

FULL LENGTH RESEARCH PAPER

Effect of Some Plant Growth Regulators on the Growth and Nutritional Value of *Hibiscus sabdariffa* L. (Red sorrel)

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ABSTRACT

The study was carried out to investigate the effects of growth regulator treatments on the growth and chlorophyll and biochemical contents of *Hibiscus sabdariffa* (sorrel). The treatments comprised of 50ppm and 100ppm each of indole acetic acid (IAA) and gibberellic acid (GA_3) and 10% and 15% coconut milk. A total of three foliar applications were made at two weeks interval commencing from two weeks after sowing. The control plants were sprayed with water. All the treatments significantly increased plant height, stem girth, leaf development and chlorophyll content of the vegetable with higher values recorded in treatments with 100ppm IAA, 100ppm GA_3 and 15% coconut milk. Treatments with 15% coconut milk and 100ppm GA_3 resulted in greater carbohydrate and vitamins A, B6 and C contents of the vegetable. Phosphorus and potassium levels were higher in 15% coconut milk treated plants, whereas sodium, copper and zinc levels were greater in 100ppm GA_3 treatment. The study suggests that 15% coconut milk and 100ppm GA_3 have potential to increase growth and nutritional value of *Hibiscus sabdariffa*.

Keywords: *Hibiscus sabdariffa*, growth regulators, chlorophyll, nutritional value.

INTRODUCTION

Vegetables are essential in the diet as they provide plant fibre, mineral elements, vitamins, carbohydrates and proteins (Hollingsworth, 1981). *Hibiscus sabdariffa* L. (Red-sorrel or Roselle) is a vegetable that belongs to the family malvaceae and is cultivated for its leaves and young shoots which are eaten either raw or as a cooked vegetable. It is also cultivated for its succulent calyx which are used as a refreshing drink or beverage and in the preparation of preservative and jellies (Tindall, 1983). The seeds of this vegetable when boiled and crushed contain 17% of an edible oil which is used for medicinal purpose. The residue is used locally as a spice in food. *Hibiscus sabdariffa* is a native of Africa and is a short-day plant requiring 12 to 12½ hrs daylength for flowering and fruit production

(Tindall, 1983).

Plant growth regulators are known to control plant's physiological and biochemical processes. These include, control of dormancy, organ size, crop development, flowering and fruit set, regulation of chemical composition of plants and control of mineral uptake from the soil (Nickell, 1978). Recent researches have shown the stimulatory effects of growth regulators in the growth and yield of vegetables. The growth regulators influence plant growth and development at very low concentrations while they inhibit at high concentrations (Jules *et al.*, 1981). Mella *et al.* (1997) reported that indole- acetic acid and gibberellic acid promote seedling growth in various concentrations. Auxins are primary regulators of plant form (Friml, 2003) while gibberellins and brassinosteroids stimulate elongation (Dugardeyn *et*

al., 2008). Gibberellic acid has been used to stimulate stem and petiole extension in rhubarb, celery and water cress (Thomas, 1976). Treatment of radish and onion seeds with auxin or a mixture of gibberellic acid (GA_3) and kinetin have been found to increase the germination of the seeds (Thomas 1976). Monthly foliar spraying of geranium (*Pelargonium graveolens*) resulted in increased plant height and herb production (Mohammed *et al.* 1983). Spraying of datura plant (*Datura innoxia*) planted in different salinity concentrations with chlormequat, ethephon or kinetin was found to enhance plant growth, alkaloidal and soluble sugar contents of leaves and reduce the harmful effect of salinity on the plant (Abdul-Rahman & Abdel-Aziz, 1983). Application of gibberellic acid, 4-chloroindole and 6-benzyl amino purine on to the standard petal and calyx of *Vicia faba* var. major was found to significantly enhance pod set (Rylott and Smith, 1990). Likewise, spraying of *Vicia faba* cv. Troy reproductive structure with indole-3-acetic acid, gibberellic acid or 6-benzyl aminopurine resulted in increased pod number (Clifford *et al.*, 1992).

This study was carried out to evaluate the growth and chemical responses of *Hibiscus sabdariffa* to some growth regulator treatments and to determine the optimum concentrations of the hormones that can be recommended for spraying on the vegetable for enhanced growth and quality.

MATERIALS AND METHODS

Planting of seeds:

The seeds of *H. sabdariffa* were collected from the National Institute of Horticultural Research Training (NIHORT), Kano branch. Kano is situated at longitude $8^{\circ}34'E$, latitude $12^{\circ} 03'N$ and altitude 486.5M (1,595Ft). The seeds were sown on prepared beds at 4 seeds per hole. There were seven beds of 2 x 2m for the hormonal treatments with a distance of 0.5m between beds. The number of beds were replicated thrice and weeding was carried out regularly. During the study period, the land area of the prepared beds had a mean temperature of $30 \pm 3^{\circ}C$, relative humidity of $58 \pm 10\%$ and average day length of $12.5 \pm 0.5h$.

