Response of waterleaf (*Talinum fruticosum*) to split doses of poultry manure after in-season intermittent harvest

*ARIT EFRETUEI, OKON EKWERE, GRACE ETUKAPKPAN
Crop Science Department, Faculty of Agriculture,
Akwa Ibom State University
Obio Akpa, Oruk Anam Akwa Ibom State
NIGERIA

Abstract: Waterleaf (*Talinum fruticosum*) is an important crop eaten as a leafy vegetable by many people in West Africa. Research has explored various rates of poultry manure (PM) application administered in single doses to waterleaf, but little is known about how waterleaf responds to split regimes of PM; particularly when its foliage/stem is harvested in-season. The objective of this study was to determine how different split regimes of PM paralleled with in-season harvesting affects the fresh weight (FW) and growth of waterleaf. The experiment was laid out as a randomized complete block design with 4 treatments and 6 replications. Treatments included: one single application (T1), 4 split regimes of ratio 25:25:25:25 (T2), 2 split regimes of ratio 50:50 (T3), and a control (0 t/ha) manure application (T0). There was no effect of PM application on growth parameters: leaf no/plant, plant height and branch number. However, PM applied in split regimes significantly affected fresh weight yield at different harvest times. At the first harvest FW reached 6.83 t/ha but this declined in subsequent harvest. Plants which received manure application produced more FW (about 1 ton/ha more) than the control at the 3rd and 6th week after planting (WAP). In the 9th WAP, T2 produced the highest FW of 2.4 t/ha while in the 12th WAP, T2 and T3 outperformed other treatments (1.87 and 1.83 t/ha). This study showed that PM application in 4 split doses of 25:25:25:25 followed by 2 split doses of 50:50 has potential to increase FW yield at intermittent harvest during the season.

Keywords: Waterleaf, Poultry manure, Split regimes, Yield, leaf numbers, plant height

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1. Introduction

Waterleaf (<u>*Talinum fruticosum*</u>) (L) Juss) is a perennial herb and a member of the Talinaceae (fenzl) Doweld family. Its genus is *Talinum* Adans. It is also known as *Talinum <u>triangulare</u>* (jacq) wild, <u>*Talinum crassifolium*</u> (jacq) wild and <u>*Portuluca fruticosa*</u> L. Due to its wide distribution it has different common names including waterleaf (West Africa), Ceylon spinach or Philippine spinach (parts of Asia). It is cultivated in tropical regions of America, Asia and Africa. Some records state that it originated from South America and was introduced to West Africa; however, there is still lack of clarity as to its true origin, [1], [2].

The leaves and stems of waterleaf is harvested and used to make vegetable soups in most parts of South and Eastern Nigeria. It is a nutritious complement to starchy and high carbohydrate foods such as cooked cassava, yam and rice. It has a high potassium content in the leaves; and is a source of calcium, carbohydrates, glycosides, starch, steroids and secondary compounds including saponins, phenolics and flavonoids, [3], [4], [5].

It has a short duration to maturity (30-45 days), and can be planted all year round in Nigeria, [6]. It produces erect succulent stems and swollen roots and can reach a height of 3-10 ft, [3],[7]. Its short duration of growth and its resistance to most pest and diseases [8], [9] makes it a favourable crop for fast subsistence farming and commercial production.

Organic manure has been heralded for its many benefits; it increases the soil macro and micronutrient elements, the soil organic matter content and improves the soil structure, [10]. Waterleaf farmers in Nigeria, particularly in Akwa Ibom State are gradually replacing inorganic fertilizer use with organic manures such as poultry manure (PM), [2]. This is because in the last decade (due to the increase in poultry farming) PM has become more accessible to small scale farmers. In [11] the authors observed that

PM application was a major determining factor in waterleaf production among farmers in Akwa Ibom State-this study revealed that for every unit increase in manure application there was a less than proportionate increase in waterleaf produced. Indicating that PM directly contributed to waterleaf yield.

