European Journal of Biotechnology and Bioscience
www.biosciencejournals.com
ISSN: 2321-9122
Received: 18-12-2021, Accepted: 03-01-2022, Published: 19-01-2022
Volume 10, Issue 1, 2022, Page No. 1-6

Rates and time of iodine agronomic bio-fortification on yield and quality of bell pepper (*Capsicum annuum*) in rivers state

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Abstract
Pot experiment was conducted at the department of Agriculture, Ignatius Ajuru University of Education to investigate the possibility of agronomic biofortification of bell pepper by fertilization of bell pepper using potassium iodide. The 3 x 4 factorial experiment had treatments as time of application (2 weeks after planting (WAP, 4 WAP, 8 WAP) and rates of application of potassium iodide KI; (0 g; 0.25 g; 0.5 g and 1.0 g), replicated three times fitted in randomized complete block design. The parameters measured were plant height, number of leaves, number of branches, number of fruits, fruit length, fruit girth fruit weight and iodine content in the fruit. Results indicate that time and rate of iodine application did not retard plant height, number of leaves and leaf area but rather favored vegetative growth and yield of bell pepper. Delayed application favored vegetative growth and yield. Application at the rate of 0.5 g KI at 8 weeks after planting favored vegetative growth and yield. Deferred or delayed application of 8WAP significantly favored plant height, vegetative growth, and yield. Increasing levels of KI increased plant height, number of leaves, number of branches, number of fruits, fruit length, fruit girth and fruit weight from 0g to 0.5 g KI after which it declined. The variation of values observed were significant and due to the different time and rates of application. Time and rate of fertilization of bell pepper with iodine lead to retention of iodine the fruits of bell pepper. Increasing levels of iodine fertilization increased the retention of iodine the bell pepper fruits. The amount retained beyond 0.5 g KI was not significant. Since application rate above 0.5 g KI depressed plant height and vegetative characteristics of bell pepper, application rate of 0.5 g KI at 8 WAP will favor vegetative growth, yield and iodine retention (agronomic biofortification) in bell pepper.

Keywords: bell pepper, iodine-biofortification, growth, yield

Introduction

Micro-nutrients such as iodine are important in human health, and they have been reported to constitute major deficiency problems especially in the developing regions of the world (McWilliams, 2011) [14]. Nutrient deficiencies pertain mainly to protein and micronutrients like vitamin A, Iron, Zinc, Selenium and Iodine. Majority people in Asia, Africa and the suburbs of south and central America are deficient or live below the recommended levels of vitamins and micronutrients such as vitamin A and Iodine. (McWilliams, 2011) [14].

Iodine is a major constituent in the proper functioning of the thyroid gland where it reacts with tyrosine an amino acid to produce thyroxin a hormone that manages the body metabolic rate and boost growth and development. Iodine deficiency instigates enlargement of the thyroid gland a condition known as goiter which makes the patient to be sluggish (hypothyroidism) and to gain weight (Abraham et al., 2002) [1]. The World Bank (1994) estimated that about 228 million people have expressed iodine deficient as goiter. This iodine deficiency disorder is as with other micronutrient deficiencies are preventable with diet (Welch and Graham 1999) [24].

The established approaches to combat these deficiencies involves use of dietary supplements, diets comprising fruits, vegetable and super foods such as blue berries, quinoa, kale, lentils and avocados. This category of the third world populace depends on single carbohydrate staples and do not have access to “super foods” daily, that help the body to prevent disease and enhance quality of life. However, Nestel et al. (2006) [15]. Suggested that the introduction of biofortified popular crops with higher nutritious content like bell pepper a vegetable fruits has a promising potential to combat micronutrient deficiency such as iodine.

Biofortification can be defined as increasing the concentration of minerals and vitamins in edible parts of plants that efficiently improves the consumer health (White and Broadley, 2009; Yang et al., 2007; Zhao and McGrath, 2009) [25, 27, 28] either by genetic or agronomic means of fertilization. It differs from food fortification because it focuses on making plant or crop produce more nutritious, rather than having nutrients added to the foods when they are being processed. Biofortification is a strategy that aims to concentrate more nutrients in staple food crops to supplement diets that are already over dependent on carbohydrate staples (Johns and Eyzaguirre, 2007) [11]. It capitalizes on the consistent daily intake of food staple, thus indirectly targeting low-income households who cannot afford a more diverse diet. Peppers are common condiments used for cooking in the developing world and it is a right choice for biofortification. One of the commonly used pepper species is the sweet bell pepper, *Capsicum annuum*.

