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FIELD PERFORMANCE OF SPIDER PLANT (*CLEOME GYNANDRA L*) UNDER DIFFERENT AGRONOMIC PRACTICES

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ABSTRACT

Field experiments were carried out at Kaguvi Vocational Training Centre located in the Midlands province of Zimbabwe, to determine the effect of planting date and fertilizer types in enhancing the productivity of spider plant, an indigenous leafy vegetable. The experimental design was a split- plot arranged in a randomized complete block design (RCBD) with three blocks. The planting date was the main plot with three levels (15/10/12, 30/01/13 and 15/02/13) and the fertilizer treatments as the subplots with seven levels including a control (no fertilizer applied), 20 t/ha cattle manure, 30 t/ha cattle manure, 5 t/ha poultry manure, 10 t/ha poultry manure, 300 kg/ha Compound D + 100 kg/ha ammonium nitrate and 300 kg/ha Compound D + 150 kg/ha ammonium nitrate). Growth parameters, vitamin A and C, crude protein, iron content, fresh and dry yield were significantly ($p<0.05$) increased by use of organic and inorganic fertilizers across all planting dates compared to the control where no fertilizers were added. The October 2012 planting date, combined with high rates of organic and inorganic fertilizers had the best response with regards to the variables measured, including the duration of the harvest period which was nine weeks, compared to the January and February planting dates where harvesting was for six weeks. The inorganic fertilizers provided readily available nutrients for uptake by the plants while the long production period for the October 2012 planting date enabled the organic manures (cattle and poultry manure) adequate time to release the nutrients for uptake, compared to the January 2013 and February 2013 planting dates. It can be concluded that there is merit in staggering the planting dates while using organic and inorganic fertilizers as the practice results in an extended harvest period. High rates of both inorganic and organic fertilizers are recommended for the different planting dates as follows; 30 t/ha cattle manure, 10 t/ha poultry manure, 300 kg/ha Compound D + 100 kg/ha ammonium nitrate and 300 kg/ha Compound D + 150 kg/ha ammonium nitrate.

Key words: Indigenous vegetable, spider plant, planting dates, fertilizers, nutrients

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INTRODUCTION

Spider plant (*Cleome gynandra* L) is an indigenous leafy vegetable, which has been widely consumed by the majority of the rural population in Zimbabwe. About 90 % of the rural population lives in arid regions and relies on indigenous leafy vegetables for relish in Zimbabwe [1]. Spider plant is ranked second amongst the top five indigenous leafy vegetables consumed as relish which include, *Amaranthus blitum* (pigweed), *Solanum scabrum* (nightshade), *Corchorus olitorius* (jute mallow) and *Vigna unguiculata* (cowpea) [2].

Studies have shown that 43 % of the population in sub-Saharan Africa suffers from chronic food shortages and deficiencies of essential nutrients such as iron, vitamin A and iodine [3]. Besides being a source of relish, fresh spider plant is rich in proteins, vitamins, carbohydrates and minerals which are lacking in most leafy vegetables [4]. Consumption of spider plant has been shown to have medicinal benefits. It also contains a lot of phenol compounds which can be used to cure diseases such as cancer, asthma, diabetes and cardio-vascular diseases [5]. The plant, which has been associated with insecticidal properties, is also a source of edible oil and livestock feed and is an ingredient in the manufacture of detergents [6, 7].

In addition to being a multipurpose plant, spider plant can be produced for sale and has the potential to generate income for rural communities in summer [8]. There is also evidence of substantial trading of spider plant in urban markets like Bulawayo, Harare and Mutare in Zimbabwe [8, 9].

Spider plant is hardy and well adapted to hot and dry conditions and grows well in summer from November to February in Zimbabwe [6, 10]. Despite these adaptations, harvesting of the fresh leaves lasts for four to five weeks during summer due to its short vegetative cycle while the flowering period lasts for two to three months [2]. This presents a problem for the farmers as the preferred fresh leaf is only available for a short time. Farmers often obtain low yields due to low use of fertilizers which are often not available, or if available are used on major cash crops like maize, tobacco and cotton at the expense of spider plant which is regarded as a minor crop. In Kenya, the application of nitrogen has been shown to increase fresh and dry above-ground biomass in leafy vegetables [11]. In Zimbabwe, research on spider plant has revealed that it responds well to organic manure and inorganic fertilizers [10].

With this in mind, the effect of varying the planting dates and incorporation of fertilizers was investigated in a quest to improve yield and extend the harvesting period. There is no published literature to support staggering the planting dates with the use of both organic and inorganic fertilizers. In addition, different types of fertilizers offer different benefits in terms of costs and utilization hence the need to evaluate the yield performance of spider plant under these conditions. Fresh spider plant is reportedly rich in nutrients such as proteins (3.1 - 7.7 % per100g, vitamins (127 – 484 mg / 100g) carbohydrates (4.4 % / 100g) and minerals like iron (1-11mg / 100g) [4, 12]. The nutrient composition of the spider plant will also be of importance under the proposed production conditions. Varying planting dates for spider plant becomes an important

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strategy in times of drought as climate change threatens food security in Zimbabwe and Southern Africa as a whole. The main objective of the study, therefore, was to establish the effect of planting date in combination with fertilizer (organic and inorganic) on fresh and dry weight of harvested leaves and the length of the harvest period of spider plant during the summer season in Zimbabwe. The success of this study will help to ensure improved yields and a constant supply of the leafy vegetable that will help reduce the relish gap just before and during the summer period.

MATERIAL AND METHODS

Research Site Location and Characteristics

The study was carried out at Kaguvi Vocational Training Centre which is located between latitude 19° 28'S and longitude 29° 45' E. The altitude is 1200 m above sea level and with a temperature range between 20°C and 30°C. The centre is in the Gweru District of the Midlands Province, in agro-ecological zone III of Zimbabwe. The area consists of heavy textured red soils and some brown soils. Rainfall ranges from 650 – 750 mm per annum and is not evenly distributed. Mixed farming is practiced in this area because of inadequate rainfall.

