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RESEARCH PAPER

Effect of Some Plant Growth Hormones on the Performance of *Artemisia vulgaris* L. Cuttings

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ABSTRACT

In the wake of the novel coronavirus (COVID-19), many plant material such as artemisia (*Artemisia vulgaris* L) have received renewed attention as cheap, easy-to-make treatment for many infections. However, the proliferation of artemisia from seeds is often a lengthy process. Here we investigated the role of commercial (Indol-3-butyric acid - IBA, Natural Rooting Hormone Powder - NRHP, Apple Cider Vinegar – ACV) and cottage-made (coconut water - CW and aloe vera gel - AVG) rooting hormone, and water as control (CONT) on the proliferation of artemisia cuttings in a greenhouse experiment in 2021. The survival of artemisia cuttings did not differ significantly ($P > .05$) across the treatments. The highest number of stems (19) and plant height (138.0 cm) was observed from CW + AVG, and the differed significantly from the others ($P < .05$) from the others. AVG produced the highest number of leaves per plant (1466), followed by CW (1317), CW + AVG (1278), and IBA (1241). The leaf dry weight was highest in CW + AVG, followed by those of CW and IBA. A similar pettern was observed for the root dry weight. The findings from this study showed that cottage-made plant based (coconut water and aloe vera gel) growth hormone has comparable effect to commercially available IBA on overall performance of artemisia cuttings. This study has great implications for low-tech proliferation of artemisia.

HIGHLIGHTS

- Cottage-prepared aloe vera gel and coconut water outcompete commercial indol-3-butyric acid in plant height and number of leaves produced by artemisia cuttings.
- An additive effect was observed for coconut water and aloe vera gel on below ground parameters, compared to single applications and indol-3-byturic acid.

Keywords: Artemisia, aloe vera, coconut water, COVID-19, growth hormone, aloe vera, Indol-butyric-acid

Artemisia (Asteraceae) is a common herbaceous plant with a global distribution (Weston *et al.* 2005). Artemisia plant shows high morphological and physiological variability depending on the place where it occurs (Ekiert *et al.* 2020; Weston *et al.* 2005). One of the most popular species is *Artemisia vulgaris* L. (common mugwort), which is also known by various synonymous Latin names and various foreign-language names (Ekiert *et al.* 2020).

This herbaceous plant can grow up to 2.5 m tall and about 75 cm wide. The plant has a thick main

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root and numerous small fibrous lateral roots, forming a vast underground network (Barney and DiTommaso, 2003). The stems are slightly wavy, straight or branched, and become woody with age. The leaves are 5-10cm long and are set densely and alternately primarily in the upper parts of the stem (Anwar *et al.* 2016). Artemisia produces flowers which develop into fruits called achenes. The seeds are brown, weighing about 0.12 – 0.14 mg (Barney and DiTommaso, 2005). The species reproduce from seeds and vegetatively with the help of its roots (Borzabad *et al.* 2010). Artemisia is characterized by a strong aroma that it releases when the leaves are macerated and spicy taste (HAS, 2014; Borzabad *et al.* 2010; Weston *et al.* 2005) indicating its high concentration of essential compounds.

The application and uses of artemisia as food, cosmetics and medicine is broad, probably due to the huge chemical deposits with essential oils, phenolic acids, sequiterpenes lactone and other groups of metabolites (Farmanpur-Kalalagh *et al.* 2022; Ekiert *et al.* 2020). For instance, artemisinin is a natural bioactive sequiterpene lactone found in artemisia plant which is used to treat malaria (Nigam *et al.* 2019; Tu, 2011; O'Neill *et al.* 2010). Artemisia is also used to treat gastrointestinal, menstruation and pregnancy related ailments (Efferth *et al.* 2015). Ekiert *et al.* (2020) has summarized the various diseases that are treated using artemisia or artemisia derivatives including spleen and liver diseases.

There is abundant evidence that artemisinin and related compounds are good in combating viral infections, cancers and inflammations (Farmanpur-Kalalagh *et al.* 2022). In the wake of the novel coronavirus SARS-CoV-2 infection or COVID-19, artemisia received a global attention as a potential candidate against COVID-19 (Orega *et al.* 2021; Ekiert *et al.* 2020; Liu *et al.* 2020). Besides antiviral properties, the essential oils of *A. vulgaris* also have antifungal and antibacterial properties. These essential oils of artemisia are used as insect repellant and fumigant (Efferth *et al.* 2015; Temraz and Tantawy, 2008).