Sweet Pepper (*Capsicum annuum* L.), also known as bell pepper, green pepper, or Pimento, belong to the family Solanaceae (Olanrewaju and Showemino, 2006; Kabura, et al., 2009) [9]. It is a warm season annual crop when grown in temperate regions and an herbaceous perennial when cultivated in tropical areas, bell pepper is considered "sweet" since it lacks the pungent chemical (capsaicin) present in hot pepper. It is an important vegetable crop all over the world, which ranks third in the vegetable cycle after tomato and onion (Akinfasoye, et al., 2006) [2]. Green pepper is a delicious vegetable that can be enjoyed either raw or cooked. In Nigeria, its cultivation which originally confined to the drier savannah regions in the north, is now gradually gaining ground in the southern parts of the country. Green pepper is an excellent source of antioxidants, vitamin A and C as well as nerve-supportive vitamin B6. It is also a very good source of heart-healthy fiber, vitamin E, folate, potassium, and vitamin K as well as the enzyme-supportive molybdenum.

Statement of Problem.

Micronutrients including iodine constitute the main nutrient deficiencies and 43 percent of the African populace are consuming below the recommended levels of iodine (McWilliams, 2011) [14]. Iodine is an essential trace mineral nutrient in humans, required to produce thyroid hormone. It occurs in food and human body in the ionized form called iodine. The thyroid gland combines iodine with amino acid tyrosine to produce thyroxin and triiodothyronine hormone that control the body idling speed (basal metabolic rate) and support normal growth and development. Symptoms of iodine deficiencies include sluggishness (hypothyroidism), weight gain and in extreme case an enlarged thyroid gland (goiter) (Abraham et al., 2002) [1].

To correct iodine deficiency, inclusion of iodine in edible salt (iodized salt) has been recommended and it has become the most common, simple and economic way of iodine supplementation in human diet. However, salt which is the main source of sodium in human diet has long been known to increase blood pressure (Jacobson, 2009) [10] and its excess consumption is the main contributor to increased occurrence of cardiovascular disease (Smolen and Sady, 2011) [20, 19].

Iodine application in small doses can improve plant growth and development (Borst-Pauwels, 1961) [7]. On the other hand, excessive iodine fertilization can induce plant damages manifested initially as marginal chlorosis and necrosis of older leaves. In the younger leaves excess uptake of iodine cause dark green pigmentation and in extreme cases whole plant death occur (Mackowiak and Grossl 1999, Mackowiak et al., 2005) [12, 13]. The effective dose for biofortification with little or no effect on bell pepper growth and yield is a focus of this study.

Objectives.

The general objective of this study is to determine the effect of iodine application on the performance and agronomic biofortification of iodine on bell pepper.

The specific objectives of this study are to evaluate the effect of:

1. Rate and time of Iodine application on growth of bell pepper.
2. Rate and time of iodine application on the yield of bell pepper.
3. Rate and time of iodine on iodine absorption (agronomic biofortification) in bell pepper fruits.

Materials and Methods

Study Area

The experiment was conducted at the teaching and research farm of the Department of Agriculture Science, Ignatus Ajuru University of Education, Ndele Campus, Rivers State Nigeria. Ndele falls on (Latitude 4°58" N and Longitude 6°48" E) with the tropical rainforest climatic zone, with all characteristics of humid tropical climate with separate dry and wet seasons. Annual rainfall ranges from 1900 mm and 3000 mm with a relative humidity ranging between 80 and 90 percent (Ansa 2016). The duration of sunshine ranges between 4.1 and 4.9 hours (Nwajiuba and Onyenike 2010).

The materials used were Bell pepper seedlings from ADPs, lines, pecks, polybags, weighing balance (Model SF-400, Digital Scale), and loam soil.

Experimental Design

The factors of the experiment were

1. Rate of application of KI (0, 0.25g, 0.5g and 1.0g)
2. Time of application of KI 4 weeks after transplanting (4WAT); 6 weeks after transplanting (6 WAT) and 8 weeks after transplanting (8WAT).

This gives a 3 x 4 factorial experimental design, replicated three times in a Randomized Complete Block Design as shown in the diagram of the field layout shown below.

The total experimental units were therefore 3 x 4 x 3 = 36 pots or units.

Transplanting of bell pepper

Experimental site will be cleared, and 4.0 m x 2.0 m plot mapped out. Polythene pots of about 27 cm will be filled to about 24 cm, perforations were made at bottom position for easy drainage of excess rain water. Transplanting of two seedlings per pot was done last week of September 2019, and after survival thinned down to one stand per pot.