Spider Plant Seed and Fertilizers

Spider plant seeds were collected from Chiwundura communal area, which has the same agro-ecological characteristics with Kaguvi Vocational Training Centre in the Midlands province. The inorganic fertilizers used were Compound D (7 % N, 14 % P_2O_5, and 7 % K_2O) which was used as the basal application and ammonium nitrate (34.5% N) which was used as the top dressing. The organic fertilizers were cattle and poultry manure. The organic basal application was dry manure while for the top dressing, the manures were soaked in water (1 kg manure: 2 ½ litres of water) overnight and applied in liquid form. Cattle manure was collected from Kaguvi Vocational Training Centre pens where cattle were housed in the evening after grazing throughout the day. The manure is similar to that found in communal areas since there is no supplementary feeding. The poultry manure was collected from poultry runs in the nearby community.

Soil Tests and Nutrient Analysis for Organic Fertilizers

The soil was tested for pH and nutrient status to enable the calculation and determination of fertilizer rates to apply. The nutrient content for both cattle and poultry manure were also analyzed at the University of Zimbabwe Soil Science Laboratory before the trial was conducted. The rates used for application of the fertilizers per treatment were as follows: Cattle manure: 20 - 30 t / ha, Poultry manure: 10 - 15 t / ha, Compound D: 300 kg / ha and ammonium nitrate: 100 - 150 kg / ha [2, 12, 13].

Trial Management

Three planting dates (15 October 2012, 30 January 2013 and 15 February 2013) were used for the trial. The spider plant crop planted in October was irrigated before the start of the rain season while supplementary irrigation was applied during the dry periods. Seeds were drilled into the soil using a spacing of 30 cm apart and thinning was done to

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a spacing of 20 cm within three - four weeks after crop emergence (WACE). Plot size was 4 m^2. Only two thirds of the inorganic fertilizer was applied before planting as a basal dressing while a third was applied as topdressing. The ammonium nitrate was applied after every leaf harvest. The weather data (rainfall, temperature and sunshine duration) for the production period were also recorded.

Experimental Design

The experimental design used was a split plot arranged in a randomized complete block design (RCBD) with three blocks. Planting date was the main plot with three levels: (15 October 2012, 30 January 2013 and 15 February 2013) and the fertilizers were the subplots with seven levels including a control: (no fertilizers applied, 20 t/ha cattle manure, 30 t/ha cattle manure, 5 t/ha poultry manure, 10 t/ha poultry manure, 300 kg/ha Compound D + 100 kg/ha ammonium nitrate and 300 kg/ha Compound D + 150 kg/ha ammonium nitrate).

Data Collection

Growth and Yield

Data were collected every two weeks for the following: plant height, leaf area (using a LI 3000 leaf area meter (LI-COR Inc., Lincoln, USA) and fresh and dry weight of the harvested leaves. Data presented are those which were collected in the final week before harvesting commenced. The length of the harvest period was calculated from the first day of harvest of the tender leaves four weeks after seedling emergence before the onset of flowering.

Nutrient analysis of harvested leaves

Nutritional analysis of the harvested leaves was carried out for protein content using the Kjeldahl method [14]. The Atomic Absorption Spectrophotometer (AAS) was used to analyze the calcium and iron contents. Vitamin C content was determined using the Calorimetric determination method based on ascorbic acid standards according to the Association of Official Analytical Chemists International (AOAC) [15]. For vitamin A, the method used was based on extracting β carotene by hexane as the solvent. Standards of β - carotene were prepared and colour intensity was measured on UV-VIS Spectrophotometer at a wavelength of 450 nm. An absorbance concentration curve was then plotted after treating samples as per standard and peak colour wavelength was scanned. Sample concentration was extrapolated by comparing with standards on the UV-VIS type GBC UV-VIS 916 AOAC [14, 15,16].

Analysis of Data

The data were subjected to analysis of variance (ANOVA) using Genstat 14 and means were separated using Fisher's LSD at 0.05 significance level.

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RESULTS

Weather data for the production period

The total rainfall for the production period was 359 mm. January 2013 had the highest rainfall total (175 mm) while November had the lowest rainfall total of 8 mm (Figure 1a). Maximum temperature was recorded in October 2012 (29.9^{o}C) while the lowest temperature of 9^{o}C was recorded in May (Figure 1b). The highest sunshine duration of 9 hours was recorded in October and November (2012), and January and February (2013). The lowest sunshine duration of 7.8 hours was recorded in May 2013 (Figure 1c.).

