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EFFECTS OF INTERCROPPING ARRANGEMENTS AND FERTILIZER APPLICATION ON GROWTH AND YIELD OF AFRICAN NIGHTSHADE (*Solanum nigrum* L.) IN KISII COUNTY, KENYA

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ABSTRACT

This study investigated the effects of intercropping arrangements and fertilizer combinations on growth and yields of African nightshade (ANS) (*Solanum nigrum* L.). The study was carried out at the KALRO research station, Kisii County. The experiments were laid in a complete randomized block design with a split plot arrangement replicated thrice. The main plots were intercropping arrangements (0:16, 1:14, 1:2, 1:3, 1:4 (Spider plant: ANS). The sub plots were fertilizer combinations of Farm yard manure (FYM), urea (NPK: 46-0-0) and triple super phosphate (TSP) (NPK: 0-46-0). Data was collected on number of branches, leaves and fresh leaf yield. The results indicated that an application of urea (60kg N ha^{-1}) + TSP (40kg P ha^{-1}) resulted in the highest number of branches (10) and leaves (32) per plant while the sole application of FYM (60kg N ha^{-1}+ 36 kg P ha^{-1}) resulted in the lowest number of branches (6) and leaves (21) per plant. Further, ANS grown as a pure stand supplied with Urea (60kg N ha^{-1}) + TSP (40Kg P ha^{-1}) resulted in the highest leaf yield (35.1 tons ha^{-1}) that was not different from 32.5 tons ha^{-1} obtained when the sole ANS was supplied with urea (40 kg N ha^{-1}) + TSP (30 kg P ha^{-1}) + FYM (20 kg N ha^{-1}+ 9 kg P ha^{-1}). To boost ANS production, farmers should grow it as a pure stand supplied with urea (60kg N ha^{-1}) + TSP (40kg P ha^{-1}) or urea (40 kg N ha^{-1}) + TSP (30 kg P ha^{-1}) + FYM (20 kg N ha^{-1}+ 9 kg P ha^{-1}).

Keywords: African nightshade, intercropping arrangements, fertilizer combinations, spider plant

INTRODUCTION

African nightshade (ANS) (*Solanum nigrum* L.) is one of the leafy vegetables in the *solanaceae* family, largely domesticated in sub-Saharan Africa (Abukusta-Onyango *et al*. 2004). It is known

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for its nutritional, medicinal value and a source of livelihood; rich in iron, calcium vitamins A and C (Yang *et al*. 2009). It has been reported that the nutrient content of this vegetable can provide 100% of the recommended daily allowance for an adult for calcium, iron, b-carotene, and ascorbic acid and 40% of protein if 100g of the fresh vegetable is consumed (Abukutsa-Onyango, 2003).

Consumption, demand, and market value of this vegetable have rapidly and steadily risen as consumers become aware of its nutritional, economical and medicinal values. In recent years, the resurgence in popularity has prompted rapid domestication and commercialization of nightshade production, from subsistence to commercial farming (Abukutsa-Onyango 2003; Mwai and Schippers 2004). The vegetable is normally grown in home gardens and usually intercropped with other vegetables or cereals like maize, sorghum or millet (Obuoyo, 2005).

The African nightshade is characterized by fast growth and tolerance to adverse ecological conditions (Adebooye and Opabote, 2004). However, it has not been fully exploited for food, nutrition and economic security in an endeavor to alleviate poverty in Kenya. Some of the major constraints of production of ANS include, poor seed quality, lack of production and utilization packages, poor marketing and processing strategies. Further, with intensified commercial agriculture and increased population, more land is converted to commercial agricultural production at the expense of the indigenous vegetables such as ANS (Netondo et al., 2010) consequently eroding the vegetable.

Soil fertility and plant nutrition are important aspect of cropping system in order to achieve high crop yields. The availability of nutrients to plants contributes to growth and yield. Adequate supply of mineral elements is of importance in the tropics where the soil is mainly nutrient mined with very little replenishment and continuous cropping. Thus, the application of fertilizer or manure to improve soil fertility is an integral part of leafy vegetable production (Aluko et al. 2014). Leafy vegetables require nitrogen for good vegetative growth (Kipkosgei et al. 2003) and the quality of the harvest and shelf life are influenced by the availability of essential minerals in balanced proportions.