A study by [12] showed that PM increased no of leaves/plant, soil fertility and soil organic matter. There was also an indication of slow release of nutrients during growth. This they concluded was suitable to maintain yield under a continuous cropping system. Additionally, a study on the influence of different PM rates and plant density on waterleaf yield showed that PM at 10 t/ha increased agronomic parameters such as: plant height, number of leaves, fresh weight, dry weight and leaf area compared with a lower rate of 5 t/ha, [13]. Similar to this work [14] also confirmed that waterleaf plants fertilized with PM of 10 t/ha performed better in all agronomic parameters compared to lower rates. However, lower rates of PM have been reported to increase yield; according to [15] PM at 3.75 t/ha increased yield of waterleaf compared to 2.75 t/ha although PM was complemented with 100 kg/ha of NPK (15:15:15) fertilizer, [15]. Although, they also observed that when PM was applied alone, manure rates of 5 t/ha produced the highest yield.

PM has also become a preferable choice among growers in Akwa Ibom State because of the high price of inorganic fertilizers such as urea and NPK. As a result of this there is a need to intensify research on the adequate application of the preferred alternative - PM. However, application of fertilizers without observing the optimum rates and the right time of application can lead to a significant loss of nutrients to the surrounding environments through leaching and nutrient run-off, [16]. Though PM is noted for increasing vegetative growth [11] this benefit cannot be achieved if it is applied in excess or inadequately. An assessment on organic manure use among farmers in Western Nigeria observed that vegetable farmers used organic manures frequently but still reported poor yields, [17]. This emphasized the need to ensure precise timing and rates as soils in the tropical savanna and rainforest zones of West Africa are prone to nutrient loss through leaching or run off largely due to the high impact of torrential rainfall.

Research has explored appropriate rates of PM application to waterleaf, [13], [14] but little is known about how waterleaf responds to split applications of PM during the growing season; particularly when it is harvested in-season. The objective of this study was to determine how different split applications of PM paralleled with foliage/stem harvesting during the growing season affects the vegetative yield of waterleaf.

2. Materials and methods

2.1 Experimental site and location

The experiment was conducted at the Akwa Ibom State University Faculty of Agriculture Teaching and Research Farm. Akwa Ibom State University is located between latitude 4.32°N and 5.33°N and longitude 7.25°E and 8.25°E. The climate of this area is classified as a tropical monsoon with average annual precipitation of 2,509 mm and temperature of 26.4°C. The experiment was conducted between the months of May and August 2020. The experimental site had been left fallow for the past 2 years.

2.2 Experimental design and field layout

The experimental design was a randomized complete block design (RCBD) with 4 treatments and 6 replications. The 4 treatments were the different split application regimes of one rate of poultry manure (PM) (10 t/ha). The single rate of 10t/ha was chosen based on recommendation from previous study (5). The split regimes included: one single application (T1), 4 split regimes in the ratio 25:25:25:25 (T2), 2 split regimes in the ratio of 50:50 (T3), and a control of zero (0 t/ha) manure application (T0). The split regimes were applied at the following times:

- T1: a single dose of 10 t/ha applied before planting
- T2: 2.5 t/ha applied immediately before planting and subsequently every 3-week interval and
- T3- 5 t/ha applied immediately before planting and another 5 t/ha after 6 weeks of planting.

Plants were grown on raised seed beds (plots) measuring 2 x 1 m. Planting distance within each plot was 3 cm within rows and 5 cm between rows. There were a total of 38 rows/plot and a total of 1,026 plants/plot. The distance between each plot was 1 m.

2.3 Land preparation and soil sampling

The field was cleared and tilled using machetes, hoes, and spades. A composite soil sample at a depth of 0-30cm was collected before preparation using a soil auger to determine the physical and chemical properties of the soil. Samples collected were taken to a soil science laboratory where they were air dried and sieved with a 2mm sieve and analysed for soil physical and chemical properties presented in Table 3.1. Once seedbeds were prepared, PM was applied to each bed by broadcast according to treatment levels (T1, T2 and T3) and the manure incorporated into the soil using a spade. Manure was left in the soil for 1 week before planting began. Waterleaf cuttings of 8 cm each in length were planted. Weeding was done manually using a hoe and hand picking 2 and 4 weeks after planting.