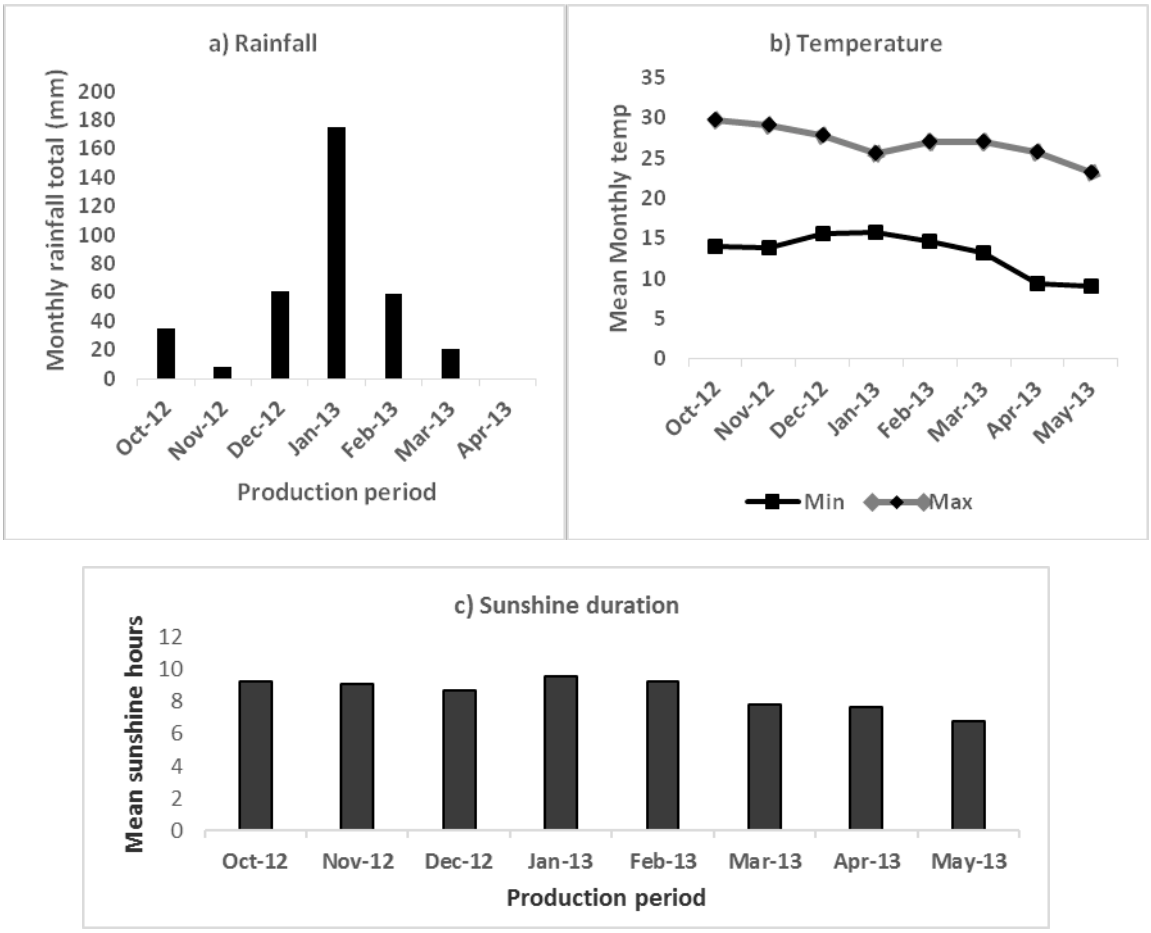

Figure 1: **a) Monthly rainfall total,**
b) Mean maximum and minimum temperatures
c) Mean monthly sunshine duration recorded at Kaguvi Training Centre from October
Source: [17]

Results of the nutrient analysis of the manures

The poultry manure had higher nitrogen and zinc contents than the cattle manure (Table 1).

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Plant height

The planting date and fertilizer treatment interaction on plant height was significant ($P < 0.05$). The fertilizer treatments and the control showed an increase in plant height ranging from 126.1 – 140 cm for the October and February planting dates, indicating higher plant growth vigour compared to the January planting date, which was significantly lower at 86.1 cm for the control at 12 WACE (Figure 2).

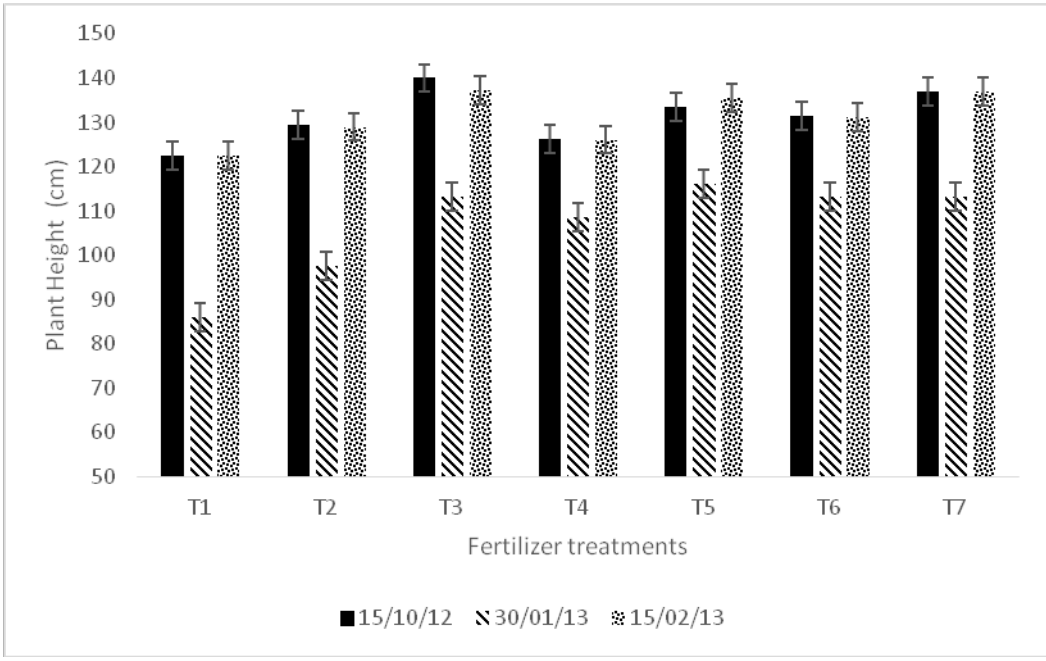

Figure 2: Interaction of planting dates and fertilizer treatments on plant height of spider plant, indicating higher plant growth vigour. Error bars = SED values

Key: T1 - *Control (no fertilizer applied), T2 - 20t/ha cattle manure, T3 - 30t/ha cattle manure, T4 - 5t/ha poultry manure, T5 - 10t/ha poultry manure, T6 - 300kg/ha Compound D + 100kg/ha ammonium nitrate and T7- 300kg/ha Compound D + 150kg/ha ammonium nitrate).*

Leaf area

The effect of planting date on leaf area was significant ($P < 0.05$). The October and January planting dates had significantly larger leaf areas (94 – 96 cm^2) compared to the February planting date which had a smaller leaf area of 66 cm^2. The effect of fertilizer treatment on leaf size was significant ($P < 0.05$). The fertilizers (both organic and inorganic) resulted in larger leaf sizes ranging from 84.2 - 87.8 cm^2 and were not significantly different from each other compared to the control, which had a smaller leaf size of 80.5 cm^2 (Figure 3).