In addition, vegetable production such as that of African nightshade has been shown to be constrained by pests and diseases that severely impacts the quantity and quality of yield (Hassan et al., 2010; as well as an overuse of chemical pesticides that lead to toxicological and environmental problems (Sikora and Fernandez, 2005). Intercropping vegetables with other crop species is increasingly gaining popularity as a potential alternative to the use of chemicals (Trdan et.al., 2005; Trdan et al., 2006). Intercropping with commonly used vegetable crop fits into environmentally acceptable and sustainable crop production practices widely adopted by

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smallholder farmers (Kabura et al., 2008). Benefits of intercropping include; optimal use of resources, stabilization of yield, weeds and pest suppression, and higher economic returns (Blaser et al., 2007; Trdan et al., 2005; Kabura et al., 2008). The objective of this study was therefore to investigate effects of intercropping arrangements and fertilizer combinations on growth and yield of African nightshade.

MATERIALS AND METHODS

Site description

The study was conducted at KALRO, Kisii and farmer's field in Kisii County, Kenya between February 2015 and February 2016. Kisii County lies between Longitudes: 34° 46' E and Latitudes: 0° 41' S. It receives a bimodal type of rainfall with both long and short rain season having a mean of 1500mm p.a. The long rains are received between March and June with a mean of 790mm while the short rains are received between September and November with a mean of 500mm. The area experiences a maximum temperatures of 30ºC and minimum temperatures of 15ºC.The soils are well drained with red volcanic soils (nitsols) which are deep in organic matter (Soil handbook of Kenya 2000). Main economic activities of the inhabitants are crop farming, small scale trade, dairy farming, commercial businesses and soapstone carvings.

Experimental design and treatments

The experiment was laid in a randomized complete block design with three replications with a split plot arrangement replicated three times. The main plots consisted of intercropping arrangements;(i) sole African nightshade, (ii) spider plant surrounding 14 rows of African nightshade (1:14), (iii) one row of spider plant intercropped with 2 rows of African nightshade (1:2), (iv) one row of spider plant intercropped with 3 rows of African nightshade (1:3) and (v) one row of spider plant intercropped with 4 rows of African nightshade (1:4). The subplots consisted of fertilizer combinations of Farm yard manure (FYM), urea (NPK: 46-0-0) and triple super phosphate (TSP) (NPK: 0-46-0) applied as pure FYM (60 kg N ha^{-1}+ 36 kg P ha^{-1}), pure inorganic fertilizer- urea (60 kg N ha^{-1}) + TSP (40 kg P ha^{-1}), urea (30 kg N ha^{-1}) + TSP (20 kg P ha^{-1}) + FYM (30 kg N ha^{-1}+ 18 kg P ha^{-1}), urea (20 kg N ha^{-1})+ TSP (10 kg P ha^{-1}) + FYM (40 kg N ha^{-1}+ 27 kg P ha^{-1}), or urea (40 kg N ha^{-1}) + TSP (30 kg P ha^{-1}) + FYM (20 kg N ha^{-1}+ 9 kg P ha^{-1}). At planting urea and tri-superphosphate were banded together while farm yard manure was applied two weeks prior to planting at rates that depended on the treatment for each plot.

Agronomical practices

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The plots were ploughed and harrowed before planting using hand hoes. Furrows were made and five seeds of both spider plant and African nightshade (depending on the intercrop arrangement) were sown directly at a spacing of 30 cm x 15 cm and thereafter thinning was done to one plant per hill giving a total of 16 rows per plot. Hand weeding was done regularly to ease competition from weeds and the crop depended solely on rainfall.

Data collection

Five plants from each sub plot were tagged for data collection on number of branches, number of leaves and the total leaf yield. Data collection for all variables started at week five after planting and continued for a period of seven weeks when crop yields declined. The number of branches per plant was recorded by counting the number of branches from each of the five tagged plants and the mean was taken to give the average number of branches per plant while the number of leaves per plant was determined by counting fully expanded leaves from each of the five tagged plants and the mean was taken to give the average number of leaves per plant. For the total fresh leaf yield, fully expanded leaves from all the five tagged plants were harvested and weighed using an electronic weighing balance and the mean fresh leaf yield was calculated per plant and using the plant population per plot, total fresh leaf yield per plot was calculate and then converted to fresh leaf yield per hectare.

Data Analysis

Data was subjected to analysis of variance (ANOVA) using GENSTAT version 15. (Payne et al., 2011) and means were separated using Fisher's protected LSD at 5% to identify differences between treatments.