2.4 Data collection and harvesting

Data were collected 3 weeks after planting and subsequently at 3 weekly intervals. From each plot, 5 plants were selected at random to measure the plant height, number of leaves per plant, and number of branches per plant. Care was taken to avoid selecting plants from the last two rows bordering the plot. The vegetative yield was determined by taking the fresh weight of all plants from each plot after each cutting. At a 3-week interval the total fresh weight for each plot (measuring $2m^2$ and covering 38 rows) was determined: by cutting all matured shoots at 5cm above the soil with a sharp knife and weighing each plot harvest on an electronic weighing scale. Fresh weight of each treatment was then calculated in tones/ha.

2.5 Data analysis

Data collected were analysed using analysis of variance (ANOVA) with a statistical software SPSS version 20. Significant differences among means were determined using the Tukey kramer test at 5 % probability level.

3. Results and discussion

Physical and chemical properties of the soil at experimental site and poultry manure analysis before application are shown in Table 3.1 and 3.2.

Table 3.1

Soil physical and chemical properties at 0-30 cm soil depth

Soil properties	**Value**
Sand (%)	82.3
Silt (%)	3.96
Clay (%)	13.74
Soil textural class	Sandy loam
pH (H_20)	3.58
Electrical conductivity (ds/m)	0.15
Organic carbon (%)	2.41
Organic matter (%)	4.17
Total nitrogen (%)	0.1
Available phosphorus (mgkg-1)	36.018
Potassium (cmol/kg)	0.16
Calcium (cmol/kg)	1.62
Magnesium (cmol/kg)	1
Sodium (cmol/kg)	0.09
Exchangeable acidity	2.08
ECEC	4.95
Base saturation (%)	58

$mgkg^{-1}$ = milligram per kilogram, $cmolkg^{-1}$ = centimole per kilogram

Table 3.2

Physical and chemical properties of poultry manure

Properties	**Value**
pH	8.1
Electrical conductivity (ds/m)	1.66
Organic carbon %	48.2
Nitrogen %	1.22
Phosphorus (mg/kg)	1101.8
Potassium (mg/kg)	1674
Calcium (mg/kg)	472.6
Magnesium (mg/kg)	1036.7
Sodium (mg/kg)	491.2

3.1 Effect of different poultry manure regimes on branch number, plant height and number of leaves/ plant

Number of leaves/plant decreased consecutively from one sample period of measurement to another in the T1, T2 and T3 treatments; for example, there was a decline from 16 leaves/plant at 3WAP to about 9 leaves/plant at 12WAP (although this difference was not tested statistically) Table 3.3. There was no significant effect of manure treatments on the number of leaves/plants at all stages of measurement. With the branch numbers, plants (across all treatments) produced an average of 2 branches at 3WAP but from the 6th WAP plants produced an average of 1 branch/plant (Table 3.4). There was no significant effect of PM on branch number, particularly no difference between the control treatments and the manure treatments. Plants reached heights of 10 cm at 3WAP but declined numerically by approximately 1cm in subsequent measurements (Table 3.5). There was also no significant effect of PM on plant height. Plant height in this work was lower than previous report on similar experiments. When PM of 10t/ha was applied to waterleaf in a study by [13] plant heights ranged from 19-34 cm. In addition, PM applied at 8t/ha also yield heights of 11-16 cm, [18]. What was consistent with previous studies were the consistent decline in leaf numbers, branch numbers and plant height from one period of measurement to another, [14], [15], [18]. This implies that vegetative growth slowed down progressively with the in-season harvesting. The no significant effect of manure treatments on the agronomic parameters- plant height, number of leaves and branch number in this study contradicts previous works by [13] and [18] where PM significantly increased plant height and leaf number. The result of this study suggests that nutrient taken up by the plants did not directly affect the parameters measured.