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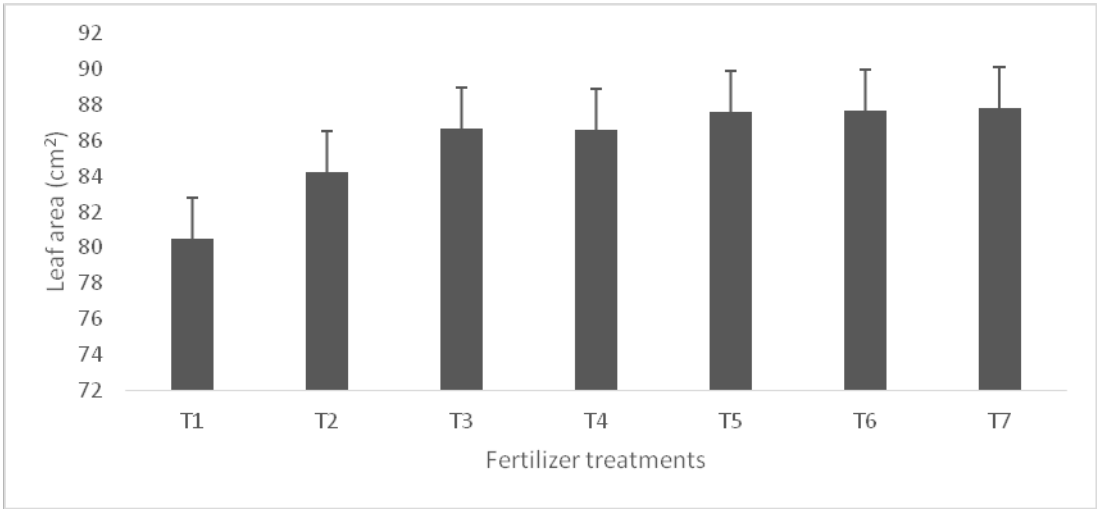

Figure 3: Effect of fertilizer treatments on leaf area of spider plant. (Error bars = SED value)

Key: *T1 - Control (no fertilizer applied), T2 - 20t/ha cattle manure, T3 - 30t/ha cattle manure, T4 - 5t/ha poultry manure, T5 - 10t/ha poultry manure, T6 - 300kg/ha Compound D + 100kg/ha ammonium nitrate and T7- 300kg/ha Compound D + 150kg/ha ammonium nitrate)*

Effect of planting dates and fertilizers on the nutrient content of freshly harvested leaves

Calcium and Iron

The planting dates and fertilizer treatments had no significant effect on the calcium content of the harvested fresh leaves. The different planting dates had a significant ($P < 0.05$) effect on the iron content of harvested spider plant leaves. Planting early (15/10/12) resulted in a high iron content of 1255 ppm compared to the January (30/01/2013) and February dates in (15/02/13) with a lower iron content of 471 ppm and 376 ppm, respectively, which were not significantly different (Table 2).

Crude protein

The crude protein content of the harvested leaves was significantly ($P < 0.05$) affected by the planting dates while the fertilizer treatments did not have a significant effect on the crude protein content (Figure 4). The planting date and fertilizer treatment interaction was significant ($P < 0.05$). Planting early in October resulted in significantly higher crude protein content for all the treatments and the control (Figure 4). A noticeable trend was the decline in the crude protein content as the planting date was delayed during the production period (Figure 4). The highest crude protein content (46.65 %) was obtained for the October 2012 planting date using the 300 kg/ha Compound D + ammonium nitrate treatment while the lowest (28.45 %) was from the control planted in January and February 2013 (Figure 4). The control had the lowest crude protein content for January and February 2013 planting dates.

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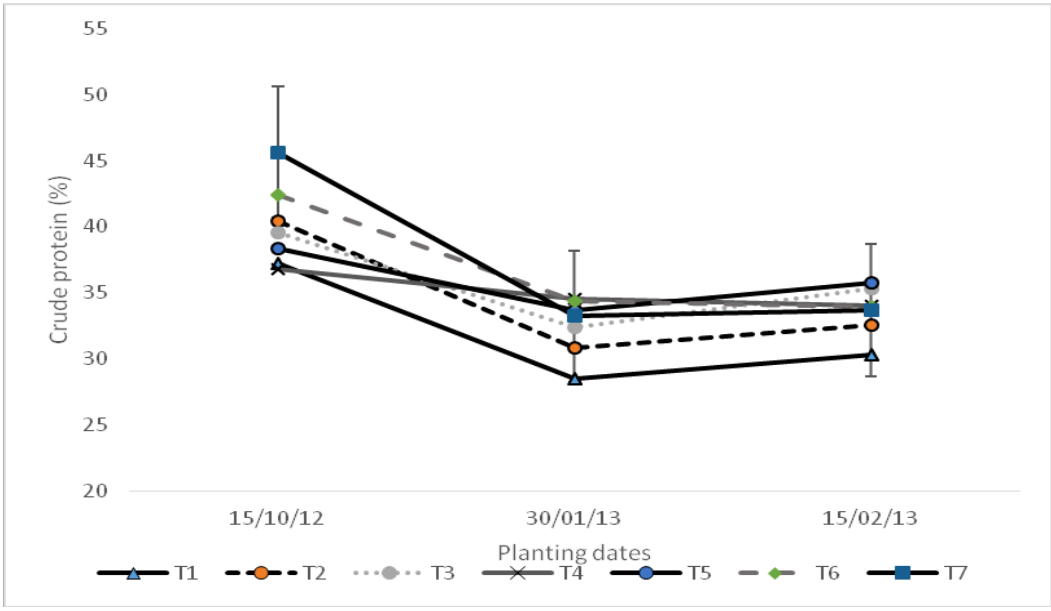