RESULTS

Number of branches

The results indicated that the fertilizer combinations had a significant (P=0.05) effect on the number of branches per plant (Table 1). Application of urea (60 kg N ha^{-1}) + triple superphosphate (40 kg P ha^{-1}) fertilizer resulted in the highest number of branches per plant (10 branches per plant) followed by fertilizer combination of urea (40 kg N ha^{-1}) + triple superphosphate (30 kg P ha^{-1}) + FYM (20 kg N ha^{-1}+ 9 kg P ha^{-1}) that recorded 9 branches per plant, urea (30 kg N ha^{-1}) + triple superphosphate (20 kg P ha^{-1}) + FYM (30 kg N ha^{-1}+ 18 kg P ha^{-1}) and urea (20 kg N ha^{-1}) + triple superphosphate (10 kg P ha^{-1}) + FYM (40 kg N ha^{-1}+ 27 kg P ha^{-1}) both of which recorded 7 branches per plant (Table 1).The application of pure FYM (60

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kg N ha^{-1}+ 36 kg P ha^{-1}) resulted in the lowest number of branches per plant (6 branches per plant) (Table 1).

Table 1: Effects of fertilizer combinations on the number of branches per plant of African nightshade (*Solanam nigrum* L)

Fertilizer Combinations	No. of branches/plant
60kgNha^{-1} urea + 40kgP/ha TSP	10a
40kgNha^{-1} urea + 30kgP/ha TSP +20kgN/ha FYM	9b
30kgNha^{-1} urea + 20kgP/ha TSP +30kgN/ha FYM	7c
20kgNha^{-1} urea + 10kgP/ha TSP +40kgN/ha FYM	7c
60kgNha^{-1} farm yard manure	6d
LSD = 0.4	

N=5. Means followed by the same letter along a column are not significantly different ($P \leq 0.05$).

Similarly, intercropping arrangement had a significant (P=0.05) effect on the number of branches per plant (Table 2). The highest number of branches per plant (9 branches per plant) was obtained when African nightshade was grown as a pure stand. However, this was not significantly different from the number of branches per plant obtained when African nightshade was grown at an intercrop ratio of 1:14 (spider plant as border rows), 1:3 and 1:4 that resulted in 8 branches per plant (Table 2). Growing of African nightshade at an intercrop ratio of 1:2 recorded significantly lower number of branches per plant (7 braches per plant). However, this was not statistically different from the number of branches per plant obtained when African nightshade was grown at intercrop ratios of 1:14, 1:3 and 1:4 (Table 2).

Table 1: Effects of intercropping arrangements on the number of branches of African nightshade (*Solanum nigrum* L.)

Intercrop row arrangement	Number of branches/plant
Sole African nightshade	9a
Spider plant: African nightshade (1:14)	8ab
Spider plant: African nightshade (1:3)	8ab
Spider plant: African nightshade (1:2)	7b
Spider plant: African nightshade (1:4)	8ab
LSD = 1.0	

N=5. Means followed by the same letter(s) along a column are not significantly different ($P \leq 0.05$).

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Number of leaves

The results indicated that there were no significant differences in number of leaves per plant between on-station and on-farm. However, the fertilizer combinations had significant (P=0.05) effect on the number of leaves per plant (Table 3). Application of urea (60 kg N ha^{-1}) + triple superphosphate (40 kg P ha^{-1}) fertilizer resulted in the highest number of leaves (32 leaves per plant). However this was not statistically different from application of urea (40 kg N ha^{-1}) + triple superphosphate (30 kg P ha^{-1}) + FYM (20 kg N ha^{-1}+ 9 kg P ha^{-1}) that resulted in 31 leaves per plant, followed by a combination of urea (30 kg N ha^{-1}) + triple superphosphate (20 kg P ha^{-1}) + FYM (30 kg N ha^{-1}+ 18 kg P ha^{-1}) that recorded 27 leaves per plant (Table 3). An application of pure FYM (60 kg N ha^{-1}+ 36 kg P ha^{-1}) resulted in the lowest number of leaves (20 leaves per plant). This was not significantly different from the number of leaves per plant that resulted from a combined application of urea (20 kg N ha^{-1}) + triple superphosphate (10 kg P ha^{-1}) + FYM (40 kg N ha^{-1} + 27 kg P ha^{-1}) (20 leaves per plant).

Table 3: Effects of fertilizer combinations on the number of leaves/plant of African nightshade (*Solanam nigrum* L)

Fertilizer Combinations	No. of leaves/plant
60kgNha^{-1} urea + 40kgP ha^{-1}TSP	32a
40kgNha^{-1} urea + 30kgPha^{-1}TSP +20kgN ha^{-1}FYM	31a
30kgNha^{-1} urea + 20kgP ha^{-1}TSP +30kgN ha^{-1}FYM	27b
20kgNha^{-1} urea + 10kgP ha^{-1}TSP +40kgN ha^{-1}FYM	21c
60kgN ha^{-1} FYM	20c
LSD = 1.82	

N=5. Means followed by the same letter along the column are not significantly different ($P \leq 0.05$).