Table 3.3

Effect of different poultry manure application regimes on number of leaves/plant at 3, 6, 9 and 12 weeks after planting (WAP)

Treatment	3WAP	6WAP	9WAP	12WAP
T0	12.10	13.47	13.63	10.07
T1	16.10	14.90	11.87	9.23
T2	12.23	12.67	11.90	9.73
T3	16.53	12.23	11.97	9.43
P value	NS	NS	NS	NS
SED	**0.952**	**0.514**	**0.481**	**0.369**

NB: NS=not significant at 0.05 probability level, SED=standard error of differences of mean, T1- one single application before planting, T2-4 split regimes in the ratio 25:25:25:25, T3- 2 split regimes in the ratio of 50:50, T0-control (no manure application)

Table 3.4

Effects of different poultry manure application regimes on number of branches/plants for waterleaf at 3, 6, 9 and 12 weeks after planting (WAP)

Treatment	3WAP	6 WAP	9 WAP	12 WAP
T0	1.2	1.07	0.63	0.77
T1	1.8	1.53	0.40	0.43
T2	1.37	1.37	0.67	0.77
T3	1.63	0.90	0.83	0.67
P value	NS	NS	NS	NS
SED	**0.133**	**0.127**	**0.101**	**0.073**

NB: NS=not significant at 0.05 probability level, SED=standard error of differences of mean, T1- one single application before planting, T2-4 split regimes in the ratio 25:25:25:25, T3- 2 split regimes in the ratio of 50:50, T0-control (no manure application)

Table 3.5

Effects of different split regimes of poultry manure on the plant height (cm) of waterleaf at 3, 6, 9 and 12 weeks after planting (WAP)

Treatment	3WAP	6WAP	9WAP	12WAP
T0	8.77	8.2	7.52	7.19
T1	10.29	9.38	7.48	6.67
T2	10.21	8.10	7.62	7.02
T3	10.28	8.30	6.99	6.47
P value	NS	NS	NS	NS
SED	**0.425**	**0.262**	**0.164**	**0.156**

NS=not significant at 0.05 probability level, SED=standard error of differences of mean, T1- one single application before planting, T2-4 split regimes in the ratio 25:25:25:25, T3- 2 split regimes in the ratio of 50:50, T0-control (no manure application)

3.2 Effect of different poultry manure regimes on fresh weight

There was a significant effect of manure application on the fresh weight of waterleaf at all the 4 harvesting times. At 3WAP, fresh weight in the T1 (single dose of 10t/ha at planting) treatment was significantly higher than the control by 3.2 t/ha (figure 3.1). This showed the effect of PM on vegetative production at 3WAP. It also confirms that PM application before planting increases fresh weight, [13]. In a similar work it has been suggested that high fresh weight in PM fertilized-African cabbage (a similar leafy vegetable consumed in South Africa) was due to high biomass accumulation and efficient utilization of nutrients, [19]. Among the manure regimes: T1 (single dose of 10 t/ha before planting), T2 (split regimes of 2.5 t/ha) and T3 (split regimes of 5 t/ha), T1 produced the highest numerical yield of 6.83 t/ha but this difference was not statistically significant (figure 3.1). No differences were observed between T1, T2 and T3 at 3 WAP.