Figure 4: Interaction between planting date and fertilizer treatments on crude protein content of harvested leaves. (Error bars = SED value)

Key*: T1 - Control (no fertilizer applied), T2 - 20t/ha cattle manure, T3 - 30t/ha cattle manure, T4 - 5t/ha poultry manure, T5 - 10t/ha poultry manure, T6 - 300kg/ha Compound D + 100kg/ha ammonium nitrate and T7- 300kg/ha Compound D + 150kg/ha ammonium nitrate)*

Vitamin A and C

The planting dates and the fertilizer treatments had a significant ($P < 0.05$) effect on the vitamin A content of the harvested leaves. The significant ($P < 0.05$) planting date and fertilizer interaction resulted in a positive response (44 – 48 % range increase) where the vitamin A content was significantly higher for all the fertilizer treatments (both inorganic and organic) compared to the control which was significantly lower for all planting dates (Figure 5).

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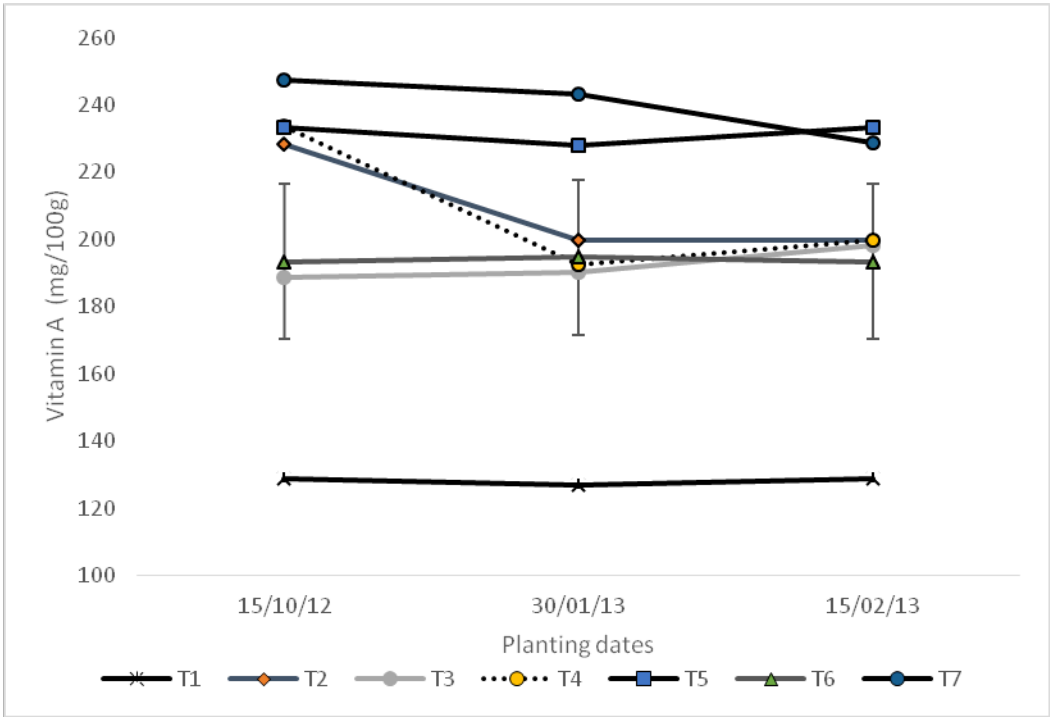

Figure 5: Interaction between planting date and fertilizer treatments on the Vitamin A content of harvested leaves (Error bars = SED value)

Key: *T1 - Control (no fertilizer applied), T2 - 20t/ha cattle manure, T3 - 30t/ha cattle manure, T4 - 5t/ha poultry manure, T5 - 10t/ha poultry manure, T6 - 300kg/ha Compound D + 100kg/ha ammonium nitrate and T7- 300kg/ha Compound D + 150kg/ha ammonium nitrate)*

The effect of planting date and fertilizer treatment on vitamin C content was also significant ($P < 0.05$). The planting date and fertilizer treatment interaction showed a higher vitamin C content as the rates of fertilizers (for both organic and inorganic) were increased. A 59 – 67 % increase was achieved with the higher fertilizer rates for the October 2012 planting date compared to the January and February 2013 planting dates. The interaction also resulted in a significant decline in vitamin C content when spider plant was planted in January and February compared to the earlier October 2012 planting date (Figure 6). The use of the inorganic and organic fertilizer treatments resulted in vitamin C content values, which were not significantly different to the control as planting dates were delayed (Figure 6).

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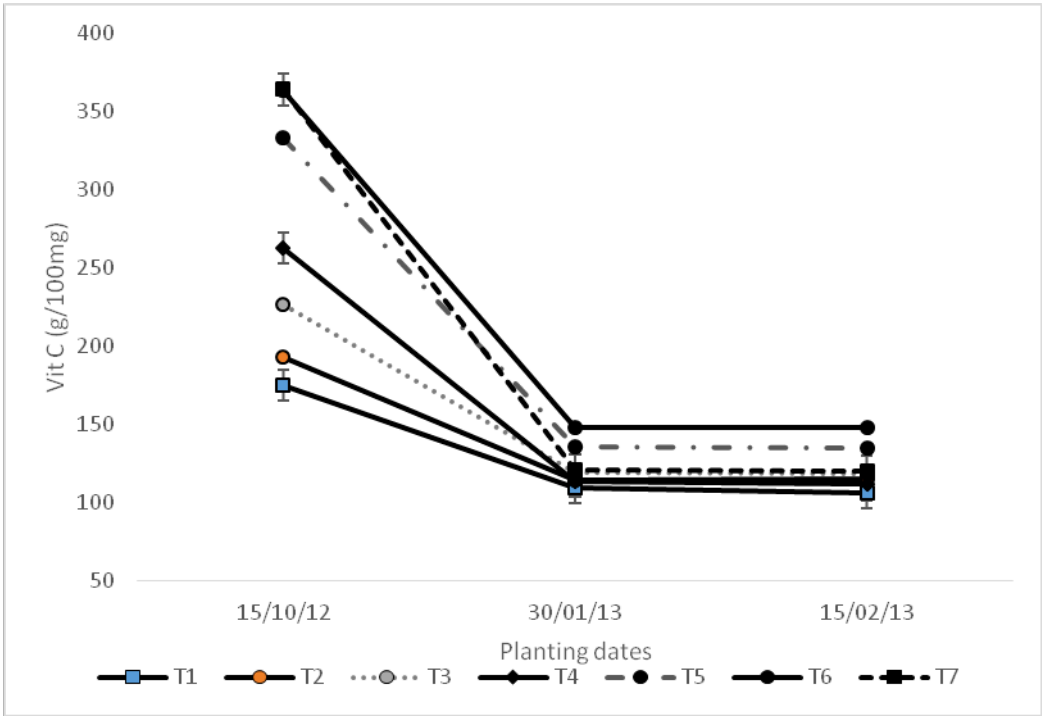