The renewed interest in artemisia in the wake of COVID-19 outbreak implies that its growth and cultivation have to increase. In this study, we exploit the effect of different plant growth promoting medium on cuttings of artemisia, a plant that is traditionally grown from seeds with low success rates (Ekiert *et al.* 2020). We hypothesize that different plant growth promoting hormones, both synthetic and locally extracted will influence artemisia cuttings differently. We use cuttings because (i) seeds are expensive and scarce and (ii) we believe that cuttings will produce a rapid propagation of artemisia to meet the high demands. Ekiert *et al.* (2020) is encouraging macro- and micropropagation of artemisia as a way to guarantee supply. We used commercially available plant growth promoters in a potted experiment to improve the growth of artemisia cuttings. In addition, we extracted aloe vera gel and used coconut water, which are reported to have some plant growth promoting properties (Mirihagalla and Fernando, 2020; Yong *et al.* 2019; Ibironke, 2016).

MATERIALS AND METHODS

1. Experimental site

The experiment was carried out in the ''OUR LADY OF BAMENDA Cisterian monastery'', Mbengwi, Momo Division, North West Region of Cameroon. The Monastery is one of the interesting sites in Mbengwi after the Abi waterfall in the hearts of the town. Mbengwi is situated some 20 km to the West of Bamenda. Mbengwi has an altitude ranging from 900 m to 2000 m above sea level. It is located on longitudes 10^{o} 00 and 10^{o} 02 East and between longitudes 6^{o} 00 and 6^{o} 05 North. The municipality lies in a transitional zone between the forest and the grassland regions of Cameroon. Mbengwui municipality has a surface area of 147000 m^2 with the Monastry occupying more than 34 ha of land.

Mbengwi is known to have a tropical savannah climatic type with two seasons. The long rainy period that extends from March to September with an annual average rainfall of 2022.3mm which favours agriculture and the rearing of animals, the dry season that runs from October to March. Average yearly temperature is 30 ^{o}C. It is dominated by the savannah vegetation (especially on the hills) which favour animal rearing while the valley is highly made up of trees like palm trees, raffia palms and many fruit trees. The area favours settlement and agriculture.

2. Experimental Materials

Stems cuttings of *Artemisia vulgaris* L., were

harvested from the Monastery farm during the early hours of the day using sterilize secateurs. The cuttings were immediately put in a clean bucket with 3 liters of water to prevent water loss and stress. The cuttings were then cut at a length of 15cm. Polythene bags of 7 × 12 cm were purchased from farmer's shop and used to propagate the stem cuttings. Only cuttings of the same size were used. The polythene bags were filled (up to three-quarter i.e. ¾) with sterilized substrate made up of 3:1 cow dung and sand.

3. Treatments

Indol-3-butyric acid (IBA), Natural Rooting Hormone Powder (NRHP) and Apple Cider Vinegar (ACV) were obtained from a local market. Coconut water (CW) was obtained from mature coconut fruits (coconut with a brown exocarp and white hard endocarp). A kilogram of aloe vera leaves were macerated using a mortar and pestle to obtain a gel. The gel was later dissolved in 1L of water and allow to stand for 24 h before use. No growth hormone was used for the control treatment. Coconut water + aloe vera gel treatment was composed of 0.5L sole coconut water treatment and 0.5L sole aloe vera gel treatment.

Table 1: Treatments and their respective doses

Treatments designation	Treatment Applied	Treatment dose
T_1	Indol-3-butyric acid (IBA)	200mg/1_L
T_2	Natural Rooting Hormone Powder (NRHP)	10g/L
T_3	Apple Cider Vinegar (ACV)	20g/1L
T_4	Coconut water (CW)	1L
T_5	Aloe-Vera Gel (AVG)	1L
T_6	Control (CONT)	0
T_7	Coconut Water + Aloe-Vera Gel (CW + AVG)	0.5L of T_4 + 0.5L of T_5

4. Experimental setup

The polythene bags, filled with rooting substrate were transferred into a greenhouse (20 × 4 m × 4m). Prior to transfer, the greenhouse was weeded. The polythene bags were arranged in small groups of 10. These small groups of 10 polythene bag were equally spaced out in the greenhouse. There were 28 of such small groupings, giving a total of 280 polythene bags. After air-drying the treated cuttings, they were planted in the substrate in the polythene bas (5 cm deep). The cuttings were made firm by gently compressing the rooting media around them. Each group of 10 polythene bag randomly received cuttings with the same treatment. Each treatment was assigned to 4 groups of polyethene bags of 10, given a completely randomized designed, which can be expressed as in equation 1.