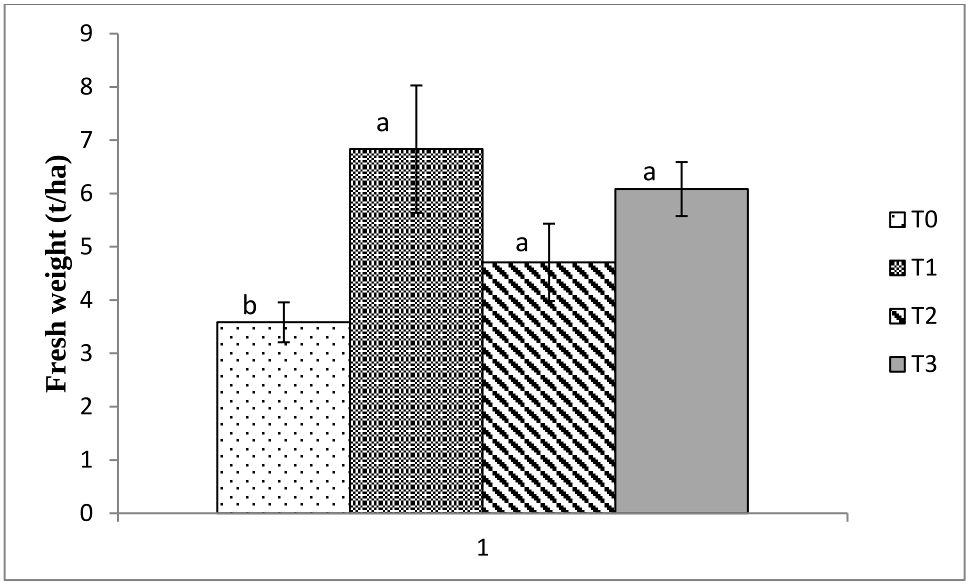

Figure 3.1 Effects of different split regimes of poultry manure on the fresh weight of waterleaf at 3 WAP. Means with the same letter are not significantly different

From 6WAP fresh weight produced by all treatments ranged from 0.7-1.9 t/ha, this was lower than 6t/ha observed at 3WAP. The reason for the lower fresh weight may be because before planting all plants (except the ones in the control plots) received a portion of manure. They had fully benefited from the readily available nutrients present in the manure. Research has shown that only a portion of the nutrients in manure applied is initially available to plants because nutrients are present in both inorganic (readily available) and organic (not readily available) forms, [20]. The complete nutrient credit from manure is estimated within the first and third year after application – For example, PM can release 50-55% of nitrogen, 80% of P_2O_5 and 55% of sulphur after 72hrs from incorporation while the other nutrients are released over time [21]. At 6 WAP, T2 produced an average of 1.9 t/ha this was significantly higher than T1 and T0 by 0.7 and 1.1 t/ha but not T3. Plants receiving T2 and T3 treatments had the same effect on fresh weight after cutting even though T3 at this time was not yet administered a second dose of manure. The difference between T2 and T0 treatments emphasizes that applying manure after the first harvest rather than no application can have an increase in vegetable yield. Plants receiving the T1 treatment were expected to outperform the T2 and the T3 treatment as they initially received a higher rate of manure (10 t/ha) but this study revealed that the single dose of 10 t/ha at the time of planting did not sustain an increase in yield until the 6th week after planting.

The highest fresh weight produced at 9WAP was from the plants receiving T2 treatment -with this treatment 2.5 t/ha of PM was administered immediately after each harvest (figure 3.2). This indicated that the application of manure in 2.5t/ha dose right after each harvest was appropriate to promote foliage/stem growth and recuperation. There were no differences observed between the T1, T3 and T0 treatments indicating that these treatments had a similar effect on yield at 9WAP. Nitrogen is a key element in manure and is responsible for plant protein build up, [22], [23]. In a study on waterleaf protein content, it was reported that shoot protein content increased during the first 60 days after planting (8WAP), then declined afterwards when the plant entered reproduction, [24]. The increase in shoot protein build-up during vegetation infers that at this stage there is an increase in nutrient (particularly nitrogen) demand. It is established that nitrogen uptake increases vegetative growth which translates into vegetative yield for waterleaf, [25]. In this study plants receiving the T2 treatment had already received 2 split doses of manure by the time it was at the 8WAP stage. This means that manure administered to the plants were available at the peak period of nitrogen demand. This explains why plants with the T2 treatment outperformed others.