The results further showed that intercropping arrangement had a significant (P=0.05) effect on the number of leaves per plant (Table 4). The highest number of leaves per plant (29 leaves per plant) was obtained when African nightshade was grown as a pure stand. However this was not significantly different from 27 leaves per plant that was obtained when African nightshade was grown at an intercrop ratio of 1:14 (spider plant as border rows) (Table 4). This was followed by intercrop ratios of 1:4 and 1:3 that resulted in 26 leaves and 25 leaves per plant respectively, however they were not significantly different when African nightshade was grown at an intercrop ratio of 1:14 (spider plant as border rows) (Table 4). Besides, growing African

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nightshade at an intercrop ratio of 1:2 recorded the lowest number of leaves per plant (20 leaves per plant).

Table 4: Effects of intercropping arrangements on the number of leaves per plant of African nightshade (*Solanum nigrum* L.)

Intercrop row arrangement	Number of leaves/plant
Sole African nightshade	29a
Spider plant as border rows (1:14)	27ab
Spider plant: African nightshade (1:3)	25b
Spider plant: African nightshade (1:2)	20c
Spider plant: African nightshade (1:4)	26b
LSD = 2.87	

N=5. Means followed by the same letter(s) along a column are not significantly different ($P \leq 0.05$).

Total fresh leaf yield

The results showed that there was a significant ($P=0.05$) interaction between fertilizer combinations and intercropping arrangements on total fresh leaf yield of African nightshade (Tables 5). However, there were no significant differences in total fresh leaf yield between on-station and on-farm trials. The sole African nightshade (0:16) supplied with fertilizer combination of urea (60 kg N ha^{-1}) + triple superphosphate (40 kg P ha^{-1}) resulted in the highest leaf yield (35.1 tons ha^{-1}) that was not significantly different from that obtained when African nightshade was supplied with urea (40 kg N ha^{-1}) + triple superphosphate (30 kg P ha^{-1}) + FYM (20 kg N ha^{-1}+ 9 kg P ha^{-1}) (32.5 tons ha^{-1}) at the same intercropping arrangement (Table 5).

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Table 5: Effect of intercropping arrangements and fertilizer combination on fresh leaf yield of African nightshade (*Solanum nigrum* L.)

Fertilizer combinations	Fresh Leaf Yield (tons ha^{-1})				
	Spider plant: African nightshade intercrop ratio				
	Sole ANS	1:14	1:3	1:2	1:4
60kgN/ha urea + 40kgP/ha TSP	35.1a	29.3bc	21.8ef	18.2fgh	23.8de
40kgN/ha urea + 30kgP/ha TSP +20kgN/ha FYM	32.5ab	27.3cd	21.3efg	15.9hij	23.5de
30kgN/ha urea + 20kgP/ha TSP +30kgN/ha FYM	21.7efg	17.8ghi	15hijk	11.8kl	16.4hi
20kgN/ha urea + 10kgP/ha TSP +40kgN/ha FYM	18.7fgh	17.3hi	14.ijk	10l	15.9hij
60kgN/ha farm yard manure	15.8hij	15.1hijk	12.2jkl	8.9l	9.2l
LSD=3.858**5**					

N=15. FYM-farm yard manure, TSP-Triple superphosphate. Means followed by the same letter(s) are not significantly different (P≤0.05).

This was followed by an intercrop ratio of 1:14 (spider plant grown on the border rows) supplied with either urea (60kg N ha^{-1}) + triple superphosphate (40kg P ha^{-1}) that produced 29.3 tons ha^{-1} or supplied with urea (40kg N ha^{-1}) + triple superphosphate (30kg P ha^{-1}) + FYM (20kg N ha^{-1}+ 9 kg ha^{-1}) that produced 27.3 tons ha^{-1}. A further increase in the plant population of spider plant and/or the amount of FYM used in the production resulted in significantly (P=0.05) lower total fresh leaf yield (Table 5). Growing of African nightshade at an intercrop ratio of 1:2 supplied with pure FYM (60 kg N ha^{-1}+ 36 kg P ha^{-1}) resulted in the lowest fresh leaf yield (8.9 tons ha^{-1}) however this was not significantly different from 1:3 and 1:4 intercrop ratios with the same fertilizer combinations that recorded 12.2 tons ha^{-1} and 9.2 tons ha^{-1} respectively (Table 5). In addition, intercrop ratios of 1:3 and 1:4 did not differ significantly across the fertilizer combinations.

