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Nitrogen Fertilization and Residual Fluridone Effects on Maize Sown in Sandy Loam Soils of the Niger Delta

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Abstract:
Background*: This study questioned whether Fluridone could persist beyond 12 months in the slightly acidic sandy loam soil of the Niger Delta, Nigeria, when its channel of contact with the soil was direct via irrigation water or indirect through foliar spray. It also questioned whether soil nitrogen fertilization affects the expression of the characteristic Fluridone toxicity effects in maize plants (bleaching of leaves).*
Materials and Methods*: Using the heavy feeder maize plant in a screenhouse bioassay, this experiment consisted of three soils collected after a yam Fluridone study in which 30 µM Fluridone was applied to the soil via irrigation water (SFIA), foliar spray (SFFA) or without Fluridone (NF). The soils were then stored up in the dark under ambient conditions for 12 months. There was also, three nitrogen rates 0, 100 and 150 kg N/ha. Thus, this study was a 3×3 factorial experiment arranged as completely randomized design with three replicates.*
Results*: Bleached leaves were observed only on maize plants grown in soil previously exposed to Fluridone via irrigation indicating that Fluridone was still present, potent and hence persists for up to 12 months when applied directly to the soil via irrigation water but not when applied via foliage. Increasing soil N to the recommended levels for maize cultivation in Rivers State (100 kg N/ha) increased in number of bleached leaves during the early growing weeks while at later weeks (when the effect of Fluridone was weaning off), 150 kg N/ha reduced the number of bleached leaves. Fluridone does not however lead to significant negative effect on many other growth attributes including germination, leaf length and plant height.*
Conclusion: *If Fluridone must be used on arable land, care must be taken to reduce its contact with soil particularly those that are high in organic carbon. The practice of split N applications, which occurs during later growth phase, may help improve the greenness of partially bleached leaves.*
Key Word*: Fluridone, environmental pollution, maize, nitrogen fertilization*

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I. Introduction

Fluridone ($C_{19}H_{14}F_3NO$) is an herbicide that was invented more than four decades ago and formulated originally for the control of weed on cotton farms. It is more commonly used in the control of aquatic weeds, and sometimes in the control of glyphosate resistant weeds on arable land[1,2,3]. Fluridone has many other nom-herbicides uses. It has been found useful in the breaking and prevention of seed and tuber dormancy in inherently dormant plants and to promote seedling emergence[4,5,6,7]. Also, Fluridone is being tested for potential use as analgesic drug on mammals[8]. Fluridone is known to work by inhibiting the activity of the enzyme phytoene desaturase, which facilitates the conversion of the phytoene (a colourless carotene) to carotene (coloured carotene) in the plastids[9]. Although carotenes are known to protect green the colouring pigment (chlorophyll) in leaves from degradation by light they also serve as the precursor substance in the biosynthesis of abscisic acid (ABA; a plant hormone that play roles in stress tolerance and plant growth regulation). The action of Fluridone causes the accumulation of the whitish substance phytoene, reduction in carotene level, the development of bleached leaves (a characteristic Fluridone effect) and then death of the affected plants.
Fluridone is has been shown to induce the Fluridone effect on plants whether applied in water bodies, directly on the soil or via foliar spray.

In water bodies, Fluridone is only effective over a short period where its half-life range between 1 to 6 days[10,1]; https://pubchem.ncbi.nlm.nih.gov/compound/fluridone). Photolysis is thought to be the major mechanism by which Fluridone is degraded in water bodies[10]. Thus, it is not persistent in water and not known to cause harm to animals[1] (https://pubchem.ncbi.nlm.nih.gov/compound/fluridone). In soils, the maximum persistence of Fluridone is still not known for many soil types. Fluridone finds its way into the soil through, direct or indirect pathways. Directly through irrigation water, as pre-planting or pre-emergence herbicide[1] or

indirectly through exudates from foliar treated plants, or as aerosols falling unto the soils during foliar sprays. Its short to medium term persistence in some soils and sediments have been reported with the duration varying from 20-240 d. Clearly, this tells that Fluridone persists in soils longer than in water[11,12,13,14]. The persistence of Fluridone in soils have been attributed to the fact that it is adsorbed easily to the organic matter and clay minerals in soil. Since its persistence in soils is regulated by pH, temperature, organic matter, and clay and moisture contents of the soil[11] underscores the need to determine the persistence of Fluridone in the sand loamy soils of the Niger Delta under the prevailing weather conditions.

