

PRE-TUBER APPLICATION OF FLURIDONE: EFFECT ON VEGETATIVE GROWTH AND SEED TUBER DORMANCY IN YAM (*D. alata*)

ABSTRACT

Aims: This paper seeks to determine the effect of pre-tuber application of FLU on vegetative growth, seed tuber production and dormancy in yam (*D. alata*).

Study design: The experiment was laid out as a completely randomized design (CRD) with 4 treatments and 3 replicates with a total of 24 plants per treatment. In storage, the experiment was laid out as CRD with 4 treatments and each tuber as a replicate. In the anatomical study, each tuber portion per treatment represented a replicate.

Place and duration of study: Field and storage studies were conducted in the Department of Crop and Soil Science, university of Port, Harcourt while the anatomical work was carried out in the yam pathology laboratory, IITA, Ibadan Nigerian. The study covered the period from April 2011 to April 2012.

Methodology: Treatments were: water (control), 10 μ M FLU, 5 μ M ABA, and 5 μ M ABA + 10 μ M FLU. 1 ml of the treatment was injected into the primary nodal complex (*i.e.*, the organ from which tubers originate) of the yam plants. Data collected include plant height, leaf number, leaf length and width, tuber number and dry matter content. At least 24 small tuber portions per treatment were sectioned and examined for internal signs of sprouting. At the end of the growth study, tubers were harvested, stored and observed for date of external sprouting.

Results: Root dry weight increased ($P=0.05$) by 29 % in FLU compared to control (10.9 g). In contrast, ABA reduced root dry weight by 17 % compared to control whereas; the application of FLU two days after ABA (ABA + FLU treatment) led to 13 % increase in root dry weight compared to ABA alone. Tuber number per plant increased under FLU, ABA and ABA + FLU compared to the control. Number of nodes per plant reduced ($p=0.05$) in ABA, while ABA + FLU did not differ from FLU or the control. All tissues sections observed at 75 days after vine emergence, did not show any clear internal signs of sprouting.

Conclusion: fluridone, can induce significant temporary effect on leaf morphology, and root development of field grown yam plants but prolonged exposure to fluridone may be required to significantly prevent dormancy in developing tubers.

Key words: dormancy, yam, fluridone, vegetative growth, seed tuber, ABA

1. INTRODUCTION

Yam (*Dioscorea* spp.) produces underground or aerial tubers, which constitutes the organ of economic importance. The tubers serve as staple food source to millions of people in the tropics (Scott *et al.*, 2000), as well as play a significant role in the culture and trade of the people in West Africa (Coursey,

1967; Martin and Sadik, 1977). In agriculture, the tuber is the major source of planting material. Yam tubers originate from the primary nodal complex (PNC), which is also the source of feeder roots and the vine (Wickham *et al.*, 1981; Ile 2004; Hamadina, 2010). The PNC can be recognised externally as a swelling at the base of the external shoot bud (Onwueme, 1973; Hamadina, 2010). Among the six economically important species, *D. alata* is the most widely consumed after *D. rotundata* in West Africa. Nonetheless, *D. alata* is cultivated more globally (Abang et al. 2003) and its tuber has high crude protein (7-8%), starch (70-85%) and vitamin C (13-25 mg/100 g) contents (Osagie, 1992) as well as good pasting and functional properties. The high pasting and functional properties of *D. alata*, suggests that it may prove important as raw material in many food and non-food industries (Oke et al. 2009). In view of the impending expansion of yam utilization, the existing pressure on available *D. alata* tubers is anticipated to increase. Thus it is even more crucial now to develop techniques that can eliminate the major constraint of yam production, which is poor availability of seed tubers/ high cost of planting material (Ezeh, 1991).