At 12 WAP T2 and T3 produced the highest fresh weight (1.87 t/ha). While T0 and T1 were significantly lower. The increase in fresh weight in the T3 plants appeared to be an immediate response to the second split dose of PM which was applied at 6WAP. On the other hand, T2 maintained consistency in high yield from 6 WAP showing that the application of manure in small doses of 2.5 t/ha was timely and may allow a more efficient uptake and utilization of nutrients for foliage yield. Fresh weight produced from waterleaf in this study was between 0.8-6.8 t/ha. This was higher than weight from similar work which reported a fresh weight range of 0.04-1.35 t/ha [13] but was well below the amounts reported in, [26] and [14]. In [14] the authors reported weights of 10-11 t/ha. The low fresh weight in this study compared to [14] may suggest that PM applied was not fully taken up or utilized by the plants. In [26] the authors looked at the effect of organomineral fertilizers on waterleaf fresh weight and reported amounts between 20-24 t/ha. The large increase in weight here suggests an advantage with the use of organomineral fertilisers on waterleaf production. Although the cost of this fertilizer compared to PM may be higher, it calls for additional exploration in future work.

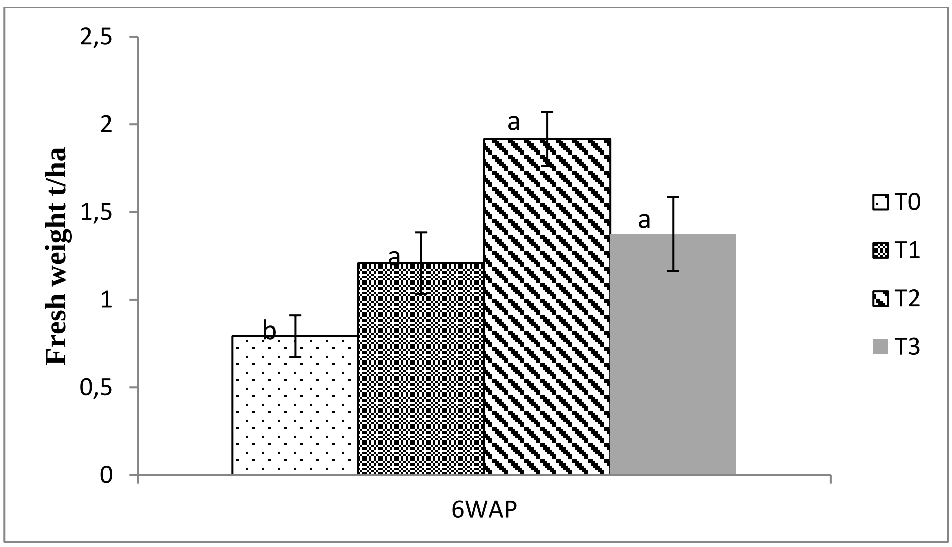

Figure 3.2 Effects of different split regimes of poultry manure on the fresh weight of waterleaf at 6 WAP. Means with the same letter are not significantly different