Persistence beyond 12 months of Fluridone in the sandy loamy soil of the Niger Delta have not been reported. Until this study, results of past works have shown that Fluridone persists in the sandy loamy soil of the Niger Delta for only up to 240 days[12,13]. The need to investigate whether Fluridone can remain in the soil for longer than 240 d is important for terrestrial agriculture and marine environmental management[15,16]. In the insightful report in a first cycle maize[14] was shown to exhibit bleached leaves when grown on Fluridone contaminated soil but not when grown as a second crop in a relay after groundnut. Since groundnuts have natural capacity to fix nitrogen, their findings did not only highlight the need to determine whether Fluridone can remain in sandy loam soil for up to 12 calendar months it stirred the need to determine whether there is a link between soil nitrogen level and the expression of Fluridone effect. Nitrogen (N) is an essential plant nutrient and an important component of plant nucleic acid, chlorophyll, enzyme, and hormone biosynthesis. Its content in leaves has been shown to be closely related to chlorophyll content[17, 118], which controls the greenness of green plant parts. Furthermore, soil N fertilization is known to readily improve maize growth, tissue N and chlorophyll content[19]. Therefore, the objectives of this research were to: (1) determine, in a maize bioassay, whether Fluridone was present in the sandy loamy soil of the Niger Delta 12 months after its exposure to 30 µM Fluridone via irrigation water (SFA) and via foliar spray (FFA), and (2) determine the effect of three soil nitrogen (ammonium nitrate) fertilization levels on the expression of Fluridone effect.

II. Material And Methods

Experimental site

This experiment was a Fluridone bioassay in which maize was the test plant, and it was conducted in a screen house in Port Harcourt, Nigeria (4° 54.2' N and 6° 55.0' E). Temperature, relative humidity in the screen were measured daily while photosynthetically active radiation (PAR) was measured using a quantum PAR meter (Hydro Farm product, USA). The soils used in this experiment were collected at the termination of an experiment involving the application of 30 µM Fluridone to yam plants via foliar sprays (FFS) with the soil covered up to prevent direct soil contact or via soil irrigation (SFA) or no Fluridone (NF). Details of the methods, which examined the effect of Fluridone on the physiology phenomena of yam dormancy, have been described[6,7]. The soils are coastal plain soils under humid tropical conditions that are inherently infertile, requiring fertilization, especially N to sustain production[20].

The respective soils from the three replicates were homogenized and stored up for 12 months in a black polythene bag under the ambient conditions in the screen house. Prior to the commencement of the study, soil sample were taken for the analysis of N, P, K, Ca, and Mg content, pH and soil moisture holding capacity/field capacity. During the experiment, soil moisture was monitored using soil probe and soil moisture was maintained at field capacity (FC) by adding any needed water.

Test Plant

Maize Oba Super 6 variety was used as the test plant. It is an open pollinated maize hybrid. It is well adapted to the conditions in Nigeria including tolerance to low soil nitrogen and with fairly-high yield records (7-8ton ha^{-1}). Oba Super 6 is produced by Premier Seeds Ltd. Two were sown and thinned to one seedling per pot at two fully opened leaf stage. Maize was chosen for this study because it is a high nitrogen (N) requiring plant, its response to Fluridone and nitrogen fertilization individually are well known but its response to Fluridone in vary N status is not well known.