Application of Iodine

The required rates of iodine applied as Potassium Iodine (KI) were weighed using sensitive balance (Model: ScoutPro). The rate applied were 0, 0.125 g, 0.25 g, 0.5 g and 1.0 g KI per pot. Iodine was applied to individual plant by band application method at, 4 WAP, 6 WAP and at 8 WAP.

Weed Management

Experimental pots/units will be kept weed-free by hand-pulling as at when due. Weeds will be completely removed to avoid competition for water and the applied nutrients to ensure maximum up take of Iodine.

Data Collection

Data was collected weekly till harvest. The following vegetative growth parameters were measured: plant height, number of leaves, leaf area, Stem thickness (girth), number of branches. Yield parameters measured were number of fruits per pot, number of fruits per treatment/pot, weight of fruit per Pot (average weight per pot) and weight of fruit per treatment.

Data Analysis

Growth and yield were analyzed statistically by the analysis of variance (ANOVA) technique of a randomized Complete Block Design and means were separated using Mean Separation by LSD: Least signification difference. GENSTAT (2009) statistical software was used to carry out the statistical analysis.

Results

Effect of Rate and Time of Iodine application on Growth Rate (Plant height) of Bell pepper *Capsicum anuumm*.

The results of the effect of time of potassium iodide on bell pepper in table 1 showed that at the 2nd and 4th week after application (WAP), application of iodine did not show any significant different in the growth rate of the bell pepper. However, at the 6th and 8th weeks after planting, application of iodine had pronounced effect such that the growth rate were significantly varied. In both 6^{th} and 8^{th} period of growth, Bell pepper plants fertilized at 4 WAP, had the least growth rate, while application of KI at 8 WAP, produced the tallest plants by the 8^{th} week after planting. That is they were distinct from each other. Analysis of variance showed that the variation of plant height was significant at P=0.5; indicating that the difference in height was as a result of the difference in time of application. Application of iodine 4WAP was significantly varied from application at 6WAP and 8 WAP; though application at 8 WAP had the highest growth rate that was not significantly different from those in which the iodine was applied at 6 WAP. Therefore, application below 4WAP will not favor growth rate significantly. The terminal plant height at 8 weeks after planting was 61.07cm. The effect of rate of iodine application on okra is shown in table 1. Growth rate increased with time at all rates of application with time or age of the bell pepper. However, plant height increased with increasing rate of KI application up till the dose or rate of 0.5 g of application. After this level or rate, growth rate in terms of plant height declined at 1.0 g of KI application rate. The effect of rate on growth was significant at 0.05% meaning the variations in plant height was due to the different rates of KI applied. Interaction between time of application and rate of application was significant at 5% probability levels

Effect of Rate and Time of Iodine application on Vegetative Growth of Bell pepper *Capsicum annuum.*

The influenced of time and rate of application of iodine application on the vegetative characteristics of Bell pepper is highlight in table 2. In this result it is observed that number of leaves of the bell pepper increased with delayed time of application pf the potassium iodide. Thus, application of iodine at 8 WAP produced a greater number of leaves in the bell pepper plants than those fertilized at either 4 WAP or 6 WAP. Applying at iodine at 6WAP produced more leaves than the bell pepper plants that received iodine at 4 WAP. The differences observed in the number of leaves produced were statistically different at probability level of five percent, indicative of the fact that the different time of application of potassium iodide was responsible for the variation in the number of leaves observed. The same trend was noticed with the leaf area. Bell pepper crops fertilized with KI at 8 WAP had bigger sizes of leaves (743.8 cm^2) than those fertilized with iodine at 4 WAP and 6 WAP (569.93 cm^2 and 658.35 respectively). The difference in the number of leaves produced in bell pepper plants that received KI at 4 WAP and 6 WAP were not significantly different, though they were significantly fewer than the bell pepper plant that were fertilized with potassium iodide at 8 WAP. The number of branches produced by bell pepper were not affected by the time of application of the iodine. Though application of Iodine to bell pepper at 8 WAP had one branch more, the difference was not significant from bell pepper plants fertilized at 4 WAP and 6 WAP. There was significant difference in number of leaves and leaf sizes (leaf area cm^2) as a result of time of application of iodine, but not in the number of branches. The interaction of time and rate of application of iodine was significate further showing or proving that the observed difference in the values of leaf area and number of leaves was due to the different rates and different time of application of KI. In terms of rate of application of KI, it was observed that as the amount in grams of potassium iodide increased the number of leaved produced by the bell pepper plants also increased from 0 g rate of application to 0.5 g rate of application, after this level of application, the number of leaves produced depressed. This observed effect was statistically significant at P = 0.05, meaning that the observed differences in number of leaves were due to the different rates of KI applied. Thus, bell pepper plants that received 0.5 g KI had the greatest number of leaves that were markedly higher than those produced by that received 0 g and 0.25 g of KI. The bell pepper plants that received 1.0 g KI produced the least number of leaves.