Figure 6: Interaction between planting date and fertilizer treatments on the vitamin C content of harvested leaves (Error bars = SED value

Key: *T1 - Control (no fertilizer applied), T2 - 20t/ha cattle manure, T3 - 30t/ha cattle manure, T4 - 5t/ha poultry manure, T5 - 10t/ha poultry manure, T6 - 300kg/ha Compound D + 100kg/ha ammonium nitrate and T7- 300kg/ha Compound D + 150kg/ha ammonium nitrate)*

Fresh and dry weight of harvested leaves

The planting dates had no significant effect on the cumulative fresh and dry weight while the fertilizer treatments had a significant effect ($P < 0.05$) on the cumulative fresh and dry weight of spider plant. The planting date x fertilizer treatment interaction was not significant. The 300 kg/ha Compound D + 150 kg/ha ammonium nitrate and the 10 t/ha poultry manure had the highest cumulative fresh and dry weight with a 20 % increase from the control which had the lowest fresh and dry weight for the spider plant (Table 3).

Harvest period of spider plant fresh leaf

The October planting date had the longest harvest period for the fresh leaf compared to the January and February planting dates. The production period for the fresh leaf was 193 days (27 weeks 4 days) inclusive of all planting dates (Table 4).

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DISCUSSION

The effect of planting date and fertilizer application resulted in an increase in plant vigour as shown by greater height and higher leaf area compared to the control. This result is also supported by findings from previous research, whereby the addition of organic and inorganic fertilizers increased plant growth due to the presence of optimum nitrogen [18]. The increase in plant height for the October 2012 and February 2013 planting dates could be attributed to more favourable environmental conditions for growth which include: adequate soil moisture, high light intensity and a temperature range of 18 - 25^{o}C [10]. Findings in this study showed that the inorganic and organic fertilizer rates used in the study provided optimum nitrogen, which resulted in rapid stem elongation which in most cases is correlated to the number of branches and leaf size. The height of the plant also influences the number of branches, leaf sizes and exposure to sunlight. The results of this study are in contrast with findings from previous research in which the addition of fertilizer failed to improve growth of spider plant when compared to the control where no fertilizer was applied [19, 20].

A plant's nutritional value can vary with soil fertility, environment, plant type, plant age and the production techniques used [21]. In this study, the plants were top dressed after every harvest to maximize the production of the leaves. Most African indigenous leafy vegetables such as *Amaranthus* species have been shown to contain high amounts of mineral nutrient elements such as calcium and iron. In this study, the treatments effected had no significant effect on the calcium content of spider plants. The October 2012 planting date, however, resulted in high iron content and this can be attributed to the more ideal production conditions, that is, sunshine duration, temperature, nutrition and rainfall. In Zimbabwe, spider plant grows best at a temperature range of 18 - 25^{o}C with high light intensity from November to February [10]. In addition, spider plant has a C_4 pathway that is associated with high rates of photosynthesis and efficient use of water and nitrogen [22].

A high level of crude protein especially in vegetables is desirable as it can be used to supplement animal protein [23]. A high crude protein content in plants can be a result of nitrogen accumulation in the young tissues which receive soluble forms of nitrogen transported from older leaves as well [24]. In this study, the interaction of the planting dates and fertilizer treatments on crude protein was significant. The October 2012 planting date had higher crude protein content due to the adequate moisture, high light intensity and temperature compared to the January and February 2013 planting dates.

The significantly high vitamin A content observed for both the organic and inorganic fertilizers points to the influence of nitrogen in improving the nutritive value of spider plant when compared to the control where no fertilizer was applied. The results tend to resemble other findings which showed that, increased soil fertility helps to improve the nutritional value of the plant [25]. The highest vitamin A content was obtained when high rates of organic and inorganic fertilizers were applied for the October and January planting dates. The inorganic fertilizers are readily available for plant growth while the organic manures had more time to release their nutrients into the soil compared to the February planting date. Previous research has also shown that farm yard manure and

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calcium ammonium nitrate increase the content of vitamin A of spider plant [13]. This was also demonstrated in this study whereby the higher rates of inorganic and organic sources of fertilizers resulted in higher rates of vitamin A content.

Spider plant planted early in October 2012 had a higher vitamin C content compared to the January and February 2013 planting dates. This can be attributed to the prevailing weather conditions during the production period. Weather conditions have been shown to alter the vitamin C level in vegetable leaves [26]. Exposure to longer sunshine duration and temperature influenced the amount of vitamin C [27]. The spider plant crop planted in October 2012 was exposed to longer periods of high sunshine duration and temperatures of above 25^{o}C compared to the January and February 2013 planting dates where vitamin C content was lower. The months of December 2012 and January 2013 had relatively high rainfall and this facilitated increased productivity of the crop planted in October 2012. Earlier studies have shown that increased high rates of nitrogen fertilizers decreased vitamin C content of many fruits and vegetables [27]. A similar result was also obtained in this study when planting was delayed.