The one major cause of poor availability of planting material during the planting season is the inability to manipulate planting time due to the presence of tuber dormancy. Dormancy is an inherent mechanism that allows affected plant parts to survive unfavourable environmental conditions as well as maintain their food value until the next planting season. In yam however, the problem is that the dormant period of the tuber is too long, ranging from 30 to 270 d depending on the definition of the start and end of dormancy, the environmental conditions during storage, the timing of tuber harvest among others (Ile et al., 2006; Hamadina, 2011). Thus, due to long tuber dormancy and the need for the tuber as source of food, the tubers that are set aside for planting in the next season (seed tubers) are constantly either eaten up for food or lost to pests and diseases during the compulsory storage period. Also, the fact that dormancy restricts the planting activity of farmers and researchers to a fixed time of the year makes yams unattractive and difficult to work with. Furthermore, the inability to manipulate this long dormant period makes it difficult for breeders to synchronise male and female flowering and this in turn slows down the pace of conventional yam breeding (Okwor and Ekanayake, 1998). Consequently, tubers are constantly in short supply even during the harvest season thus leading to high cost of tubers for food. This condition is worst by the start of the next planting season, which in turn leads to high price of seed yams and small size of land put to yam cultivation. Planting

69 material alone is known to account for as much as 40% of the total cost of yam production (Ezeh,
70 1991).

71 The ability to drastically shorten the duration of dormancy will: reduce losses of yams to pests
72 and diseases by avoiding storage, increase tuber production/availability due to the ability to plant more
73 than ones per year (i.e. immediately after the early harvest in the month of August/September) and
74 encourage the expansion of yam utilization because more tubers will be available. Unfortunately, past
75 studies are only able to slightly shorten a small proportion of the dormancy period mainly because the
76 studies have concentrated on the manipulation of the short duration, late stages of dormancy
77 (Hamadina et al., 2010).

78 The anatomical and *in-vitro* studies of Ile et al. (2006) and Hamadina et al. (2010) clearly show
79 that there is a relationship between the start of dormancy and tuber initiation/ early tuber development.
80 The study also shows that *in-vitro* micro tubers could commence vegetative growth as early as the
81 month of September/October by exposing the developing tubers to a medium containing 10 μ M or 30
82 μ M fluridone. Fluridone is a herbicide that is consistently shown to inhibit the biosynthesis of the plant
83 growth inhibitor, abscisic acid (ABA) (Srivastava, 2002; Lindgren *et al.*, 2003; Mulwa and Nwanza,
84 2006) leading to early sprouting in many plant parts that exhibit dormancy (Suttle and Hultstrand,
85 1994; Kim *et al.*, 1994; Yamazaki *et al.*, 1999; Hole *et al.*, 1989; Le Page-Degivry and Garelo, 1992).
86 However, there is a dearth of information on the effect of fluridone on seed yam tuber dormancy and
87 there are no established methods to either prevent the start of dormancy in seed yams. Furthermore, it
88 is common to study the effect of fluridone on dormancy but the effect of fluridone on vegetative growth
89 and development of yams is unclear. In a potato study (Suttle and Hultstrand, 1994), fluridone did not
90 induce a bleaching effect on the shoot system but it induced varying degrees of bleaching of the shoot
91 and root systems of yam plantlets (Hamadina et al. 2010). The bleaching effect of fluridone is thought
92 to result from the accumulation of phytoene rather than the inhibition of chlorophyll (Mulwa and
93 Nwanza, 2006) and the effect wears out over time (Hamadina *et al.*, 2010). In view of the fact that
94 fluridone can affect leaf physiology, and the fact that tuber yield is determined by early vegetative
95 growth and development, it is important to evaluate the effects of fluridone on vegetative growth of
96 yam.

97 This study therefore hypothesizes that: 1. exposure of *D.alata* to fluridone will negatively affect
98 leaf morphology but not shoot and root growth, and 2. dormancy in seed yams can be drastically