$$y_{ij} = \mu + \tau_i + \epsilon_{ij} \quad \ldots(1)$$

Where y_{ij} is the response variable (e.g. plant height) of the *i*-the treatment in the *j*-the repetition, μ is the true overall mean, and τ_i is the effect of the *i*-the treatment, and ϵ_{ij} is the experimental error of the *i*-the treatment in the *j*-repetition.

The setup was water *adlibidum* using a watering can. A second dose of rooting hormone was applied 5 days after setup. With the help of a syringe, 5 ml of each treatment was applied 1cm deep into the substrate 1cm away from the cutting. The door of the greenhouse was left open but covered with mesh net to allow the cuttings to acclimatize for the first 10n days of the study. The study ran from June to August of 2021. Average daily greenhouse temperature was 31.0 °C with a relative humidity of 68 %.

5. Data collection

5.1. Aboveground parameters

5.1.1. Survival of cuttings

After 21 days, the number of dead and living cuttings were counted. The survival (%) of artemisia cuttings was expressed using equation 2:

Survival (%) of artemisia cuttings =

$$\frac{\text{Number of living cuttings}}{\text{Total number of cuttings planted}} \times 100 \quad \ldots(2)$$

5.1.2. Number of stems

The number of stems was countered manually after 60 days of planting. The stems considered were primary stems, radiating from the main stem (cuttings). This was done on all the cuttings from each subgroup of 10 polythene bags and an average was considered as replicates.

5.1.2 Stem diameter

The stem diameter was measured after 60 days of planting with the help of a caliper. This was obtained from stem attached at the base of the cuttings: closest to the substrate. This was done on all the cuttings from each subgroup of 10 polythene bags and an average was considered as replicates.

5.1.3 Number of branches

The number of branches was counted manually 60 days after planting. This was done on all the cuttings from each subgroup of 10 polythene bags and an average was considered as replicates.

5.1.4. Number of leaves

The number of leaves was countered manually 60 days after planting. This was countered from 3 randomly selected branches per plant. This was done on all the cuttings from each subgroup of 10 polythene bags and an average was considered as replicates.

5.1.5. Leaf area

The leaf area was calculated from the length (cm) and width (cm) of the leaf 60 days after planting with the help of a tape. The length was measured from the apex of the leaf to the petiole. The width of the leaf was measured from the widest portion of the leaf. Ten randomly selected leaves were measured per cutting and the average leaf area was considered the leaf area for the cutting. This was done on all the cuttings from each subgroup of 10 polythene bags and an average was considered as replicates.

5.1.5. Plant height (cm)

The plant height was measured 61 days after planting with the help of a tape. This was done on all the cuttings from each subgroup of 10 polythene bags and an average was considered as replicates.

5.1.6 Leaf biomass

All leaves were harvested per plant 66 days after planting and weighed using a weighing balance in order to obtain the leaf fresh weight. In order to obtain the leaf dry weight, the leaves were oven-dried at 70 ^{o}C for two days. This was done on all the cuttings from each subgroup of 10 polythene bags and an average was considered as replicates.

5.2 Belowground parameters

5.2.1 Number of roots

The polythene bags were cut open and the root infrastructure of the cuttings were gently separated from the substrate manually. The root infrastructure was later washed gently with the help of tap water in order to remove debris. The number of primary and secondary roots were counted per cutting. This was done 67 days after planting. This was done on all the cuttings from each subgroup of 10 polythene bags and an average was considered as replicates.

5.2.2 Root biomass

The roots obtained above were weighed with the help of a balance to obtain the fresh weight. In order to obtain the root dry weight, the roots were oven-dried at 80 ^{o}C for 2 days and later weighed.

6. Data analysis

Normality and homogeneity of variance tests were conducted using Kolmogorov-Smirnov test and Levene's test, respectively, prior to one-way analysis of variance (ANOVA) test for statistical significance for the response variable. Significantly different means were separated using the *posthoc* test Duncan's Multiple Range Test (DMRT) at an alpha (α) level of .05. All statistical analyses were done using SPSS (ver. 23).