Cattle and poultry manure are the most common types of organic fertilizers used by communal farmers in Zimbabwe. In this study, the higher fresh and dry weight obtained from the high rates of poultry and cattle manure and Compound D +150 kg/ha ammonium nitrate, can be attributed to high growth rate and efficient utilization of nutrients, leading to higher biomass accumulation. These results are consistent with findings from earlier studies in which the yield was increased through application of farm yard manure and calcium ammonium nitrate [10, 28]. The high fresh yields observed for the high rates of poultry manure were attributed to the slow release of nutrients by organic fertilizers. The organic fertilizer has a high nutrient sustainability and improves the biological properties of the soil, thereby promoting plant growth and consequently higher yields. Poultry manure in particular has been observed to improve the soil chemical properties including the exchangeable cations and cation exchange capacity [29]. The control where no fertilizers were applied had the lowest fresh and dry weight, indicating low fertility levels in the soil to support growth.

Production of spider plant is from November to February and harvesting starts 4 to 6 weeks after seedling emergence and may last 4 to 5 weeks [10]. The October 2012 planting date had the longest harvest period from November 2012 to January 2013 (9 weeks) compared to the January and February planting dates where harvesting was from March 2013 to April 2013 (6 weeks for each plating date, respectively). The spider plant planted in October 2012 had a better chance of utilizing the prevailing weather conditions during the peak of summer, combined with the application of both organic and inorganic fertilizers, compared to the January and February planting dates where the summer conditions were declining. Planting the same crop several times in the season or in succession is highly recommended as this prolongs the harvest season of the crop [30]. In this study, it has been demonstrated that by staggering the planting dates, harvesting can be earlier in November (if planted in October) and can be extended to April (if planted late in February).

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CONCLUSION

Previous studies involving spider plant have shown that it responds well to organic and inorganic fertilizers. This has also been proven in this study whereby the cumulative fresh and dry weight increased by 20% when the soil was amended with organic and inorganic fertilizers. The early planting date resulted in an increase in vitamin A (44 - 48% increase), vitamin C (up to 67% increase), crude protein (39% increase) and iron content (68% increase) compared to later planting dates. However, by staggering the planting dates from October to February of the following year, the harvest period can be extended significantly thereby enabling the farmers to harvest the vegetable for a longer period. It is, therefore, recommended that farmers stagger the planting dates and combine this with high rates of cattle and poultry manure and inorganic fertilizers (Compound D and ammonium nitrate) as follows: 30 t/ha cattle manure, 10 t/ha poultry manure, 300 kg/ha Compound D + 100 kg/ha ammonium nitrate and 300 kg/ha Compound D + 150 kg/ha ammonium nitrate to achieve good yields and high nutrient content of the freshly harvested leaves.

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Table 1: Cattle and poultry manure nutrient analysis

Nutrient	Cattle Manure	Poultry Manure
Nitrogen	0.7%	1.5%
Phosphorus	0.4%	0.7%
Potassium	0.4%	0.5%
Zinc	32.25ppm	52.25ppm

Table 2: Effect of planting dates on the iron content of freshly harvested leaves

Planting dates	Iron content (ppm)
15/10/2012	1255[a]
30/01/2013	471[b]
15/02/2013	376[b]
P value	0.034
SED	235
$LSD_{0.05}$	652.4

Means followed by the same letter in a column are not significantly different at P<0.05

$LSD_{0.05}$

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Table 3: Effect of fertilizers on fresh and dry weight of spider plant

Fertilizer treatments	Fresh yield (g / m^2)	Dry Yield (g / m^2)
Control (No fertilizer)	1455.4d	784.4b
20t/ha Cattle manure	1562.6c	841.1b
30t/ha Cattle manure	1645.7b	883.1b
5t/ha Poultry manure	1610.2b	889.1b
10t/ha Poultry manure	1802.7a	995.3a
300kg/ha Comp D + 100kg/ha AN	1647.2b	887.6b
300kg/ha Comp D + 150kg/ha AN	1827.4a	973.3a
P value	< 0.001	< 0.001
SED	21.53	29.14
$LSD_{0.05}$	43.67	59.10

Means followed by the same letter in a column are not significantly different at P<0.05

$LSD_{0.05}$

Table 4: The harvesting dates and durations

	Planting dates		
	15/10/12	**30/01/13**	**15/02/13**
Start of fresh leaf harvests	16 Nov 2012	8 Mar 2013	15 Mar 2013
End of fresh leaf harvests	18 Jan 2013	19 Apr 2013	26 Apr 2013
Length of harvest period	**9 weeks** (63 days)	**6 weeks** (42 days)	**6 weeks** (42 days)

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REFERENCES

1. **Concern Worldwide.** Poverty Assessment and Monitoring in Zimbabwe. Report in Zimbabwe volume 1, 2007. Retrieved on 15/10/2012 from www.fao.org/ .. Zimbabwe.

2. **Abukutsa MOO** African Indigenous Vegetables in Kenya. Strategic Repositioning in the Horticultural Sector. Inaugural Lecture. Nairobi, Jomo Kenyatta University of Agriculture and Technology, 2010. Retrieved on 10/05/2013 from. www.kjuat.ac.ke/article.plp?id-177

3. **FAO**. Agriculture, Food and Nutrition for Africa: a Resource book for Teachers; Chapter 5- Promotion of Food and Dietary Strategies to Enhance and Sustain Household Food Security, 2013. Retrieved on 12/06/2014 from www.fao.org/docrep/w0078/w0078e06.html

4. **Abukutsa MOO** Researching African Indigenous Fruits and Vegetables. Consumed for Nutrition, 2011. Retrieved on 02/02/17 from http://knowledge.cta.int/Dossiers/Commodities/Fruits/Feature-articles/Researching-African-Indigenous-Fruits-and-Vegetables-Why

5. **Tregold NH, Biegel HM, Mavi S and H Ashton** Food of Zimbabwe. Bulawayo. Mambo Press, 1986.