Treatment and experimental design

The experiment consisted of three soil levels and three nitrogen rates. The soil levels were: soil collected from a previous no Fluridone treatment (control; NF) and then stored up for 12 months, soil from a previous 30 µM Fluridone foliar spray treatment (FFS) and then stored up for 12 months, and soil from a previous 30 µM Fluridone soil irrigated treatment (SFA) and then stored up for 12 months. The nitrogen levels were: No nitrogen (0 N), nitrogen at recommended rate for Rivers State (100 kg N/ha) and nitrogen at 50% greater than the recommended (150 kg N/ha. Thus, there were two factors each at three levels making a 3x 3 factorial experiment with nine treatment combinations. The experiment was laid out as a completely randomized design (CRD) with three treatments replications. There were four maize plants per treatment per replication and one plant per perforated pot containing 250 g soil.

Treatment application

The major nitrogen source was ammonium nitrate while phosphorus and potassium were applied as calcium phosphate and potassium nitrate respectively. Following the recommended fertilizer rate of 20N:15P:5K for cereals cultivation in Rivers State (FISS NCA, 2016) and a nitrogen application rate of 100 kg/ha, the corresponding phosphorus (P) and potassium (K) levels per pot was applied. Full dose phosphorus and potassium were applied before planting (basal application) to all treatments. Nitrogen was applied in three splits at planting, 5 and 10 days after emergence (DAE). Nitrogen was applied at 5 DAE (i.e. 8 DAS) because earlier studies have shown that Fluridone effect is observed by the expansion of the third leaf, which appears to occur between 6 and 10 DAS[13,14].

Since nitrogen is normally applied in two or three splits corresponding to different maize growth stages (at planting and/or at V5 stage and at tasseling), and because this experiment was designed to terminate well before tasseling only 1/3 of the total N requirement was applied. Since potassium nitrate contains small amounts of nitrogen, the percentage of the 1/3 required was determined. Thus, the percentage of the 1/3 required N applied through potassium nitrate prior to planting was 26.84% and 17.9% in the optimum and 50% above recommended treatments respectively. The remaining nitrogen was applied through the major N source (ammonium nitrate). All nutrients were applied in liquid form dissolved in distilled water.

At 5 days after planting (*i.e.*, at 3 days after 50% emergence), 36.58% N and 41.05% N was applied. This marked the second application/split of the 1/3 required quantity of nitrogen. At this stage therefore, the soil had received 63.42% and 58.85% of the 1/3 required quantity of nitrogen in the recommended and 50% above recommended treatments respectively. Since the expected timing of the first appearance of bleaching was 6 days after planting[12,13,14], nutrient application at this date was important in order to ensure that more at least 50% of the 1/3 required nitrogen was applied. Since the nitrogen was applied in the nutrient form, it was also hoped that the treated plants would quickly absorb considerable quantity of nitrogen prior to the estimated timing of the appearance of bleaching. At 10 days after planting, the last application of nitrogen (36.58% N and 41.05% N in the optimum and 50% above optimum treatments respectively) was done. This application was so timed to increase the likelihood of maintain adequate nitrogen levels in the plant tissue during the Fluridone expression phase.

Data collection

Emergence:

Pots were observed daily for shoot appearance and date of emergence. Percentage emergence was calculated by dividing the number of plants per treatment by the number of emergences multiplied by 100. Date of 50, and 90% emergence were noted.

Bleaching effect:

Plants were observed at two days interval for the onset of bleaching. Date of first sign of bleaching was noted. Thereafter, the number of bleached leaves per plant was counted at two days interval.

Vegetative growth data:

Plant height was measured, from the base of the plant to the tip of the longest leaf. Height measurements were carried out at 2 days intervals beginning from 8 days after sowing (DAS). Number of leaves per plant was determined by counting. Leaf length and width was measured with the widest width conserved as the leaf width. Leaf chlorophyll content was measured at 2 days intervals using atLEAF® STD chlorophyll meter. Two spot measurements per leaf was made and this was done on all leaves per plant to reflect to increase accuracy of data. The *at*LEAF® meter estimates chlorophyll content based on the algorithms derived from the transmissions of red light at 660 nm (where chlorophyll absorbs light) and infrared light at 940 nm wavelength (where no light is absorbed by chlorophyll). The meter compares the transmissions to give the measure of chlorophyll content. Chlorophyll value of 35 and above suggests that a plant is healthy with adequate nitrogen content (https://www.download.atleaf.com/mainp). Since the concentration of chlorophyll is approximately proportional to leaf tissue nitrogen content[17,18] chlorophyll measurements in this study are expected to reflect nitrogen content.