RESULTS

1. Aboveground parameters

1.1 Survival of cuttings (%)

The survival of artemisia cuttings was assessed 21 days after plant. The results revealed that there was no significant difference (F = 0.845, df = 6, 21, P = .550) in the percentage survival of artemisia cuttings from the different plant growth promoting media. The percentage survival ranged from 10% to 7.75% (Fig. 1). CW+ACV treatment had the highest cutting survival while NRPH treatment had the lowest cutting survival at 7.75%. The percentage survival of the cuttings was 9.5 for IBA, ACV, and CW**.** The

percentage survival for AVG, and control treatments were 9.25% and 8.75%, respectively (Fig. 1).

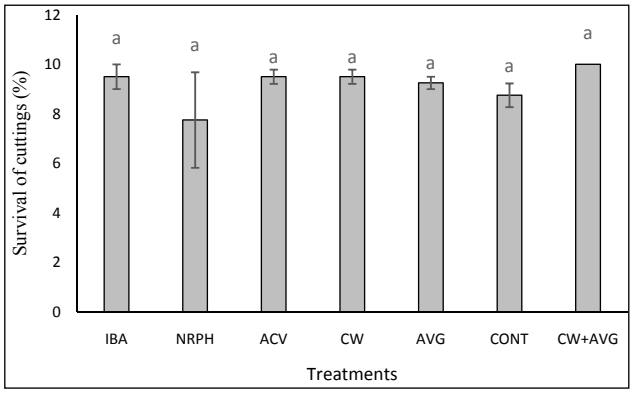

Fig. 1: Survival of artemisia cuttings (%) from different plant growth hormones. IBA – Indol-3-butyric acid; NRPH – Natural, rooting powder hormone; ACV – Apple Cider Vinegar; CW – coconut water; AVG – aloe vera gel; CONT – control; CW+AVG – coconut water and aloe vera gel. Mean bars with the same letter(s) are not significantly different (α = .05, DMRT)

1.2. Number of stems, stem diameter, number of branches, number of leaves, leaf area and plant height of artemisia as influenced by plant growth hormones

The results of number of stems over time for the different growth media is shown in table 1. At 60 days after planting, there was a significant difference (F = 3.528, df = 6, 21, P = .014) in the number of stems of artemisia from different plant growth promoting media. The highest number of stems (24) was observed from AVG treatment, followed by 19 stems from control and CW + AVG treatments. The smallest number of stems after planting was 10, recorded from NRPH treatment (Table 1).

The stem diameter of artemisia was measure at 60 days after planting. The result of the stem diameter (cm) was significantly influenced (F = 2.20, df = 6, 21, P = .044) by different plant growth promoting media (Table 1). The highest stems diameter was observed from CW+AVG and IBA at 1.75cm. The stems diameter for CW treated artemisia was 1.0cm. The stem diameter for NRPH, ACV, and AVG were 1.25cm (Table 1).

At 55 days after planting the number of branches was also significantly affected by different plant growth promoting media (F = 3.812, df = 6, 21, P = .010, Table 1). At this stage the highest number of branches, 258, was recoded from CW+AVG treatments followed by 253 for ACV and 246 for control treatment. The number of branches for NRPH remained the lowest throughout the study duration (Table 1).

The number of leaves at 51 days after planting showed significant variations F = 2.084, df = 6, 21, P = .049) from the different plant growth promoting media (Table 1). The highest number of leaves (2498.0) was recorded from CW+AVG treatment. This was followed by 1465 leaves, observed from AVG treatment. The smallest number of leaves (526.50) was recorded from control treatment, and followed by ACV which recorded 855 leaves (Table 1).

The leaf area for artemisia from different plant growth promoting media was significantly different (F = 3.495, df = 6, 21, P = .015). Indole-3-butyric acid produced the highest leaf area (35.74 cm^2), followed

Table 1: Effect of different plant growth hormones on number of stems, stem diameter, number of branches, number of leaves, leaf area index and plant height of artemisia