The leaf area also followed the same pattern as the number of leaves. There was increase in the leaf size or leaf area and rate of iodine fertilization increased from 0 g to 0.5 g KI, then there was a sharp decline in leave area. The highest leaf area was observed in bell pepper plants that were fertilized with 0.5 g KI which were significantly higher and different from other rates of application. The least was observed in the plants that were fertilized with 1.0 g KI. The variation in leaf sizes were significantly the result of the different rates of iodine applied. The number of branches produced by bell pepper in relation to iodine application did not deviate from the trend of the other vegetative characteristics. Number of branches increased with KI application rates up till 0.5 g and decreased thereafter. This effect was statistical proven to be as a result of the different rates of applied KI, and by mean separation the bell pepper plants that received 0.5 g KI were most different from those that received 1.0 g.

Table 1: Influence of time and rate of application of iodine on the growth rate of plant height of bell pepper (cm)

	Weeks After Planting (WAP)			
Time of Application	**2**	**4**	**6**	**8**
4 WAP	8.35^a	21.2^a	43.47^a	55.07^a
6 WAP	8.23^a	21.1^a	39.87^b	58.87^b
8 WAP	8.18^a	20.95^a	46.80^a	61.07^b
SE	0.269	0.343	0.881	1.045
Rate of KI				
0.0 g	8.11^b	22.33a	32.33^b	58.00^b
0.25 g	8.11^b	23.22^a	31.67^{ab}	60.11^{ab}
0.5 g	8.56^c	23.33^a	28.67^{ab}	63.67^c
1.0 g	7.44^a	22.56^a	26.64^a	50.67^a
SE	0.348	0.429	1.135	1.345
Interaction				
R x T	*	*	*	*

Mean with same alphabets in the same column are not significantly different at P = 0.5 by LSD. * = Significant NS = not significant.

Table 2: Effect of time and rate of iodine application on vegetative growth of Bell Pepper

	Vegetative Growth		
Time of Application	**No. of leaves**	**Leaf Area (cm^2)**	**No. of branches**
4 WAP	10.2^a	569.93^a	3^a
6 WAP	11.3^b	658.35^b	3^a
8 WAP	13.3^c	743.83^c	4^a
SE	0.169	3.145	0.109
Rate of KI			
0.0 g	10.46^b	632.48^b	4.89^b
0.25 g	10.56^b	639.91^b	5.00^b
0.5 g	11.68^c	757.38^c	6.65^b
1.0 g	7.88^a	522.80^a	3.88^a
SE	.217	4.057	.192
Interaction			
R x T	*	*	*

Mean with same alphabets in the same column are not significantly different at P = 0.5 by LSD. * = Significant

Effect of Rate and Time of Iodine application on yield characteristics of Bell pepper *Capsicum annuum.*

The yield characteristics response because of application of iodine at different rate and time on bell pepper is reflected in table 3. The yield characteristic observed and measured were number of fruits, fruit length, fruit girth and fruit weight. A trend was observed, the number of fruits, fruit length, fruit girth and fruit weight increased as the time of application increased. Therefore, the number of fruits, fruit length, fruit girth and fruit weight were highest in plants that were fertilized with iodine at 8WAP and least in plants fertilized at 4 WAP. The observed values in the various yield parameter were different significantly at P = 0.5 using the analysis of variance of the randomized complete block design. However, though there was difference in the values observed, there was no serious significant different in number of fruits, pod length, pod girth and pod weight in the plants fertilized at 6 WAP and 8 WAP.

Generally, the rate of iodine had significant different on number of fruits, pod length, pod girth and pod weight. From the table it can observed that as the rate of iodine increased, values of the number of fruits, fruit length, fruit girth and fruit weight increased up on till after 0.5 g of iodine, and then dropped. Indicating that higher quantity of iodine can affect yield adversely. In all cases or yield parameters measured, the bell pepper plants that received 0.5 g KI recorded the highest values, followed by those that received 0.25 g KI, then the control plants that received no iodine. The least values were obtained in bell pepper plants that were fertilized with 1 g KI.