shortened by inhibiting the initiation of dormancy at early tuber formation (*i.e.*, prior to the long, phase I of dormancy) using fluridone (an inhibitor of ABA biosynthesis). As proposed by Ile *et al.* (2006), Phase I of dormancy begins from tuber initiation or early tuber development to the appearance of the tuber germinating meristem (TGM); Phase II, from TGM to the initiation of foliar primordium (FP); and Phase III from FP to the appearance of shoot bud (sprout) on the surface of the tuber. In yam, the true dormant phase or endo-dormancy (Lang *et al.*, 1987) corresponds to the long (approx. 220 d) Phase I of dormancy, which is unaffected by plant growth regulators (PGR) (Ile *et al.*, 2006). 'Eyes' may be present on the tuber surface at the end of Phase II, while external shoot buds appear on the surface of the tuber during Phase III. The duration of Phases II and III are short (< 70 d in total) and may be affected by exogenous factors such PGRs. Studies with whole tubers also show that tubers harvested as early as 75 or 90 d after emergence will not grow spontaneously (Swannel *et al.* 2003; Ile *et al.* 2006; Hamadina *et al.* 2010). This is contrary to earlier believe that the start of dormancy coincides with vine senescence when tubers are mature for harvest (coursey, 1967; Orkwor and Ekanayake, 1998). Therefore, the yam sprout to sprout cycle is < 360 d with the visible end of dormancy coinciding with a defined period of the year (between December of the growing year and February of the next growing season). Therefore, this study seeks to determine the effect of pre-tuber application of 10 µM fluridone on vegetative growth, seed tuber production and tuber dormancy in *D. alata*.

2. MATERIAL AND METHODS

Mature seed yams, *Dioscorea alata*, var. TDa 98/01166 were gotten from IITA, Ibadan. The tubers were cut into setts of about 50±3 grams. The cut surfaces were treated with wood ash air dried for two days before planting in 7 litre plastic pots filled with top soil of the type Typic pauluedult. The soil was slightly acidic (pH= 6.2) and low in total nitrogen (0.01% N). Its total organic matter content was 5.3% with a phosphorus and potassium contents of 0.26 and 2.73 mg/20 g respectively. The tuber setts were planted on the 28 of April, 2011. The pot study was conducted on the field at the Crop and Soil Science farm, University of Port Harcourt, 4°47'N; 7°27'E while the anatomical study was conducted in the yam pathology laboratory, IITA, Ibadan.

2.1 Treatment and Treatment Application

The treatments were: 10 µM Flu, 5 µM ABA, 10 µM fluridone+ 5 µM ABA and water (Control). These treatments and concentrations were chosen based on their effects on vegetative growth and yam

tuber dormancy in previous *invitro* studies (Ile, 2004; Hamadina et al. 2010). Absciscic acid is a well known inhibitor of vegetative growth and promotes dormancy. On the other hand, fluridone inhibits yam shoot growth and inhibits ABA biosynthesis (Ile *et. al.*, 2006; Suttle and Hultstrand, 1998) while increasing root development, tuber number and inhibits dormancy (thus promoting sprouting) in *invitro* tubers by removing dormancy induced by ABA biosynthesis (Suttle and Hultstrand, 1998). This study represents a part of a larger study aimed to prevent phase 1 of dormancy in seed yams.

The treatments were applied by injecting 1 ml of the above concentrations into the PNC of the plant prior to tuber initiation. The PNC was the target organ because it is the organ from which dormant tubers originate. The application of chemicals by injection is a well known method of applying herbicides and other chemicals to plants. Fluridone or ABA application was done at 12 days after average vine emergence date. At this time, there was no external indication of tuber formation. For the ABA+fluridone treatment, fluridone was applied two days after ABA application.

2.2 Vegetative Growth

Date of vine emergence was noted and only the plants that emerged within the first 10 days from the first plant emergence were used for this study. Before treatment application and weekly after until nine weeks after treatment (WAT), data on plant height, number of leaves, number of nodes, leaf length and width were recorded on three randomly selected plants per treatment per replicate. Leaf length and width measurements were taken over the same period on five randomly selected leaves in each of the three plants.

At 9 WAT, two plants per treatment per replicate were randomly selected to determine dry matter content of the component plant parts. At 9 WAT also, the number of tubers produced by each of the sampled plants was counted and the fresh weight of tubers per plant was recorded.

