in the metabolism of starch because the starch content, activity of the enzyme starch synthetase, and the number of starch grains are all depressed in zinc deficient plants (Alloway 2008). The increase in water content of sweet potato in response to $ZnSO_4$ fertilizer application can be attributed to the fact that Zn in soil increased the capacity of water uptake and transport in the sweet potato plant (Kasim, 2007; Disante et al. 2010). Also, the increase in protein content in response to Zn application highlights the importance of Zn in protein synthesis in plants. It also means that relatively high zinc concentrations are required by meristematic tissue where cell division as well as synthesis of nucleic acid and protein is actively taking place (Brown et al.1993**)**. The most fundamental effect of zinc on protein metabolism is through its involvement in the stability and function of genetic material. Alloway (2004) also reported a decrease in performance and quality of potato due to decrease in Zn. Mohamadi (2000) and Mousavi et al. (2007) reported increases in performance and quality of sweet potato storage roots to application of micronutrients. The better quality of sweet potato at 5 kg ha^{-1} $ZnSO_4$ fertilizer is consistent with storage root and foliage yield parameters. This might be due to Zn contribution in photosynthesis, chlorophyll, metabolism of starch formation and enzymes carbonic anhydrase accelerating carbohydrate formation. The maximum Zn requirement at 5 kg ha^{-1} were enough to accumulate suitable fat, moisture, protein and fibre for the potato plant.

5 Conclusion

Application of $ZnSO_4$ fertilizer increased soil chemical properties (except P), foliage and storage root yields parameters and proximate qualities of sweet potato compared with the control. Using the mean of the two years and compared with the control and 20 kg ha^{-1} application, $ZnSO_4$ fertilizer at 5 kg ha^{-1} increased storage root yield of sweet potato by 17.4 and 40.3%, respectively. On fitting the mean tuber yield data of the two sites into a cubic equation, the optimum rate of Zn for sweet potato was found to be 3.9 kg ha^{-1} for the maximum storage root yield. There were no consistent patterns of variation between 5, 10, 15 and 20 kg ha^{-1} $ZnSO_4$ for proximate qualities except that the highest values of fat, protein, carbohydrate and ash was at 5 kg ha^{-1} $ZnSO_4$. In this study, relative to the control, $ZnSO_4$ fertilizer increased moisture and decreased the fibre contents of sweet potato. Application of $ZnSO_4$ fertilizer in the appropriate rate will increase the proximate qualities of sweet potato.

Conflict of interest: Authors declare no conflict of interest.

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