DISCUSSION

Treatments with higher rates of inorganic fertilizer resulted in higher number of branches per plant compared to treatments with pure farm yard manure. The nitrogen and phosphorous from the inorganic fertilizer have been shown to be readily available for plant uptake compared to that supplied by farm yard manure (Powlsen et al. 2014). Nitrogen is an essential element and important determinant in growth and development of vegetables. It plays an important role in chlorophyll, protein, nucleic acid, hormone and vitamin synthesis and also helps in cell division

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and cell elongation hence facilitates more shoot formation (Miller, 2010). Adequate supply of phosphorus early in plant life is important in laying down the primordial for plant growth. It is also an essential constituent of majority of enzymes which are responsible in the transformation of energy in carbohydrate metabolism, fat metabolism and also in respiration that stimulates shoot formation in vegetables (Fink et al. 1999). Therefore with synergetic influence of nitrogen and phosphorus, there is a possibility of more photosynthates being allocated for new branch formation. This therefore can be attributed to the high number of branches recorded in this study when combination of urea (40 kg N ha^{-1}) + triple superphosphate (30 kg P ha^{-1}) or urea (40 kg N ha^{-1}) + triple superphosphate (30 kg P ha^{-1}) + FYM (20 kg N ha^{-1}+ 9 kg P ha^{-1}) fertilizer was applied. Gambo *et al*., (2008) working with onion; Babajide *et al*., (2008) working with tomato and Ouda and Mahadeen, (2008) working with broccoli reported that the use of pure farm yard manure results in reduced number of branches while incorporation `of organic and inorganic fertilizers results in more branches per plant. Similarly, Kipkosgei et al. (2003) working on fertilizer application on African nightshade reported that a combination of farm yard manure and inorganic fertilizer in which, the percentage of the inorganic fertilizer is higher than that of the organic fertilizer increases the number of branches produced per plant.

In addition, intercropping arrangements significantly influenced the number of branches of African nightshade. The sole African nightshade obtained higher number of branches compared to all other intercrop ratios. This could be due to below and above ground competition between spider plant and African nightshade for available soil nutrients, space, light and CO_2. It could be possible that there was completion of available nutrients by the two crops and reduced number of branches of African nightshade per plant. Besides, plant architecture plays an important role for shoot in intercropping arrangements (Liu *et al.* 2010). Spider plant and African nightshade have different architecture and growth habits which could be the reason for decreased number of branches compared to sole African nightshade. These results agree with those of Schnieders (1999) working with *Solanum nigrum* intercropped with Witloof chicory who showed that African nightshade at a ratio of witloof chicory: *Solanum nigrum* (1:2) produces fewer number of branches per plant compared to the respective mono crops.

Treatments with higher rates of inorganic fertilizer resulted in higher number of leaves per plant compared to treatments with pure farm yard manure. Nitrogen is an essential element required for successful plant growth. Application of inorganic and farm yard manure increases the nitrogen, phosphorus, and potassium content in soil (Ginting et al. 2003; Watts et al. 2010). These nutrients are essential constituents of majority of enzymes which are responsible in the transformation of energy in carbohydrate metabolism, fat metabolism and also in respiration that stimulates leave formation in vegetables (Fink et al. 1999). Besides, phosphorous is a constituent of nucleic acid, phytins and phospholipids (Ndakemi and Dakora, 2007). Research has also been

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shown that there exists a synergetic effect of inorganic fertilizers and farm yard manure in facilitating new leaf formation. This therefore can be attributed to the high number of leaves recorded in this study when combination of urea (40 kg N ha^{-1}) + triple superphosphate (30 kg P ha^{-1}) or urea (40 kg N ha^{-1}) + triple superphosphate (30 kg P ha^{-1}) + FYM (20 kg N ha^{-1}+ 9 kg P ha^{-1}) fertilizer was applied. Makinde et al. (2013) working on amaranths, reported that inorganic fertilizer results in a high number of leaves per plant, however, a combination of inorganic fertilizer and organic fertilizer at the ratio of 2:1 (inorganic: organic) for the supply of nitrogen in this study resulted in number of leaves per plant that was not significantly different from that obtained when pure inorganic fertilizer was used. The complementary application of organic and inorganic fertilizers has been found to meet the immediate soil nutrient deficits, improve the soil physical properties and enhance yield stability (Aluko *et al.* 2014).