2.3 Preparation of Tubers for Dormancy Studies

To assess anatomically the state of dormancy of young, just developing tubers and to determine the effect of the treatments on dormancy, 6- 8 tubers per treatment were harvested at 75 days after vine emergence (*i.e.*, at 9 WAT), washed, air dried and then, split longitudinally into two. Each tuber half was again split longitudinally to give four tuber portions per tuber. The length of the tuber portions was reduced by cutting off the distal part of the tuber until it was about 1 cm long. Only the proximal ends of the tuber were used because shoot buds develop more readily from the proximal end than other

parts of the tuber. Thus, there were 32 small tuber portions per treatment except the control which had 24 tuber portions. All tuber portions were quickly fixed in FAA to halt biochemical reactions.

2.4 Preparation of Tuber Portions for Anatomical Examination

The embedding, tissue sectioning and staining procedures used in this study were similar to that reported by Ile (2004) and Ile et al. (2006). To prepare the tuber portions for anatomical examination, only 12 portions per treatment were used. Thus, in each of the FLU treatments, 12 tuber portions were randomly selected from a pool of 32 tuber portions. Embedding was done using parafin. Ten tissue sections, each 25 µm were made from each tuber portion using a rotary microtome. The stained sections were observed under the microscope to determine whether any signs of internal shoot development were present or absent.

According to Ile et al. 2006, a dormant section has a meristematic region that is made up 2-4 layers of flattened oval shaped cells (Fig. 1) while a non-dormant tuber section has a meristematic region that has a tuber germinating meristem (TGM), shoot apical meristem (SAM) or internal shoot bud/foliar primodium (FP) (Fig. 2a,b,c).

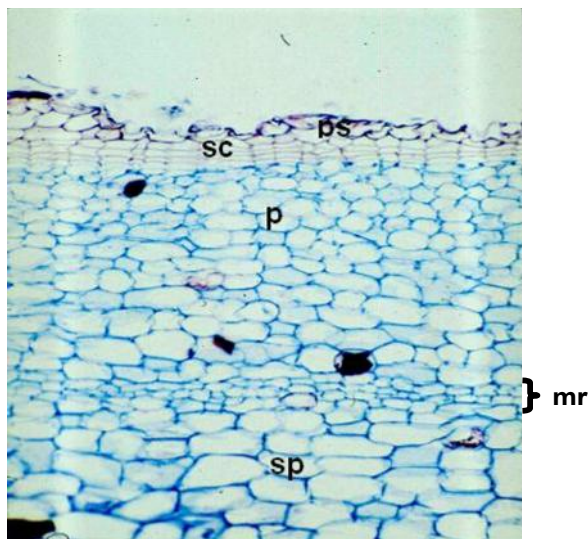


Figure 1. Longitudinal section of the head region of a dormant *D. rotundata* tuber. Abbreviations: ic = inner cork cells; oc = outer cork cells; p = cortical parenchyma; mr = meristematic region; sp = storage parenchyma. Magnified 28X. Source: Ile (2004)

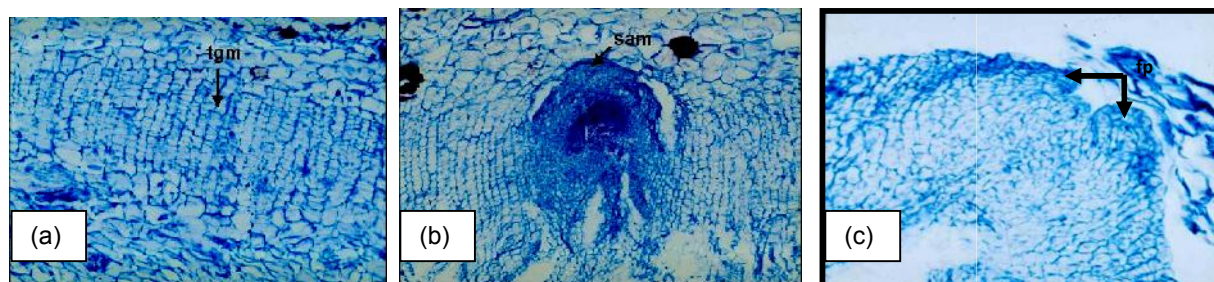


Figure 2. Tissue sections from non dormant *D. rotundata* yam tubers. (a) presence of tuber germinating meristem (TGM), (b) presence of shoot apical meristem (SAM) and (c) presence of foliar primordia (FP). Source: Ile (2004)

2.5 Storage study

To determine the effect of the treatments on date of emergence of external shoot bud (sprout), also referred to as date of sprouting, the tubers that were harvested at maturity by 196 DAE were stored at room temperature and observed weekly for sprouting. Ten tubers per treatment per replicate were observed weekly for sprouting for a period of 12 weeks.