To determine dry mater content, one plant per treatment per replication was sampled and partitioned into its component parts. shoots and roots were harvested by neatly cutting the seedlings at the base (soil surface) to obtain the shoots, while and the roots were washed gently to separate the roots from the soil medium. The shoots and the roots were dried at 70°C to constant weight using a forced air oven.

III. Result

Growing environment

Property of Soils prior to inorganic nutrient application

Analysis of the soil status prior to inorganic nutrient fertilization showed that all three soils were slightly acidic (Table 1). Soil organic carbon, nitrate nitrogen, ammonium-nitrogen, available P and K level were low to moderate in the soil without residual Fluridone (NF), mostly low in the soil from treatment where Fluridone was applied by foliar spray (FFA), and mostly moderate to high in the soil from the treatment where Fluridone was applied by irrigation (SFA). Thus, apart from the presence of very low ammonium nitrogen in the SFA soil, nutrient status was generally better in SFA than other soils.

Table 1: Selected chemical properties of experimental soil exposed

Parameters	NF	FFA	SFA
Soil pH	6.5	6.0	6.5
Organic C (%)	M (0.5-0.75)	M (0.5-0.75)	H (>0.75)
NO_3^-N (kg ha^{-1})	M (10-25)	L (5-10)	H (>25)
NH_4^+-N (kg ha^{-1})	L (0-10)	L (10-20)	VL (0-10)
Available P (kg ha^{-1})	M (10-25)	L (0-10)	H (25-40)
Available K (kg ha^{-1})	L (<60)	L (<60)	M (60-160)

NF =No Fluridone, FFA = Foliar Fluridone Application, SFA = Soil Fluridone Application
VL = Very Low, L = Low, M = moderate, H = High

Temperature and relative humidity of during plant growth

Relative humidity was generally highest (approx. 90%) during the morning hours and lower (approx. 80%) during the afternoon and evening hours (Fig.1). Temperature increased until the afternoon and decline as the evening approached. The trends observed in this study are normal and indicates that temperature and relative humidity during the study period were within optimum conditions for growth.

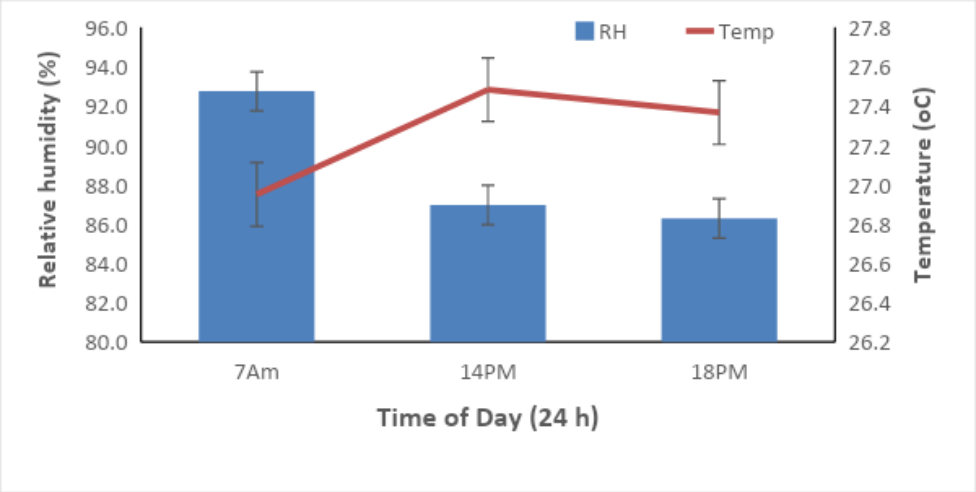

Fig. 1. Average ambient air temperature and relative humidity

Seedling emergence

There was no significant ($p<0.05$) effect of soil on duration from sowing to seedling emergence. Most seeds germinated by the third DAS and was complete by 4 DAS under all the soils tested. By the 5 day after emergence (DAE), the number of fully expanded leaves was two in most treatments and no significant difference was observed in number of green leaves across treatments. Thus, the relative difference in nutrient levels of the soil, at the commencement of the study, did not affect germination and early seedling growth.