Treatments	Number of stems	Stem diameter (cm)	Number of branches	Number of leaves	Leaf area	Plant height (cm)
IBA	14 ± 7.71bc	1.75 ± 0.50a	192.0 ± 92.10bc	1241 ± 879.2ab	66.25 ± 20.95a	107.75 ± 32.73b
NRPH	10 ± 5.10c	1.25 ± 0.50ab	117.0 ± 33.12c	1046 ± 675.25b	58.75±17.15ab	69.0 ± 33.88c
ACV	17 ± 5.68abc	1.25 ± 0.05ab	253.75 ± 78.82ab	855 ± 710.16b	35.0 ± 2.00c	101.5 ± 24.93b
CW	13 ± 1.62cb	1.00 ± 0.0b	182.50 ± 57.16bc	1317 ± 355.38ab	45.50 ± 9.88bc	109.75 ± 31.38b
AVG	24 ± 5.85a	1.25 ± 0.50ab	311.75 ± 53.32a	1466 ± 606.63ab	47.25 ± 6.6abc	143.25 ± 39.69a
CONT	19 ± 1.91ab	1.00 ± 0.0b	246.25 ± 73.68ab	527 ± 226.01b	35.50 ± 10.88c	98.0 ± 18.11bc
CW+AVG	19 ± 6.00ab	1.75 ± 0.50a	258.00 ± 53.67ab	1278 ± 960.53a	50.0 ± 7.07abc	138.0 ± 54.47a

IBA – Indol-3-butyric acid; NRPH – Natural rooting powder hormone; ACV – Apple Cider Vinegar; CW – coconut water; AVG – aloe vera gel; CONT – control; CW+AVG – coconut water and aloe vera gel. Means within the same column with the same letter(s) are not significantly different (α = .05, DMRT).

by NRPH treatment at leaf area of 31.70 cm² (Table 1). The smallest leaf area was 18.88 cm², observed from ACV. The leaf area control, ACV and AVG were 19.15 cm², 24.55 cm² and 25.49 cm², respectively (Table 1).

At 55 days after planting, the plant height was 143.25 cm for AVG, and it was significantly (F = 2.034, df = 6, 21, P =.047) higher than those of the other treatments. It was followed by 138.0 cm from CW + AVG treatment. The smallest plant height was 69.0cm, observed from NRPH treatment (Table 1).

1.3. Leaf biomass (g) of artemisia from different plant growth hormone

The fresh leaf biomass (g), assessed 66 DAP is shown in Fig. 3. The fresh leaf biomass differed significantly (F = 1.092, df = 6, 21 P = .043, Fig. 2). The highest fresh leaf biomass was 88.0g, recorded from CW+AVG, followed by 77.50g from CW treatment. The smallest fresh leaf biomass was 27.0g, recorded from control treatment. The dry leaf biomass was also significantly different (F = 11.896, df = 6, 21, P < .001, Fig. 2). The dry leaf biomass ranged from 7.0g to 19.5g. The highest dry leaf biomass (19.5g) was observed from CW + AVG treatment. The smallest dry leaf biomass (7.0g) was observed on control treatment (Fig. 2).

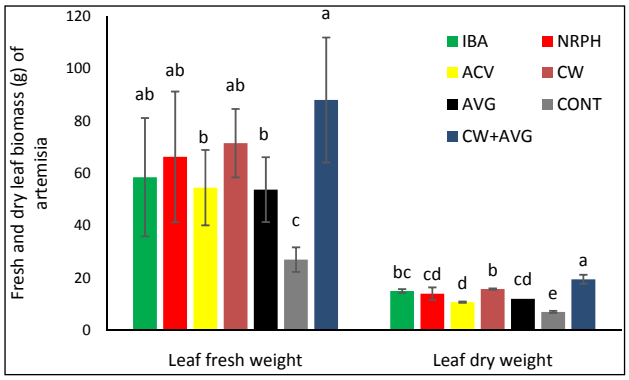

Fig. 2: Fresh leaf and dry leaf biomass of Artemisia as affected by different plant growth hormone. IBA – Indol-3-butyric acid; NRPH – Natural, rooting powder hormone; ACV – Apple Cider Vinegar; CW – coconut water; AVG – aloe vera gel; CONT – control; CW+AVG – coconut water and aloe vera gel. Mean bars within the same parameter with the same letter(s) are not significantly different (α = .05, DMRT)

2. Below-ground parameters

2.1. Number of roots of artemisia as affected by different plant growth hormone

The number of roots of artemisia cutting at 61 days after planting as affected by different plant growth promoting media is summarized in Fig. 3. There was a significant difference (F = 4.982, df = 6, 21, P = .003) in the number of roots. The number of roots ranged from 185 to 628. The number of roots for IBA was 628 while that for the control treatment was 185. The number of roots for CW + AVG was the second highest number of roots at 570 roots (Fig. 3).