2.6 Experimental Design

The study was a pot experiment, laid out as a completely randomized design (CRD) with 4 treatments and 3 replicates. Plant spacing was 50 × 50 cm inter row and intra row spacing. A total of 24 plants per treatment were grown. In storage, the experiment was laid out as a completely randomized design (CRD) with 4 treatments and each tuber was a replicate.

2.7 Data Analysis

Data was analyzed using Genstat Discovery Edition 4. Count data such as number of leaves, number of nodes, and number of tubers were transformed using square root transformation prior to data analysis to make sure that the distribution is normal. The standard error of differences (SED) was used to separate treatment means (any two treatment means treatments are significantly different if their difference is equal to or greater than the product of SED and 1.5).

3. RESULTS AND DISCUSSION

3.1 Plant environment

The average atmospheric temperature and relative humidity during yam growth was 30 °C and 78% respectively.

3.2 Effect of fluridone on leaf morphology

The effect of fluridone on leaf colour was first observed at 3 weeks after treatment when patches of bleaching was observed on some leaves (Plate 1) of some plants treated with 10 µM fluridone. However, by the end of the study, i.e. by 9 WAT, the leaves were all green.



Plate 1: Effect of fluridone on leaf morphology

3.3 Effect of PGR treatments on vegetative growth and development of *D. alata* plants

Compared to the control, the application of ABA significantly ($p= 0.05$) reduced the number of nodes per plant by 21% by 8 WAT (Table 1). Similarly, 5 μ M ABA ($p= 0.05$) reduced the number of nodes per plant compared to 10 μ M fluridone. However, 10 μ M fluridone+ 5 μ M ABA did not significantly reverse the effect of ABA on number of nodes per plant.

Plant height, leaf number, and leaf length and width were reduced by the PGR treatments (10 μ M Flu, 5 μ M ABA, 10 μ M fluridone+ 5 μ M ABA) compared to the control but these effects were not significant ($p=0.05$).

TABLE 1: Effect of fluridone and ABA on number of nodes per plant at 8 WAT

Treatments	Mean no of node
Control	6.6
Fluridone	6.0
ABA	5.2
ABA +Flu	6.1
S.E.D	0.3

Means with similar alphabet are not significantly ($p=0.05$) different

The At 9 WAT/ 75 days after vine emergence, the mean total dry matter content per plant was 35.0 g in the control. Compared with the control, the application of 5 μ M ABA reduced the mean total dry matter content (33.9 g) while the application of 10 μ M Flu and 10 μ M Flu + 5 μ M ABA increased the mean total dry matter content (Table 2). In the control and all PGR treatments, the largest proportion of the total assimilate was partitioned to the leaf (e.g. 47.1% of total dry matter in the control) than to the root and stem. However, leaf dry matter content did not vary significantly across treatments.

The effect of fluridone on the proportion of total assimilate partitioned the stem and root was significant (Table 2). Stem dry matter (SDW) content per plant was generally higher under the PGR treatments, increasing in the order 10 μ M Flu<5 μ M ABA< 10 μ M Flu + 5 μ M ABA. ABA significantly ($p=0.05$) increased SDW by 1.3 g compared with the control while the combination of fluridone and ABA further increased it by 2.3 g compared with the control. Root dry weight was significantly increased by 3.2 g in 10 μ M Flu compared with the control, while ABA significantly reduced RDW by 1.9 g compared with the control. Root dry weight in fluridone + ABA treatment did not differ significantly from the control however, the root dry weight was significantly lower (3.9 g) in fluridone +

ABA than in fluridone alone. These relationships suggest that ABA can reverse the effect of fluridone on stem and root dry weights.