Effect of Rate and Time of Iodine application on iodine absorption in Bell pepper *Capsicum annuum*

The effect of time and rate of Iodine application on Iodine absorption in bell pepper fruits is displayed in table 4. Generally, the iodine content in the bell pepper fruit were low.

Iodine absorbed or the content in the fruit of bell pepper plants fertilized at eight weeks after planting 8 WAP were higher than those absorbed by the plants that were fertilized at both two weeks after planting 2 WAP and four weeks after planting 4 WAP. Consequently, this study indicates that early application of iodine may not favour retention of iodine in bell pepper fruits.

The table also indicate that iodine retention or absorption in the bell pepper fruits increased as the dose of application of potassium iodide increased.

The control plants had less than 0.3 mg/kg of iodine and thus could not be detected in the tissues of the fruits, but from application rate of 0.25 g of KI iodine was retained in the fruit tissues. Thus, iodine retention in bell pepper plants increased from 0 g KI to 1.0 g KI. There was a positive relationship between iodine retention in bell pepper fruits with rate of application of KI. The separation of mean showed significant difference between the rates of application to the amount of iodine retained in the fruits, however those plants that received 0.5 g KI and 1.0 g KI were not significantly different.

Analysis of variance of the randomized complete block design show rate and time of application of KI significantly affected the amount of iodine retained in the bell pepper fruit. Thus, the variation in the quantity of iodine retained the bell pepper fruits was because of the different rates and time of application of KI.

Table 3: Influence of time and rate of application of iodine on Bell Pepper yield characteristics

Yield Characteristics				
Time of Application	**No. of fruits**	**Fruit length (cm)**	**Fruit girth (cm)**	**Fruit weight (cm)**
4 WAP	7.42^{a}	4.76^{a}	5.82^{a}	219^{a}
6 WAP	8.50^{b}	6.41^{b}	6.72^{b}	261^{b}
8 WAP	8.83^{b}	6.78^{b}	6.84^{b}	269^{b}
SE	.252	.201	.258	2.182
Rate of KI				
0.0 g	6.0^{b}	4.73^{a}	5.01^{a}	209.6^{a}
0.25 g	8.89^{c}	6.48^{c}	6.97^{b}	289.93^{b}
0.5 g	11.33^{b}	6.69^{b}	7.13^{b}	301.3^{b}
1.0 g	6.67^{a}	4.68^{a}	5.03^{a}	211.679^{a}
SE	.326	.260	.333	1.993
Interaction				
R x T	*	*	*	*

Mean with same alphabet in the same column are not significantly different at P = 0.5 by LSD. * = Significant NS = not significant.

Table 4: Effect of Time and Rate of Iodine Application on Iodine Absorption in Bell Pepper Fruits (mg/kg)

Time of Application	**Fruit Iodine content**
2 WAP	0.40^{a}
4 WAP	0.52^{b}
8 WAP	0.68^{c}
SE	0.184
Rate of KI	
0.0 g	<.3
0.25 g	0. 56^{b}
0.5 g	0.72^{c}
1.0 g	0.78^{c}
SE	0.271
Interaction	
R x T	*

Mean with same alphabets in the same column are not significantly different at P = 0.5 by LSD. * = Significant NS = not significant.

Discussions

Influence of time and rate of iodine application on the growth rate of Bell Pepper [plant height (cm)].

This study observed that of time and rate of iodine application affected the growth rate (plant height). The result showed that plant height increased with time and the tallest bell pepper plant were observed in plants fertilized at 8 WAP. Statistical Analysis of variance of the complete randomized design showed that the disparity in plant height obtained were significant at P = 0.5; this indicate that the fertilization of iodine at the different time of application was responsible for the difference in growth rate observed. In summary delayed or late application of iodine favored growth or height increment in bell pepper.

Also variation in the rate of KI application produced significantly different plant height observed in bell pepper at P=0.5; this indicate that the rates of applied iodine was responsible for the different growth rate observed in bell pepper. Application of more than 0.5 g KI led to a reduction in growth rate.

The report of Mackowiak et al. (2005), corroborates the observation in this study, they reported that excess iodine in plants produce severe physiological symptoms which can result in retarded growth and even death of entire plant in extreme cases. Zhu et al. (2003) also opined detrimental effects and yield reduction in spinach when high levels of iodine were applied.