Further, intercropping arrangements significantly influenced the number of leaves of African nightshade. The sole African nightshade and 1:14 intercrop ratio obtained higher number of branches compared to other intercrop ratios. This could be attributed to below and above ground competition for light, nutrients, space and CO_2. However, growth synchronies as well as canopy design could be also the main mechanisms that contributed to this intercropping performance. These results agree with the findings of Santos et al. (2002) working on broccoli, who reported that intercropping broccoli with cauliflower results in reduced number of leaves compared to mono crops. Besides, Matusso et al. (2014) working with soybean -maize intercrop reported that maize mono crop intercepted more light and hence higher number of leaves and leaf index area. However it has been reported that a greater yield advantage can be realized when the component crops have complementary growth patterns in terms of growth rate, maturity, and plant architecture (Ghosh et al., 2006).

Intercropping arrangements and fertilizer combinations greatly influenced the total fresh leaf yield. During growth and development, vegetable plants intercept and absorb light, water and nutrients and use them to produce biomass (Mohamed *et al.* 2007). Part of this biomass is the harvestable yield. The factors that affect growth are distributed in space and time. Complementary and supplementary relations between crops determine the magnitude of intercrop competition (Ofori and Gamedoaghao, 2005). Farm yard manure is a slow release of soil nutrients for plant uptake; however the residual benefits of farm yard manure on the soil physical and biological properties cannot be under estimated. In this study, African nightshade as pure stand supplied with either urea (60 kg N ha^{-1}) + triple superphosphate (40 kg P ha^{-1}) or urea (40 kg N ha^{-1}) + triple superphosphate (30 kg P ha^{-1}) + FYM (20 kg N ha^{-1}+ 9 kg P ha^{-1}) recorded the highest total fresh leaf yield. However, intercrops with more rows of spider plant across fertilizer combinations recorded low yields compared to sole African nightshade. This could be attributed to competition for available nutrient base, CO_2 and light interception. These results

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agree with those of Mohamed et al., (2007) working on okra, who reported that intercropping okra with cucumber significantly reduces the fruit yield of cucumber compared to the respective mono crops. In addition, Kipkosgei et al., (2003) working on African nightshade reported that synergetic effect of inorganic and organic fertilizer increases African nightshade leaf yields. Further, Mahadeem and Ouda (2008) working on broccoli, reported that inorganic fertilizer produces the highest yields compared to the corresponding amounts of organic manure, however combined fertilizer application produces comparably higher yields as pure inorganic fertilizer. Similarly, low yields exhibited in 1:2, 1:3 and 1:4 intercrop row ratios when supplied with only farm yard manure as compared to sole African nightshade could be associated with inter-specific competition for nutrients, moisture space and slow mineralization rate of farm yard manure (Adani et al., 2007). Further, Olufajo (1992) reported that shading by taller plants in intercrops reduce the photosynthetic rate of the lower growing plants and thereby reduce their yields. However it was noted that farmers can use pure farm yard manure over a fertilizer combination of urea (20 kg N ha^{-1}) + triple superphosphate (10 kg P ha^{-1}) + FYM (40 kg N ha^{-1}+ 27 kg P ha^{-1}) across intercropping arrangements to cut extra cost of production as there was no yield advantage gained at this fertilizer combination rates. Even though there was no yield benefits exhibited in African nightshade after intercropping with spider plant, there is a possibility that the combined yield obtained from different spider plant: African nightshade intercropping system for both vegetables could be greater than for the mono-cropped African nightshade. In addition, 1:4 and 1:3 intercrop ratios may be more important to the farmer in terms of income diversification and diversity in crops available for both food and nutrition needs when compared to sole African.

CONCLUSIONS

The fertilizer combinations and intercropping arrangements influenced the growth and yield of African nightshade. An application of Urea (40 kg N ha^{-1}) + triple superphosphate (30 kg P ha^{-1}) recording a high number of branches and leaves per plant that was comparable to when Urea (40 kg N ha^{-1}) + triple superphosphate (30 kg P ha^{-1}) + FYM (20 kg N ha^{-1}+ 9 kg P ha^{-1}) was used. Intercropping arrangements reduced the number of branches and leaves compared to sole African nightshade. Further, high total fresh leaf yield was produced when sole African nightshade and, intercropping of Spider plant and African nightshade at a ratio of 1:14 (spider plant as border rows) supplied with either Urea (40 kg N ha^{-1}) + triple superphosphate (30 kg P ha^{-1}) or Urea (40 kg N ha^{-1}) + triple superphosphate (30 kg P ha^{-1}) + FYM (20 kg N ha^{-1}+ 9 kg P ha^{-1}) was used in the production of the vegetable.