Growth regulator treatments: The growth regulators employed in the experiment were indole -3-acetic acid (IAA), gibberellic acid (GA_3) and coconut milk. The concentrations of the growth regulators treatments were IAA and GA_3 50ppm and 100ppm and coconut milk (10% and 15%). Thirty (30ml) of the various concentrations were applied on the planted vegetables by foliar spraying of 4 doses at 2 week-intervals commencing from 2 weeks after sowing. The control vegetable plants were sprayed foliary with 30ml water also applied in 4 doses at 2 week-intervals starting from 2 weeks after sowing.

Effects of growth regulator treatments on vegetative growth and chlorophyll content:

The treated and control vegetables were sampled at 9 weeks after planting. Plant heights and stem girth were measured using a metre rule with the aid of a thread. Number of leaves on each of the treated and control plants was counted and the leaves were subsequently detached and their outlines traced out on a graph paper to measure the leaf area. The leaf area ratio was calculated using the formula;

$$\text{Leaf area ratio} = \frac{\text{Leaf area total}}{\text{Dry weight of whole plant}}$$

Another parameter measured was shoot/root ratio. For all the parameters measured, three replications were taken and the means were recorded. The chlorophyll contents of the leaves were determined using the method of Witham *et al.*; (1971).

Effect of growth regulator treatments on carbohydrate, protein and vitamin contents:

The leaves of the treated vegetable and controls were harvested at 9 weeks after sowing, dried in an oven at $80^{\circ}C$ for 48hrs, grounded into powder and the powder were used for carbohydrate, protein and vitamins content determination. Total carbohydrate was analysed using the anthrone method of southgate (1969) following extraction for 4h with 250ml of 1% sulphuric acid. Protein was determined using the micro - kjeldahl method. Vitamin A was analysed using the method of Beols and Troet (1959) by boiling 1g powder sample with a mixture of 30ml ethanol and 3ml 85%KOH for 30mins. Vitamin B₆ analysis was carried out according to the method of Heochberg *et al.* (1944) in which 1g powdered sample was hydrolysed with 4N HCL in a boiling water bath for 1hr. The colouring dye was 2,6- dichloroquinone - chloroimide reagent which complexes with pyridoxine at pH 5.7 to form reddish brown chromophore that absorbs at 620nm. The determination of vitamin C was carried out using the method described by Lambert and Muir (1983) by completely homogenizing 500mg of each powdered sample in 10ml of 4%HCL in a blender. The colouring dye was 2,6-dichloroindophenol which on titration forms a pink colour with vitamin C.

Effect of growth regulator treatments on mineral elements content:

One gram of each powdered sample prepared as indicated above, was used to determine some mineral elements namely, Phosphorus, Calcium, Magnesium, Potassium, Sodium, Manganese, Iron, Copper and Zinc. The various determinations were done using atomic absorption spectro-photometer, flame photometer and phosphor vanado-molybdate reaction according to the International Institute for Tropical

Agriculture (I.I.T.A) manual of 1979. The data collected were subjected to analysis of variance using completely randomized design. Least significant difference (LSD_{5%}) test at $P \leq 0.05$ was used to separate the means where significant difference was observed.

RESULTS AND DISCUSSION

Significant ($P \leq 0.05$) increases in all the vegetative growth parameters monitored were observed in the treated vegetable compared with the control. Gibberellic acid (GA₃ 100ppm) treatment resulted in greater plant height (56.2cm) followed by GA₃ 50ppm (54.2cm) and 15% coconut milk (53.9cm). Treatment with 15% coconut milk induced greater stem girth, and number of leaves in the vegetable (Table, 1). The IAA treatments (100ppm and 50ppm) and 15% coconut milk stimulated greater leaf area ratio (288.2, 276.0 and 260.4 respectively). Shoot /root ratio was greater in treatments with 100ppm GA₃ (0.19) and 100ppm IAA (0.16) (Table, 1). Similar results of plant height stimulation were observed by Currah & Thomas (1979) upon application of 100mg/L GA₃ on carrot plant. Spraying of kinetin on *Datura innoxia* plant at 1mg/L, 5mg/L and 10mg/L was found to cause increased vegetative growth (Abdel-Rahman & Abdel-Aziz, 1983). Similarly, GA₃ spraying was found to stimulate production of flowers in lettuce (Metzger,1988). Biddington & Dearman (1987) also observed that GA₃ application increased the growth of bean and leaf length of lettuce (Olympios, 1976). Gibberellic acid was also reported to increase plant height, number of leaves and total plant weight of some cowpea cultivars (Mukhtar, 2004).