Effect of soil and nitrogen levels on number of bleached maize leaves during growth

The first indication of bleaching was observed when the third leaf opened, which occurred at about 9 DAS. Leaves varied in degree of bleaching; from spot, partial to bleached whole leaf and the degree of bleaching increased per leaf increased with time.

Data collected 2 days after nitrogen application and thereafter showed that number of bleached was affected by soil (mostly) and nitrogen rate. Soil significantly ($P<0.05$) affected number of bleached leaves throughout the study while the effect of nitrogen rates was significant only at the first sampling date (i.e., at 10 DAS). The interaction effected was significant at 10 and 14 DAS. Throughout the observation period (10, 12, 14, 16 and 20 DAS), bleached leaves were observed only on plants grown on soil in which Fluridone was applied to the soil

via irrigation water (SFA) (Fig.2). Within the SFA soil, the number of bleached leaves increased with days until 16 DAS and then declined. The development of bleached leaves (Fluridone effect) under SFIA only was a significant finding.

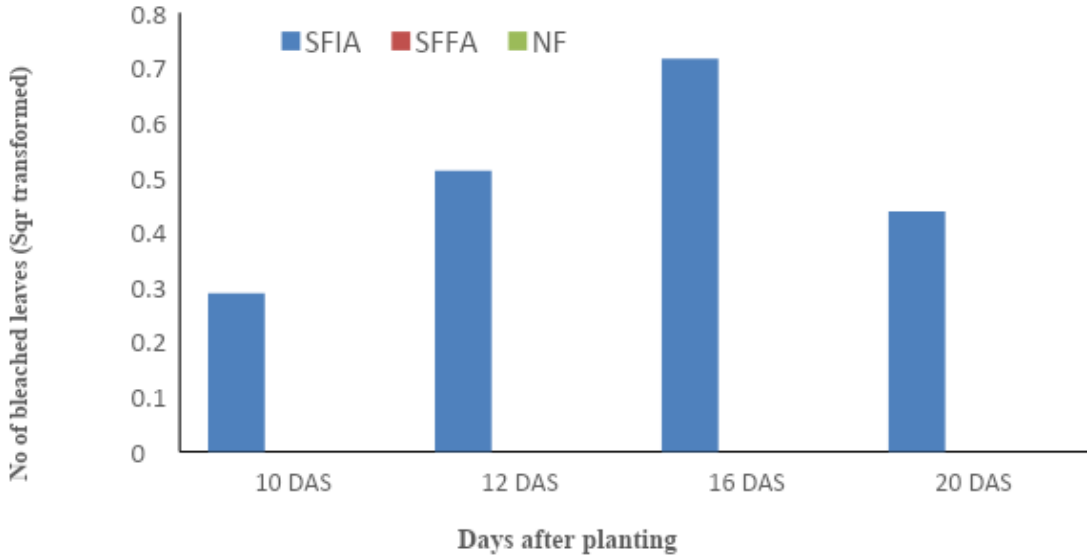

Fig. 2. Effect of soil on total number of bleached maize leaves during growth

The number of bleached leaves within the SFA varied depending on nitrogen rate applied and this was most evident at 10 DAS (Fig. 3). At 10 DAS (i.e., 2 days after second N application), bleached leaves were observed on control plant as well as under all nitrogen rates tested. The number of bleached leaves on this date was significantly ($P<0.05$) higher in the presence of nitrogen at 100 kg N/ha than in the control; being more than double the number in the control while 150 kg N/ha significantly reduced the number of bleached leaves compared to 100 kg N/ha but increased it compared with the control. The trend observed at 10 DAS was essentially the same as that at other dates except at 12 DAS where the number of bleached leaves under 100 kg N/ha did not significantly vary from that under 150 kg N/ha. Thus, generally, it appears that when Fluridone is most potent and soil N is raised via fertilization, number of bleached leaves is increased (particularly by 100 kg N/ha) but as the effect of Fluridone weans the difference between number of bleached leaves in the control and nitrogen treatments becomes insignificant with high N tending to reduce the number of bleached leaves.