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REFERENCES

Abukutsa-Onyango MO (2003) Unexploited potential of indigenous African indigenous vegetables in Western Kenya. Maseno Journal of Education, Arts and Science; 4:103-122.

Abukutsa-Onyango MO (2004) Crotalaria brevidens Benth. In: GJH Grubben, & Denton, OA (Eds). Plant Resources of Tropical Africa 2.Vegetables. PROTA Foundation, Wageningen, Netherlands/Backhuys Publishers, Leiden, Netherlands/CTA, Wageningen, Netherlands:229-231.

Adani F, Genevini P, Ricca G, Tambone F, Montoneri E (2007) Modification of soil humic matter after 4 years of compost application. Waste Manage 27: 319–324. doi: 10.1016/j.wasman. 2006.04.004

Adebooye O. C. and Opabote J. T. (2004) Status of conservation of the indigenous leaf vegetables and fruits of Africa. African Journal of Biotechnology 3, 700-705

Aluko et al (2014) Effects of inorganic and organic fertilizer on jute fluke. Vol.2,No.3,pp.1-9, September 2014

Babajide P.A., Olabode O.S., Akanbi W.B., Olatunji O.O and Ewetola E.A. (2008) Influence of composted Tithonia-biomass and N-mineral fertilizer on soil physico-chemical properties and performance of tomato (*Lycopersican lycopersicum*). Research Journal of Agronomy*,* 2(4): 101-106

Blaser B.C., Singer J.W. and Gibson L.R. (2007). Winter cereal, seeding rate and intercrop seeding rate effect on red clover yield and quality. Agron. J., 99: 723-729.

Fink M., Feller C. and Scharpf H.C. (1999) Nitrogen, phosphorus, potassium and magnesium contents of field vegetables – Recent data for fertilizer recommendations and nutrient balances. Journal of Plant Nutrition and Soil Science, 162, 71–73

Gambo B. A., Magaji M.D., Yakubu A.I and Dikko A.U. (2008) Effects of Farmyard manure, nitrogen and weed interference on the growth and yield of onion (*Allium cepa* L.) at the Sokoto Rima valley. Journal of Sustainable development in Agriculture and Environment*,* 3(2): 87-92.

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Ghosh P. K., Mohanty M., Bandyopadhyay K. K., Painuli D. K. and Misra A. K. (2006) Growth, competition, yield advantage and economics in soybean/pigeonpea intercropping system in semi-arid tropics of India: I. Effect of subsoiling. Field CropRsch. 96:80-89

Ginting D., Kessavalou A., Eghball B., Doran J.W. (2003) Greenhouse gas emissions and soil indicators four years after manure compost applications. J. Environ. Qual.32:23–32. doi: 10.2134/jeq2003.2300.

Hassan M.K., Chowdhury B.L.D. and Akhther N. (2010) Final Report- Postharvest Loss Assessment: A Study to Formulate Policy for Loss Reduction of Fruits and Vegetables and Socio-Economic Uplift of the Stakeholders, Department of Horticulture, Bangladesh Agricultural University, Mymensingh (Funded by USAID and EU & Jointly implemented by FAO and FPMU of MoFDM). p. 189

Kabura B.H., Musa B. and Odo P.E. (2008) Evaluation of the yield components and yield of onion (*Allium cepa* L.)- pepper (*Capsicum annum* L.) intercrop in the Sudan savanna. J. Agron., 7: 88-92.

Kipkosgei L.K., Akundabweni L.S. and Hutchinson M.J. (2003) The effect of farmyard manure and nitrogen fertilizer on vegetative growth, leaf yield and quality attributes of *Solanum villosum* (Black nightshade) in Keiyo district, rift valley. African Crop Science Conference Proceedings, 6: 514-518.

Liu B., Liu XB., Wang C., Jin J., Harbert S.J. and Hashemi M. (2010) Response of soybean yield and yield components to light enrichment and planting density. International Journal of Plant Production, 4 (1): 1-10.

Makinde E.A. and Ayoola O.T. (2008) Residual Influence of early season crop fertilization and cropping system on growth and yield of Cassava. American Journal of Agricultural and Biological Science 3: 712-715.

Matusso J.M.M., Mugwe J.N., Mucheru-Muna M. (2014) Potential role of cereal-legume intercropping systems in integrated soil fertility management in smallholder farming systems of sub-Saharan Africa. Res. J. Agric. Environ. Manage. 3(3): 162-174.