Table 2: Effect of fluridone on dry matter partitioning at 9 WAT/75 days after vine emergence

Treatment	Dry weight (g)			
	LDW	SDW	RDW	Total
Control	16.4	7.7	10.9	35.0
Fluridone	15.9	8.2	14.1	38.2
ABA	15.9	9.0	9.0 ^c	33.9
Flu+ABA	16.2	10.0	10.2	36.4
SED	0.9	0.6	0.9	5.1

The number of tubers produced per plant was increased by applying the PGR treatments. Number of tubers ranged from 1 tuber per plant in the control to 1 - 3 tubers per plant in the PGR treatments (Table 3). However, only the effect of ABA was significant ($p=0.05$) with each plant producing 2 to 3 tubers. Tuber weight per plant in the control at 9 WAT/ 75 days after emergence was 22 g. All PGRs increased tuber weight compared with the control but this effect was not significant (Table 3). Among the PGRs, the fresh weight of tubers per plant was higher in fluridone treatment than in abscisic acid while Flu+ABA increased tuber weight per plant compared with ABA but not fluridone.

Table 3: Effect of fluridone and abscisic acid on tuber number and weight (g)

Treatment	Tuber number	Tuber weight (g/plant)
Control	1.0	22
Fluridone	1.1	33
ABA	1.2	26
ABA+ Flu	1.1	29
SED	0.06	11.8

3.4 Effect of PGR treatments on *D. alata* tuber dormancy at 75 days after vine emergence

All the tissue sections examined showed no internal signs of sprouting. In all tissue sections, the meristematic regions were found inner to the region of parenchyma cells and it was about 2 to 3 cell layers thick. The cells were flattened and oval in shape. Below the layer of meristematic cells was a large area of parenchyma cells containing starch grains. Thus, the application of 10 μ M Flu and 5 μ M ABA + 10 μ M FLU by injecting 1 ml of the chemicals into the PNC prior to tuber formation, did not

clearly prevent the induction of dormancy during early tuber bulking nor did they induce the start of sprouting. It also definitely shows that young *D. alata* tubers are dormant as early as 75 days after vine emergence.

3.5 Effect of PGR treatments on date of sprouting

First sprouting was observed 63 days after harvest at tuber maturity, *i.e.* in mid February 2012. By the end of the sprouting study, *i.e.* by 84 days after harvest at tuber maturity, more than 50% of tubers in all treatments had sprouted. There was no significant difference in days to sprouting across treatments. Thus, the duration from vine emergence to 50% vein emergence was 273 days.

The bleaching effect of fluridone observed as bleached patches on some leaves at three weeks after application, is indicative of fluridone absorption by the tissues of the PNC. Bleaching of vegetative parts of plants treated with fluridone is a well documented characteristic of fluridone effect (Sandmann and Mitchell, 2001; Mulwa and Nwanza, 2006). Bleaching has been associated with the accumulation of the whitish substance phytoene Phytone, which accumulates following the inhibition of the activity of the enzyme phytoene desaturase (PDS) that is important in the conversion of phytoene to carotenoids (Mulwa and Nwanza, 2006).

Although 1 ml of a single application of 10 μ M fluridone had some effect on the morphology of leaves produced from a 25 g sett of *D. alata* three weeks after application, it did not significantly affect shoot growth and development in terms of plant height, leaf number, leaf length and width and leaf dry matter content. Also, the pattern of dry matter partitioning (leaf>root>stem) was unaffected by either fluridone or ABA application. In the work of Suttle and Hulstrand (1994) with potato plantlets, fluridone did not also induce any noticeable effect on shoot growth and leaf morphology even though the duration of tuber dormancy was shortened. Therefore, short term exposure to fluridone may not induce significant effect these traits

However, the increase in root dry weight observed in the fluridone treated plants is associated with increase in root number, which may in turn be associated with lowered root ABA content. Increase in lateral root number and stem branching of fluridone treated plants has been severally reported (Hamadina *et al.*, 2010). Often, root growth increases with reduction in ABA content of roots (Zeevaart and Creelman, 1988) as well as under conditions of stress such as water stress. Fluridone

perhaps increases root dry weight and number due to its ability to inhibit the biosynthesis of ABA (Srivastava, 2002; Lindgren *et al.*, 2003; Mulwa and Nwanza, 2006).