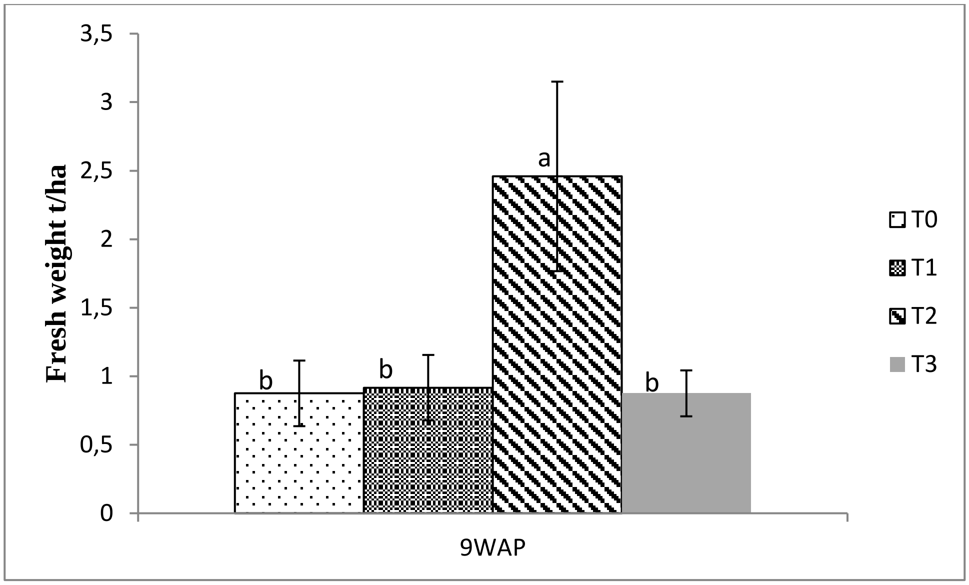

Figure 3.3 Effects of different split regimes of poultry manure on the fresh weight of waterleaf at 9 WAP. Means with the same letter are not significantly different

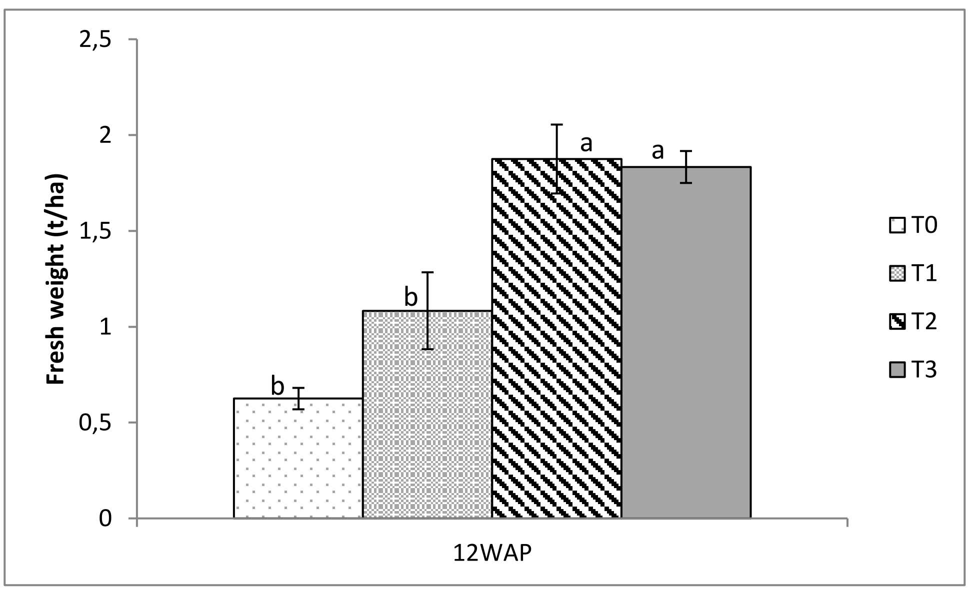

Figure 3.4 Effects of different split regimes of poultry manure on the fresh weight of waterleaf at 12 WAP. Means with the same letter are not significantly different

4. Conclusion

This study investigated the effects of different split regimes of PM on the growth and vegetative yield of water leaf. Although fresh weight in the control was significantly lower at most harvesting times, the randomly selected plants measured did not show a deficit in leaf/branch numbers or plant height throughout this experiment. Manure application at the 4 splits doses of 2.5 t/ha (applied at 3 weeks interval) was consistent in high yield compared to other treatments. This was followed by the 2 split doses of 5 t/ha (applied at 6-week interval). This work has shown that manure in 4 split doses of 2.5 t/ha will increase vegetative yield. Despite this, it is worthy of note that under practical conditions, this number of split applications may demand additional labour during the growing season. Therefore, to increase yield, growers should aim to apply manure at 4 split doses of 2.5 t/ha (3 weeks interval). When this is not realizable due to labour cost, growers can apply manure at 2 split doses of 5 t/ha. Waterleaf is an important vegetable crop for people in Nigeria and tropical Africa. This study has contributed to the knowledge on the precise timing of PM split application, which would increase vegetative yield as well as maximize labour and manure use during production.

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