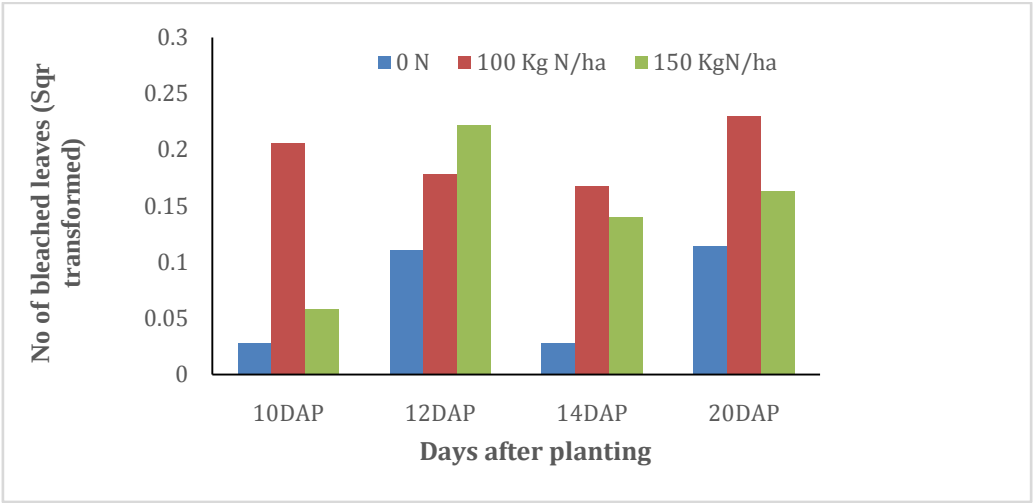

Fig. 3. Effect of nitrogen rates on number of bleached maize leaves during growth of maize in soil that

Effect of soil and nitrogen on number (square root transformed) of green maize leaves during growth

Soil (SFIA and SFFA) and the interaction of soil and nitrogen rate did not significantly affect number of green leaves. Number of green leaves was however, significantly affected by nitrogen rate particularly at 10 DAS (Table 2). The mean number of leaves per treatment was significantly increased by the application of 100 kg N/ha compared to the control and 150 kg N/ha. Higher N rate (150 kg N/ha) on the other caused a decline in number of leaves compared with 100 kg N/ha. Therefore, 100 kg N/ha encouraged green leaf development better than the control while leaf development was negatively affected when N rate was 50% above the recommended rate.

Table 2: Effect nitrogen levels on number (square root transformed) of green leaves at 10 DAS

Nitrogen	No of leaves
0 kg N/ha	1.104
100 kg N/ha	1.337
150 kg N/ha	1.032
LSD (p<0.05)	0.244

Effect of soil and nitrogen on vegetative growth parameters

Plant height

Mean plant height before N fertilization (i.e., at 8 DAS) was 10.1 cm with the tallest (10.8 cm) plants found in the SFIA treatment and the shortest in the control (9.5 cm). Although the differences between soils was not significant at p<0.05, the trend indicated that SFIA promotes seedling growth. Only nitrogen rate was found to significantly affect plant height at 10 DAS (i.e. two days after 50% N application), 12, and 14 DAS (Table 3). At the end of the study, neither soil nor N rates had significant effect on plant height. The trend however showed that plants were slightly taller in SFA (27.8 cm) followed by FFA (26.9 cm) and then NF (23.7 cm) while height was most improved under 100 kg N/ha (27.9 cm) and lowest under 150 kg N/ha (24.3 cm). Therefore, irrespective of the soil, N fertilization significantly increased plant height at the listed dates with the application of the recommended 100 kg N/ha resulting in about 2 cm taller plants compared with the control, and 150 kg N/ha causing up to 4 cm reduction in plant height compared to 100 kg N/ha.