Mohamed F.M., Mohamed H.D., Mousa A.A and Emad-Elden F. (2007) Yield of Crops in Within-Row Intercropped Okra-Cowpea or Okra-Cucumber, International Journal of Vegetable Science,13:2, 33-48, DOI: 10.1300/J512v13n02_04

Mwai G.N, and Schippers R.R. (2004) Solanum tarderemotum Bitter. In: Grubben GJH, Denton OA (Eds) Plant Resources of Tropical Africa 2. Vegetables, PROTA Foundation, Wageningen,

 Copyright © IJAER 2016, All right reserved

Netherlands/ Backhuys Publishers, Leiden, Netherlands/ CTA, Wageningen, The Netherlands, pp 498-501

Netondo G.W., Fuchaka W., Maina L., Naisiko T., Masayi N., Gaira J.K. (2010) Agro-biodiversity endangered by sugarcane farming in Mumias and Nzoia Sugar belts of Western Kenya. Afr.J. Environ. Sci. Technol. 4:437-445.

Obuoyo J.A. (2005) The role of traditional crops in promoting food security in the dry Siaya district, Kenya. MA thesis, Maseno University,Kenya.

Olufajo O.O. (1992) Response of soybean to intercropping with maize in a subhumid tropical environment.Trop. Oil seeds J. 1:27-33.

Ofori K. and Gamedoaghao D.K. (2005) Yield of scarlet eggplant (Solanumaethiopicum L.) as influenced by planting date of companion cowpea. ScientiaHorticalture105: 305-312.

Mahadeem A.Y. and Ouda B.A., (2008) Effect of fertilizers on growth, yield, yield components, quality and certain nutrient contents in broccoli (*Brassica oleracea*). International Journal of Agriculture and biology, 10(6): 627-632.

Payne R.W., Harding S.A., Murray D.A., Soutar D.M., Baird D.B., Glaser A.I., Welham S.J., Gilmour A.R., Thompson R., and Webster R. (2011) *GenStat Release 14 Reference Manual, Part 2 Directives*. VSN International, Hemel Hempstead, UK.

Powlsen D.S., MacDonald A.J., Poulton P.R. (2014) The continuing value of long-term field experiments: Insights for achieving food security and environmental integrity. In: Dent D (ed) Soil as world heritage. Springer, Dordrecht, pp 131–157. doi:10.1007/978-94-007-6187-2_16

Santos H.S., Gliessman R. and Cecon R. (2002) Crop Interactions in Broccoli Intercropping, Biological Agriculture & Horticulture, 20:1, 51-75, DOI:10.1080/01448765.2002.9754948.

Schippers R.R. (2002) African indigenous vegetables and overview of the cultivated species. Chatham, UK. Natural Resources Institute /ACP-EU Technical Centre for Agricultural and rural Cooperation.

Schnieders B.J. (1999) A quantitative analysis of inter-specific competition in crops with a row structure. PhD Thesis, Agricultural UniversityWageningen, The Netherlands

Sikora R.A. and Fernandez E. (2005) Nematode Parasites of Vegetables. In: Plant Parasitic Nematodes in Subtropical and Tropical Agriculture. Luc M, Sikora RA, Bridge J (Editors) 2nd Edition, CABI Wallingford, UK. pp 319-392.

 Copyright © IJAER 2016, All right reserved

ISSN: 2455-6939

Volume:02, Issue:05

Soil fertility management handbook for extension staff and farmers in Kenya (2000)

Trdan S., Znidar D., Vali N., Rozman L. and Vidrih M. (2006) Intercropping against onion thrips, *Thrips tabaci* Lindeman (Thysanoptera: Thripidae) in onion production: On the suitability of orchard grass, lacy phacelia and buckwheat as alternatives for white clover. J. Plant Dis. Protect., 113: 24-30.

Trdan S., Milevoj L., ZeZlina I., Raspudic E. and Andjus L. (2005) Feeding damage by onion thrips, *Thrips tabaci* Lindeman (Thysanoptera: Thripidae), on early white cabbage grown under insecticide-free conditions. Afr. Entomol., 13: 85-95

Watts D.B., Torbert H.A., Prior S.A., Huluka G. (2010) Long-term tillage and poultry litter impacts soil carbon and nitrogen mineralization and fertility. Soil Sci. Soc. Amer. J. 74:1239–1247. doi: 10.2136/sssaj2008.0415.doi:10.1371/journal.pone.0062173

Yang R.Y. and Keding G.B. (2009) Nutritional contributions of important African indigenous vegetables: African indigenous vegetables in urban agricul-ture.(Shackleton C.M., Pasquini M.W., Drescher A.W., eds.) London, Earthscan, pp.:105-143.

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