2.2. Root biomass (g) of artemisia from different plant growth hormone

The fresh root biomass, assessed 66 days after planting is represented in Fig. 3.

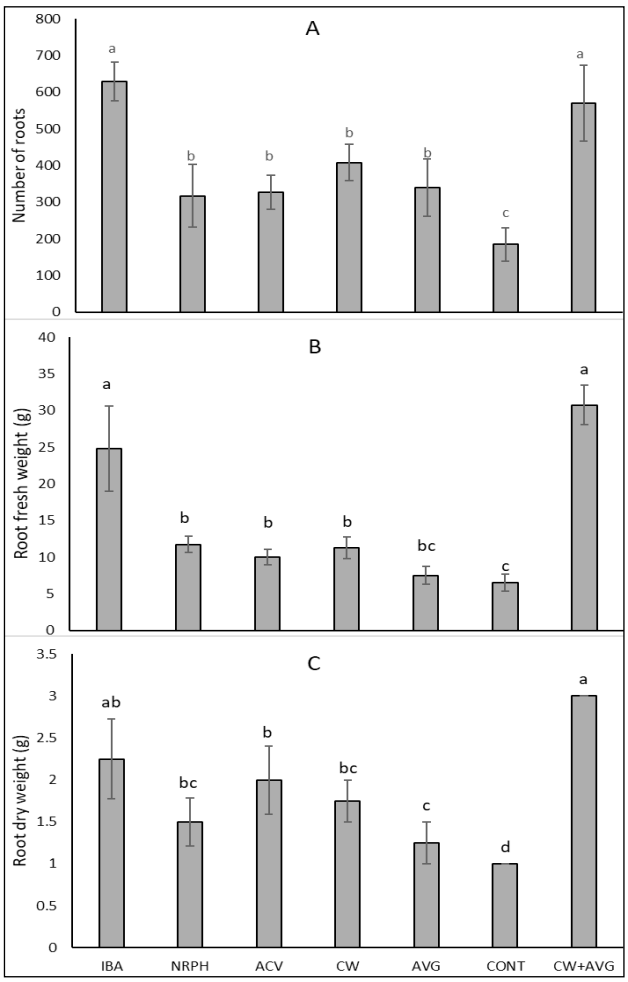

Fig. 3: (A) Number of roots, **(B)** Root fresh weight and **(C)** Rood dry weight of Artemisia as affected by different plant growth hormone. IBA – Indol-3-butyric acid; NRPH – Natural, rooting powder hormone; ACV – Apple Cider Vinegar; CW – coconut water; AVG – aloe vera gel; CONT – control; CW+AVG – coconut water and aloe vera gel. Mean bars within a parameter with the same letter(s) are not significantly different (α = .05, DMRT)

There was a significant difference in the fresh root biomass (F = 12.583, df = 6, 21 P < .001). The highest

fresh root biomass (30.75g) was recorded from CW + AVG, followed by 24.75g recorded from IBA treatment. The smallest fresh root biomass (6.5g) was recorded from control treatment followed by 7.5g from AVG treatment. Meanwhile, the root fresh biomass for NRPH and CW were 11.75g and 11.25g, respectively (Fig. 3).

The dry root biomass, was also significantly affected by plant growth promoting media ($F = 5.241$ $df = 6, 21$, $P = .002$). The highest dry root biomass (3.0g) was observed from CW+AVG, followed by IBA treatment at 2.25g. The smallest dry root biomass (1.0g) was reported from control treatment. The dry root biomass for NRPH and CW were 1.5g and 1.75g, respectively (Fig. 3).

DISCUSSION

Plants have always been an integral component of the way of life of mankind. Consequently, man has been on a quest to increase production of many plants material using available technology. One of such plants that has played a medical role to mankind is Artemisia. Its importance has even attained greater height as it is now attributed as one of the botanicals with potential cure the dreadful corona virus. As a result, fast production of Artemisia, using indigenous, cheap and really available material is emphasized.

This work evaluates the potential of some plant growth regulators (PGPS) or plant growth promoting substances (PGPS) to improve the growth of Artemisia cuttings. The plant growth regulators represent a wide array of some locally available alternative to synthetic chemical plant growth regulators.