A single pre-tuber application of 5 μ M abscisic acid (ABA) to the PNC of *D. alata* plants significantly reduced the number of nodes at 8 WAT and RDW compared with the control. Absciscic acid is known to play significant role in plant growth and development; inhibiting plant growth and promoting dormancy in dormant organs (Suttle and Hulstrand, 1994; Suttle, 2004, Kim *et al.*, 1994; Hamadina *et al.*, 2010). The observed effect of ABA on number of nodes and RDW represents a typical response to ABA. However, ABA did not significantly affect plant height and the leaf parameters measured. Similarly, ABA did not induce leaf formation in studies with bulblet, (Kim *et al.*, 1994) but it stimulated tuber formation, in-vitro, in *D. alata* (Ammirato, 1976) and in *D. rotundata* (Hamadina *et al.*, 2010). Also, ABA regulates various processes of assimilate uptake and metabolism to enhance assimilate accumulation in the tuber (Peng *et al.*, 2003; Pan *et al.*, 2005).

The application of ABA two days after fluridone did not significantly increase plant height, leaf number, leaf length and width as compared with the control but it increased the number of nodes at 8 WAT as compared with ABA. Throughout this study ABA + fluridone tended to increase all growth parameters than ABA alone and sometimes fluridone alone. Kim *et al.*, (1994) have also observed that ABA did not induce leaf formation, but the addition of fluridone after ABA caused leaf formation. Also, root length was shown to increase when fluridone was applied after ABA to maize plants that were exposed to moisture stress (Sharp and Le Noble, 2001). The result of this study therefore suggests that the application of fluridone after ABA may reverse the growth effect of ABA in *D. alata*. Further studies may be conducted to confirm this in *D. alata*. For example, endogenous ABA content of the plant can be measured at regular intervals during plant growth in each treatment to confirm whether fluridone can cause a decline in ABA content of *D. alata*.

In this study, the bleaching effect of fluridone wore off fast before or during tuber formation. If the quick return of relatively green leaves, observed in this study, is symptomatic of a reducing effect of fluridone with later development (Hamadina *et al.* 2010), this may explain why fluridone had no obvious effect on renewed shoot growth/sprouting. Since fluridone is required to inhibit the biosynthesis of the dormancy promoting plant growth regulator ABA, then 1 ml of a 10 μ M fluridone may be inadequate to sustain the inhibition of tuber dormancy in seed tubers originating from a 25 g tuber sett. To successfully prevent dormancy in young seed tubers that are formed from a 25 g tuber

sett, further studies will be required to determine the most effective duration of treatment in fluridone as well as the most effective timing of the application of fluridone.

4. CONCLUSION

In conclusion, this study has shown that: a single pre tuber application of 1 ml of 10 μ M fluridone can cause bleaching of leaves of *D. alata* plants three weeks after treatment, 1 ml of 10 μ M fluridone can significantly increase the number of nodes per plant and root dry weight, a pre tuber application of 1 ml of 5 μ M ABA can reduce root dry weight and number of nodes produced per plant while the application of fluridone two days after ABA will moderate the effects of ABA, and that 1 ml of a 10 μ M fluridone is inadequate to sustain a fluridone effect, which is required to inhibit the induction of dormancy during early tuber development. This study has provided some information on the possible role of ABA in the regulation of yam growth. Thus to double yam cycle per annum through the prevention of seed tuber dormancy, yam plants derived from the propagation of tubers portions may need to be exposed to fluridone for a prolonged period of time.

ACKNOWLEDGEMENT

The authors wish to thank IITA, Ibadan, Nigeria, and Dr Asiedu in particular for accepting to provide laboratory space and facility for carrying out the anatomical study reported here. We also appreciate the assistance of Mr Tammunobelega Solomon in formatting the manuscript prior to submission.

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