Table 3: Effect of nitrogen rates on plant height at 10, 12 and 14 DAS

Treatment	10 DAS	12 DAS	14 DAS
0 kg N/ha	11.9	13.8	16.1
100 kg N/ha	14.4	16.2	18.5
150 kg N/ha	10.7	12.4	14.9
LSD	2.12	3.95	4.34

Leaf length and width

Prior to N fertilization, mean leaf length and width were 7.6, 7.7 and 9.4 cm, and 0.933, 1.02 and 1.11 cm for NF, FFA and SFA respectively. With LSD values of 1.524 and 0.136 for the leaf length and leaf width data, the result indicated that leaf growth was promoted by soil containing FLU. Days after the application of N, leaf length was also found to be promoted by both soil and N rate treatments (Tables 4, 5 and 6) with most of the effect on leaf growth being associated with elongation by length than width. Generally, soil had greater effect on leaf dimension than N rate. Soils that received 30 UM FLU via irrigation (SFA) were found to significantly (P<0.05) increase length and by at least 4 cm by the end of the study. The application of 100 kg N/ha increased leaf length compared to the control while 150 kg N/ha caused a reduction in length and leaf width compared with the control or 100 kg N/ha treatment.

Table 4: Effect of soil and nitrogen rates on leaf length at 10 DAS

Treatment	0 kg N/ha	100 kg N/ha	150 kg N/ha	Mean
NF	7.2	9.9	7.1	8.2
FFA	8.0	10.0	14.9	7.9
SFA	9.8	10.2	9.1	9.8
Mean	8.3	10.1	7.1	
$LSD_{soil\ (P<0.05)}$	1.251			
$LSD_{N\ (P<0.05)}$	1.255			
$LSD_{Int\ (P<0.05)}$	2.182			

Table 5: Effect of soil and nitrogen rates on leaf length at 12 DAS

Treatment	0 kg N/ha	100 kg N/ha	150 kg N/ha	Mean
NF	10.4	9.8	8.7	9.7
FFA	9.08	10.9	6.1	8.8
SFA	10.5	10.9	8.8	10.1
$LSD_{soil\ (P<0.05)}$	1.251			

$LSD_{Int\ (P<0.05)}$	2.182

Table 5: Effect of soil on leaf length at 14 and 20 DAS

Treatment	14 DAS	20 DAS
NF	10.3	11.7
FFA kg N/ha	9.8	12.9
SFA	10.2	16.0
LSD	1.323	2.684

IV. Discussion

The characteristic bleaching effect of Fluridone on leaves of treated plants was observed as earlier as This study has shown that Fluridone can persist on the slightly acidic sandy loam soil of the Niger Delta for up to 12 months if the mode of contact is through irrigation. Its persistence was evident by the expression of the characteristic Fluridone effect (development of bleached leaves and other plant parts) on the heavy feeder crop, maize, in a bioassay. Since bioassays are credible avenues for assessing the effect of herbicides etc. on living dicot and monocot tissues[1], the result presented here provides useful information for agriculture and environmental management. The observed bleaching is a clear fact that Fluridone was present in the soil even after 12 months, it was taken up by the maize plants and utilized in reactions that had strong enough effect to cause bleaching. Fluridone is thought to cause bleaching due to its inhibitory action on the activity of the enzyme (phytoene desaturase) involved in the conversion of phytoene (a colorless carotene) to the colored carotene (a protector of chlorophyll from destruction by light)[21,24]. The persistence of Fluridone for up to 12 months in the sandy loam soil of the Niger Delta has not been earlier reported. Previous studies had only reported Fluridone persistence in contaminated soils over short periods (<240 d). From their studies Fluridone persistence of up to 3 months have been reported in sediments with or without clay or organic matter enrichment and under different light and temperature regimes have been reported[26]. Its persistence for up to 240 d in sandy loam soil of the Niger Delta of Nigeria have been reported[12,13,14] and in water for 1-6 days have been shown. The long (12 months) persistence of Fluridone shown in this study cannot be easily explained by the experimental design since its objectives were mainly to assess the presence of Fluridone in the test soil and its relationship with soil N level. Nonetheless, based on existing evidence[1,23], this study suggests that the persistence of Fluridone in the slightly acidic sandy loam soil of the Niger Delta may be attributed to the high tendency of Fluridone to attach to soil organic matter, which was observed to be medium to high in level. The observed weaning off tendency of the Fluridone effect with time; seen in this study as well as other plant and soil studies[24,25,23], suggests that this seemingly negative presentation of whitish leaves is temporary and short lived. The number of bleached leaves reduces after a peak number is attained due to the dropping off completely bleached leaves (as in this study), reduction in the number of new bleached leaves and as some partially bleached leaves gradually regain greenness[24,26,26]. In short duration fast growing plants, with less time available for the plants to return to normal growth, however, the effect of Fluridone may be more drastic.