6. **Abukutsa MOO** Seed Production and Support Systems for African Leafy Vegetables in Rural Communities in Western Kenya. *Afr. J. Food Agric. Nutr. Dev*. 2007: 7 (3): 1-16.

7. **Maumba K** The Effect of Nitrogen Application and Deflowering on Vegetative Growth, Yield and Quality and Post-Harvest Storage Stability of *Gynandropsis gynandra* L Briq. Msc Thesis. Nairobi University, 1993.

8. **Mvere B and ES Mutimutema** The Status of Spider Plant [Cleome Gynandra, (*Nyevhe*, *Runi*)] In Mutare, Zimbabwe. APEX, Mutare, and East-West Seed Company, Harare, Zimbabwe and Natural Resources Institute (NRI), Chatham, Kent, UK. 8 pp, 2002.

9. **Ngwerume FC and B Mvere** The Biodiversity of Traditional Leafy Vegetables. Bioversity International Rome, Italy. 1999: 155-171. Retrieved on 21/06/2017 from http://www.bioversityinternational.org/fileadmin/user_upload/online_library/publications/pdfs/The_biodiversity_of_traditional_leafy_vegetables.pdf.

10. **Fusire M** Seed production manual for Indigenous Vegetables. A Guide for Small Scale Farmer. Community Technology Development Trust (CTDT). Harare, Zimbabwe. 2008.

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11. **Mauyo LW, Anjichi VE and GW Wambugu** Effect of Nitrogen Fertilizer Levels on Fresh Leaf Yield of Spider plant (*Cleome gynandra*) in Western Kenya. *Scientific Research Essays Academic Journals* 2008; **3** (**1**): 24-244.

12. **Hutchinson MJ, Kipkosgei LK, Obudho E and LSM Akundabweni** The Effect of Farmyard manure and Calcium Ammonium Nitrate on Vegetative Growth, Leaf yield and Nutritive Quality of *Cleome gynandra* (Cat's Whiskers) in Kenya District, Rift Valley Province. *Journal of Agriculture, Science and Technology* 2006; **8** (**1**):55-74.

13. **Chweya JA and N Mnzava** Domestication Strategy for Underutilized African Vegetables. In R Schippers and L Budd (Eds.) Workshop on African indigenous vegetables, Limbe Cameroon, January 13-18, 1997. 1997: 22-24.

14. **Okalebo JR, Gathua KW and PL Woomer** Laboratory methods of Soil and Plant Analysis: A Working manual. Tokyo. Hirayama manufacturing, 1985.

15. **AOAC INTERNATIONAL** Official Methods of Analysis 19th edition. AOAC INTERNATIONAL, Washington, D.C. 2012.

16. **Anderson JM, Ingram JSI, Leonard MA and SA Roper** Tropical Soil Biology and Fertility Programme. TSBF Methods Handbook, 1987.

17. **Meteorological Services Department** of Zimbabwe, 2013.

18. **Nyakanda P** Crop Production Module 1 -2. Harare. Zimbabwe Open University, 2000.

19. **Machakaire V, Chigumira F and V Mushita** Comparing and Contrasting Different Research Approaches on Semi and Uncultivated Food Plants. Proceedings of a Workshop September 2001. Harare. Community Technology Development Trust. 2001: 11-31.

20. **S Mavengahama S, Ogunlela VB and IK Mariga** Response of paprika (*Capsicum annuum L.*) to basal fertilizer application and ammonium nitrate topdressing in semi-arid Zimbabwe. *Crop Res* 2006; **32 (3)**: 421-429.

21. **Mishra SS, Moharana SK and MR Dash** Review on *Cleome gynandra*. *Int. J. Res. Pharm* 2011; **1**(**3**): 681-689.

22. **Brown HA** Agronomic implications of C_4 photosynthesis. **In** C_4 Plant Biology Sage, R.F. and Monson, R.K., (Eds.) San Diego, CA: Academic Press, 1999: 473–508.

23. **Agbaire PO** Nutritional and Anti-nutritional levels of some local vegetables (*Vernomia anydalira, Manihot esculentus, Teiferia occidentalis, Talinum triangulare, Amaranthus spinosus*) from Delta State Nigeria. *Journal of Appl. Sci. Environ. Manege* 2011; **15** (**4**): 625-628.

CC BY NC ND

24. **Salisbury FB and CW Ross** Plant physiology. CBS Publishers & Distributors. Delhi, 1991.

25. **Onyango MA** Effect of Nitrogen on Leaf Size and Anatomy in Onion (*Allium cepa* L). *East African Agriculture and Forestry Journal* 2002; **68** (**2**):73-78.

26. **Podsedek A** Natural antioxidant and antioxidant capacity of Brassica vegetables. *Food Sci. Technology* 2007; **40** (**1**): 1-11.

27. **Lee SK and AA Kader** Pre-harvest and postharvest factors influencing vitamin C content of horticultural crops. *Postharvest Biology and Technology* 2000; (**20**): 207-220.

28. **Onyango MA and R Fordham** Effect of Nitrogen Concentration on Growth, Development and Nitrogen Content of Temperate and Tropical Onion (*Allium cepa L*) Cultivars Grown in Solution Culture. *Maseno Journal of Education, Arts and Science* 2000; **3**: 84-99.

29. **Onwu AC, Abubakar JR and PO Unah** Effect of poultry manure on growth, yield of Okra and soil properties in Makurdi, North Central Nigeria. *International Journal of Agricultural and Food Science* 2014; **4(1)**: 9-12.

30. **Bachmann J** Scheduling Vegetable Planting for Continuous harvest. NACT. Army Smith Production, 2008. Retrieved on 21/06/2017 from https://www.google.co.zw/search?q=29.%09Bachmann+J+Scheduling+Vegetable+Planting+for+Continuous+harvest.++NACT.+Army+Smith+Production&ei=h9VKWcftD8u6UrmDpdgF&emsg=NCSR&noj=1.

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