The result the current study revealed that, the different PGR medium did not affect the survival rate of Artemisia cuttings. 61DAP was generally low, ranging between 7.0 % to 10%. Generally, most perennial ornamental plants are multiplied and propagated through asexual means of reproduction such as cuttings, layering or grafting (Rauf, 2011). Success of rooting ornamental plant cuttings depends on their growth response, based on nutrient present with aid of growth promoting substances (Longman, 2002) the low survival of the Artemisia cutting in the present study maybe associated with the fact that the soil medium did not have the requisite nutrient amount for growth. The PGPS only aid a growing plant to grow well.

The number of stems of the artemisia cuttings differ significantly. The highest number of stems was observed from AVG treatment and CW +AVG treatment. This was followed by that of ACV. Aloe vera gel (AVG) has been reported to poses plant growth promoting substances with huge potential to increase growth. This is also the situation of coconut water (CW). The same pattern was observed for the diameter of the stem. The finding of the current study is in line with that of Asma and Kashif (2008) and Ibironke (2016). Ibironke (2016) reported that coconut water significantly increased shoot length, number of shoots and shoot girth in some plants. Asma and Kashif (2008) observed that addition of coconut water to a culture media resulted into maximum shoot number and length. Aloe vera gel has been used to increase vegetative growth of some crop species (Padmajaya *et al.* 2007) because it is rich in plant hormones such as auxins and gibberellin (Surjuste *et al.* 2008). Coconut water is reported to have a large diversity of biologically active components as plant growth hormones including auxins, gibberellins, cytokinins, ethylene, abscicic acid and jasmonic acids (McGregor, 2008).

The trend of number stems was observed for number of branching. At all stages, the number of stems from NRPH remained the lowest.

The highest leaf length, leaf width and leaf area wre recorded from IBA, CW+ AVG and AVG.

The highest leaf length, leaf width and leaf area were recorded from IBA, CW+AVG and AVG treatments. The current study is in line with that of Hanes and Leonhardt (2008), who reported optimum growth of cuttings treated aloe vera and coconut water. It should be noted that auxin present in coconut is in the form of indole-3-acetic acid (IAA) which plays a fundamental role in shoot growth (Prusty *et al.* 2004; Dewi *et al.* 2016). For the same reasons, the number of leaves and plant height followed the same pattern as the leaf length, leaf width and leaf area, with the highest value recorded from CW+AVG, AVG, CW and IBA treatments.

Both fresh and dry leaf biomass varied significantly in the same manner. The highest values were obtained from CW+AVG, CW, and IBA. This result further highlights the potential of coconut water

and aloe vera as sustainable alternative sources of plant growth promoting substances (Ibironke, 2016; Mirihagalla and Fernando, 2020).

Like the aboveground parameters, the below ground parameters of Artemisia cuttings were significantly affected by different PGPS media. The highest number of roots was observed from IBA and CW+AVG treatments. This is due to the fact that CW+AVG is rich with plant growth promoting hormones that have huge effects on root length and number of roots (Ibironke, 2016). The current study is accordance with that of Skoog and Yildiz (2000) who reported that ornamental cuttings such as of roses treated Indole-3-butyric acid produced the highest root length and the highest number of roots. The high number of roots from CW+AVG treatments is due to the high concentrations of auxin and gibberellic acid in this plant material. These plant materials have very profound growth promoting effect on ornamental roots (Sardoei *et al.* 2013).

The fresh and dry root biomass also followed the trend of the number of roots. In addition to IBA, CW+AVG, ACV also produced high root number and biomass. The current study is in agreement with that Mu *et al.* (2003) who reported high rooting activity from vinegar prepared plant growth promoting hormone. However, the use of vinegar in plant derived plant growth-promoting substance preparation should be done with caution since vinegar has herbicidal properties.

CONCLUSION

Plant growth regulators (PGRs) trigger numerous metabolic and other vital plant physiological processes involved in the growth and development of plants. These growth regulators are abundant in many plants and can be harnessed for sustainable crop production. Cuttings of artemisia treated with coconut water, aloe vera and IBA provided the highest number of leaves and roots and other growth parameters. The findings provide basis for the incorporation of botanical sources of plant growth promoting hormones for artemisia production.

This could be used in developing natural root and shoot inducing substance and resolving and reducing the risk of chemical toxicity in plants due to PGRs.

Therefore, aloe vera gel and coconut water are recommended as sustainable sources of plant growth promoting hormones.

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