The hormonal treatments stimulated significant increases in the total chlorophyll contents of the vegetable except IAA treatments. The highest total

chlorophyll content (1.08mg/g) at 9 weeks was obtained in *H. sabdariffa* treated with 15% coconut milk, followed by 100ppm GA₃ (0.93mg/g). Similar increases in chlorophyll a and b contents were obtained in *chlorella vulgaris* 157 upon treatment with kinetin (Atanasiu *et. al.*, 1983).

The hormone treatments induced significant increases in the carbohydrate, vitamins A,B₆ and C contents of the vegetable (Table, 2). The greatest increase in all the biochemical components was obtained in the treatment with 15% coconut milk followed by 100ppm GA₃ (Table, 2). Abdul Rahman and Abdul Aziz (1983) also reported an increase in total soluble sugar percentage in leaves of *Datura innoxia* plant following application of chlormequat, ethephon and kinetin. Dybing and Lay (1982) observed that application of growth regulators improves the quality of plants with respect to oil, latex, sucrose and protein contents. Kadiri *et al.* (1997) reported similar increases in vitamin A,B₆ and C contents of *Abelmoschus esculentus* and *solanum gilo* following foliar spraying with IAA, GA₃ and coconut milk. Greater contents of phosphorus (7.55mg/g) and potassium (56.53mg/g) were obtained in treatments with 15% coconut milk while 100ppm GA₃ treated plants recorded greater sodium (43.15mg/g), copper (0.192mg/g) and zinc (0.277mg/g) contents (Table, 3).

CONCLUSION

The growth regulator treatments resulted in significant increased growth and food quality of the *H. sabdariffa*. Treatments with 100ppm GA₃ and 15% coconut milk induced the greatest increase in height, chlorophyll, biochemical and some mineral element content of *H. sabdariffa*. These treatments could thus be used to enhance the growth and quality of this vegetable.

Table 1: Effect of different concentrations of some plant growth regulators on some vegetative parameters and chlorophyll content of *H. sabdariffa* (sorrel) at 9 weeks after sowing.

Treatment (ppm)	plant height (cm)	stem girth (cm)	No.of leaves	Leaf area ratio	shoot/ root ratio	chlorophyll content (mg/g)
IAA (50)	37.7	2.46	67.3	276.0	0.12	0.67
IAA (100)	38.3	2.48	71.3	288.2	0.16	0.70
GA ₃ (50)	54.2	2.13	103.3	171.0	0.15	0.79
GA ₃ (100)	56.2	2.04	103.7	189.5	0.19	0.93
10% coconut milk	42.8	2.78	109.0	193.0	0.12	0.91
15% coconut milk	53.9	3.23	122.0	260.4	0.14	1.08
control (water)	25.9	2.04	27.3	124.4	0.10	0.66
LSD _{5%}	5.45	0.33	12.21	28.94	0.02	0.09

(P< 0.05)

Table 2: Mean carbohydrate (%), protein (%), and vitamins A, B₆ and C contents (ug/g) of *H. sabdariffa* as affected by different concentrations of IAA, GA₃ and coconut milk at 9 weeks after sowing.

Treatment (ppm)	carbohydrate (%)	protein (%)	vitamins (ug/g)		
			A	B ₆	C
IAA (100)	5.42	4.69	216.2	364.5	591.0
GA ₃ (100)	6.58	5.86	224.0	361.5	528.0
15% coconut milk	7.56	5.47	251.4	388.4	742.5
Control (water)	1.71	5.70	157.2	337.6	345.0
LSD _{5%} (P< 0.05)	0.74	N.S	7.83	10.54	35.31

N.S – not significant

Table 3: Mean mineral element (mg/g) contents of *H. sabdariffa* as affected by different concentrations of IAA, GA₃ and coconut milk at 9 weeks after sowing.

Treatments (ppm)	P	Ca	mg	K	Na	Mn	Fe	Cu	Zn
IAA (100)	4.267	0.426	1.079	20.00	25.02	0.050	2.783	0.101	0.064
GA ₃ (100)	6.397	0.137	1.698	25.75	43.15	0.016	0.539	0.192	0.277
15% coconut milk	7.550	0.052	2.059	56.53	40.87	0.017	0.263	0.179	0.155
control (water)	4.160	0.579	2.058	16.88	39.02	0.036	0.574	0.126	0.076

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