In contrast to the above, Fluridone effect was not expressed when maize seedlings were grown on soil collected from a site where 30 µM Fluridone was applied via foliar application on yam plants and then kept in the dark under ambient conditions for 12 months. This result suggests that the Fluridone in the soil had degraded by the 12th month or was too weak to induce any significant Fluridone effect. This conclusion was reached because slight bleaching of maize leaves had been reported for same soil when it was assessed at about 3 months[14], 7 months[12] and 8 months[13] after Fluridone application. Since Fluridone indirectly enters soil matrix through root exudates from foliar treated plants, particularly where measures were taken to prevent direct soil contact[1] this study has shown that such weak presence of Fluridone is lost at about 12 months after application.

Under nitrogen fertilization, Fluridone was found to be even more potent (i.e., increased number of bleached leaves) when soil N was raised, particularly at 100 kg N/ha, during the early growth stages As the effect of Fluridone weaned off on later weeks however, the difference between number of bleached leaves in the control and nitrogen treatments got narrower and insignificant with high N (150 kg N/ha) tending to reduce the number of bleached leaves. Similar trend was reported in a yam study[2]. Why this happens is not very clear. However, since the soil containing Fluridone in this study (SFA) was found to contain medium to high soil N content and since the presence of Fluridone in soil has been shown to support N uptake[27], it may follow that the additional supply of 100 kg of inorganic N/ha to sunlit plants during the Fluridone active phase could have led to the accumulation of photosensitizers and hence increased bleaching. Photooxidation of photosensitizers such as chlorophyll and protoporphyrin ix has been reported[28,22].

The response of green plants (grown on NF or SFA soils) and green parts of plants grown on Fluridone containing soil (FFA) to nitrogen fertilization was different compared to those of bleached leaves. Nitrogen fertilization increased the number of green leaves per treatment irrespective of soil Fluridone status. It also increased leaf length rather than leaf width as well as plant height. This effect of N fertilization on growth of

attributes of green plants (grown on NF or SFIA soils) and green parts of plants grown in Fluridone containing soil (FFA) is usual since it increases tissue N and chlorophyll content, and hence increased photosynthesis.

V. Conclusion

This study has shown that Fluridone can persist in the slightly acidic sandy loam soils of the Niger Delta for at least 12 months if the Fluridone is applied directly to the soil via irrigation. While present in the soil Fluridone will affected green plant part to bleach or cause affected newly developing leaves to bleach. On the other hand, when Fluridone is applied via foliar spray, the potency of the Fluridone in the soil is lost by the 12th month after application. Increasing soil N to the recommended levels for maize cultivation in Rivers State (100 kg N/ha) led to increase in number of bleached leaves during the early growth weeks while at the later growth weeks (when the effect of Fluridone was weaning off), 150 kg N/ha reduced the number of bleached leaves. Fluridone does not however lead to significant negative effect on many growth attributes including germination, leaf length and plant height. Further studies may be conducted to provide full explanation on how nitrogen might be interacting with Fluridone. If Fluridone must be used on arable land, care must be taken to reduce its contact with soil particularly those that are high in organic carbon. The practice of split N applications, which occurs during later growth phase, may help improve the greenness of partially bleached leaves.

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