Effect of time and level of iodine application on vegetable growth of Bell Pepper

Table 2 highlights the influence of time and rate of iodine fertilization on vegetative growth in Bell Pepper. In all the vegetative parameter measured, bell pepper plants that were fertilized later in the plant life exhibited better vegetative growth. This may suggest that application of iodine early in the plant life may depress growth, development and leave production in bell pepper. Also it was observed that increasing the dose of iodine in bell pepper increased vegetative growth but depressed it at higher dose of 1 g per plant. The observations above may indicate that early application of iodine and even at a higher dose may cause adverse retarding growth and development physiological disorders in the bell pepper plants as reported by Mackowiak et al. (2005) [13].

Impact of time and rate of application of iodine on Bell Pepper fruit yield.

Table 3 displays the yield characteristics of bell pepper plant to application of iodine at different rates and period of planting. The study observed that the number of fruits, fruit length, fruit girth and fruit weight increased as the time of application increased. It was also observed that as the rate of iodine increased, values of the number of fruits, fruit length, fruit girth and fruit weight increased up on till after 0.5 g of iodine, and then dropped. This is contrary to the of Ansa (2017) that rate and time of iodine application did not affect vegetative growth and yield of cassava.

In this case study iodine rate and time of application seem to have affected vegetative growth and yield of bell pepper. This can be explained by Borst-Pauwels (1961) [7] who stated that iodine fertilization in small dosages can improve plant growth and development. Conversely, excess application of iodine can lead to plant damages expressed initially as marginal chlorosis and necrosis of older leaves, dark green pigmentation in the younger leaves and in extreme cases whole plant death occur (Mackowiak and Grossl 1999, Mackowiak*et al.*, 2005) [12, 13].

Effect of time and rate of iodine application on iodine absorption in Bell Pepper fruit.

This research observed that time of application affected the retention of iodine in bell pepper fruits. Retention of iodine increased from 2 WAP application time to 8 WAP time of application. The trend was the findings of Ansa *et al* (2016) who reported that iodine retention in casava increased with time of application, with those cassava plants fertilized with iodine at 12 WAP having more retained iodine in the tuber than those fertilized at 8 WAP and 6 WAP.

This study also found that increasing doses of iodine resulted to increasing levels of retained iodine in the bell pepper fruits. The iodine rates positively correlated the with amount of iodine found in the fruit. This was the finding reported by several authors.

Smollen and Sady (2011), observed and reported significant increase in iodine content with increase of iodine rates of application in fresh vegetable leaves of spinach. Zhu et al (2003) and Strzetelski et al (2009) also reported increasing absorption of iodine in tissue content of spinach and radish. Ansa *et al* (2017) and Ansa (2017) also stated in their publication that increasing iodine doses in cassava also favored the retention of iodine in cassava.

This work also noted an exceptionally low level of iodine the bell pepper fruits. This is explained by Mackowiak and Grossl (1999) [13] who expounded that xylem vessel in plants instead the phloem vessel is responsible for the translocation and the accumulation of iodine in vegetative plants parts. Therefore, since the phloem accounts mainly for translocation of iodine from vegetative organs to the reproductive organ, accumulation, or retention of iodine in the fruits will be hampered. They explain that this is the reason rice plants deposits less iodine in the grains.

The overall findings of this investigation show that agronomic biofortification of iodine is realistic as it showed that time and rate of application of KI can lead to accumulation of iodine for human consumption in the bell pepper leaves. This research suggests that application of 0.5 g of KI at eight weeks after planting can affect agronomic iodine biofortification of iodine in bell pepper in rivers state.

Conclusions

Iodine fertilization did not adversely affect growth and yield of bell pepper. Time and rate of iodine application did not significantly retard plant height, number of leaves and leaf area rather it favored vegetative growth and yield at lower rates or quantities. Delayed application favored vegetative growth and yield. Application at the rate of 0.5 g KI at 8 weeks after planting favored vegetative growth and yield.

The time and rate of fertilization of bell pepper with iodine lead to retention of iodine the fruits of bell pepper. Delayed application favored retention. Increasing levels of iodine fertilization increased the retention of iodine the bell pepper fruits. The difference in amount retained was not markedly different after application rate of 0.5 g KI. Also application rate above 0.5 g KI depressed plant height and vegetative characteristics of bell pepper. Therefore, application rate of 0.5 g KI will favor vegetative growth, yield and iodine retention in bell pepper.

This shows that agronomic bi fortification is possible in bell pepper. Application of 0.5 g KI at eight weeks after planting 8 WAP is recommended for agronomic biofortification of bell pepper.

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