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Effect of Plant Extracts on Growth and Yield of Maize (*Zea mays* L.)

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ABSTRACT

An experiment was conducted at Andalas University area to evaluate the efficacy of plant extracts on the growth and yield of maize. The first trial was testing the crude extracts of several plants on vegetative growth of maize factorial completely randomized design (CRD). The first factor crude extract sources from five species of plants, and the second factor was levels of extract concentration. The second trial was application of the purified extracts on growth and yield of maize using factorial CRD. First factor was the purified extract concentrations, and second factor was application frequencies. Results showed that application of 100 mg/L crude extract of *Gleicheni linearis* leaves was the most effective in increasing plant height and leaf area, compared to control. Treatment with 100 mg/L crude extract was better than the purified one. However, application of purified extract resulted in lower growth and yield of maize compared to control. The highest growth and yield attributes were recorded in 100 mg/L crude extract of *G. linearis* when applied at 15 days after planting (DAP). Further experimentation is needed for confirmation of the results.

Keywords: Crude extract, growth, maize, purified extract, yield

INTRODUCTION

Maize (*Zea mays* L.) is an important food commodity occupying the second rank of plant after rice in Indonesia. National maize demand in 2015 was 12.4 million tons, whereas national production was only 5.178 ton/ha (CBS, 2016). Therefore, maize production failed to fulfill the national demand.

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Indonesian government has set up the target to increase maize production 2.3% by 2019 with the productivity more than 5.178 ton/ha every year (Directorate General of Crop Plants, 2014). One of the strategies to reach the target is through maize extensification using suboptimal land. According to Utomo (2002), there was still huge suboptimal lands in Indonesia with an estimate about 60.7 million hectares. However, there is an obstacle in using suboptimal land because in general it consists of Ultisol soil having low fertility.

The fertility of Ultisol soil has been increased by using organic and inorganic fertilizers but it does not give good results. Therefore, other alternative ways are needed. One of them is using biostimulants that can promote plant growth (Abbas, 2013), increase plant response on stress (Du Jardin, 2012), and enhance plant physiological process (Abbas, 2013). Biostimulants can be obtained from microbial inoculant, humic acid, fulvic acid, amino acid, sea grass extracts (Calvo, Nelson, & Kloepper, 2014), and plant secondary metabolite compounds (Du Jardin, 2015).

Culver, Fanuel and Chiteka (2012) reported that application of crude extract of *Moringa oleifera* leaves on tomato leaves 2 weeks after germinating could increase growth and yield, dry roots weight, and height of tomatoes. Abdalla (2013) also reported that application of 2% leaf extract and 3% branch extract of *M. oleifera* with the frequency two times (7 and 14 days after planting) in a planting season, significantly increased height, fresh and dry weight of *Eruca vesicaria* subsp. s*ativa*. Ertani et al. (2015) found that extract of grape fruit skin with a dose 50 mg/L sprayed at 2 and 4 weeks after planting could increase biomass and dry weight of chili pepper.

Groups of secondary metabolite compounds that have been isolated from plants and used as biostimulants among other thing are triterpenoid saponin (Andresen & Cedergreen, 2010), flavonoid (Prabhu, Kumar, & Rajamani, 2010), and alkaloid (Aniszewski, 2007). In Indonesia, some plants dominantly contain secondary metabolites are leaves of cassava (*Manihot esculenta*) containing rutin glicoside and leaves of fern (*G. linearis*) containing kaempferol glicoside, which is the highest component of flavonoid found in plants (Bakhtiar, Jubahar, Ahmad Mahyudin, & Rivai, 1994). Alkaloid was found in stem bark of *Alstonia scholaris* (Marliana & Ismail, 2011), terpenoid in *Centella asiatica* (Singh, Singh, Gupta, Solanki, Sharma, & Nema, 2012) and xanthon in fruit pericarp of mangosteen (*Garcinia mangostana*) (Orozco and Failla, 2013). Effect of plant extract on maize has not been reported in Indonesia. Therefore, the present study has been initiated to evaluate the efficacy of plant extracts on the growth and yield of maize.

MATERIALS AND METHODS

A research was conducted at Andalas University area surrounded with screen cloth wall and a netting roof for insect protection. This study consisted of two trials, test of

crude extracts of several plants on vegetative growth and test of purified extracts (results from trial 1) on growth and yield of maize. The first trial was conducted from April to August 2016, and the second one was from October 2016 to February 2017.

Design

This trial was done using experimental method arranged in two factors of completely randomized design (CRD). The factor in the first stage was crude extract sources from five species of plants: (A1) leaves of cassava, (A2) leaves of *G. linearis*, (A3) *C. asiatica*, (A4) fruit pericarp of mangosteen, and (A5) stem bark of *A. scholaris*. The nested factor in the second stage was levels of extract concentration: (B1) control, (B2) 25 mg/L, (B3) 50 mg/L, and (B4) 100 mg/L. The experiment was replicated three times.

Source of Crude Extracts

Crude extracts of cassava and *G. linearis* leaves, *C. asiatica*, fruit pericarp of mangosteen, and stem bark of *A. scholaris* were obtained on Laboratory of Sumatran Biota, Andalas University. Extracts were prepared by standard method by Zakiah, Suliansyah, Bakhtiar and Mansyurdin. (2017). et al. (2017) and Ummah, Noli, Bakhtiar and Mansyurdin (2017). Crude extracts of cassava and fern leaves were prepared by boiling method (Bakhtiar et al., 1994) and those of *C. asiatica*, fruit pericarp of mangosteen and stem bark of*A. scholaris* by macerated with methanol (Orozco & Failla, 2013; Singh et al., 2012).

Test Crop and Planting

Planting media were Ultisol soil mixed with compost (5:1 in volume) that were placed in polybags (60 × 40 cm). Maize cv. *Bima-19 URI* was used as test crop and it was collected from the Research Station of Cerealia, Makasar, Indonesia. Two seeds were planted per polybag with a depth of 3 to 5 cm, and the distance among polybags was 25 × 75 cm^2. Removing worse seedling, the healthy seeding was allowed to grow. Seedlings were fertilized with urea (1.05 g/polybag) and MoP (0.53 g/polybag), based on the recommended dose of chemical fertilizer for maize.

Application of Crude Extracts

Crude extracts were diluted in organic solvent, dimethyl sufoxide (DMSO), and then diluted with 1-L water. Crude extracts, ±25 mL per plant, were sprayed evenly on maize leaves 2 weeks after planting. Application of crude extracts was carried out in morning when relative humidity was close to saturation (Kalaivanan, Chandrasekaran, & Venkatesalu, 2012).

Measurement of Growth Parameters

Parameters measured were vegetative growth of maize up to 49 DAP (days after planting) that covered the growth parameters such as plant height, number, and leaf area were measured at every week up to 49 DAP. Then plants were removed from the soil, fresh, and dry weight of shoot and roots were also measured.

Statistical Analysis

The analysis of variance (ANOVA) for various growth characters was performed following *F* test. When *F* was significant at the $p < 0.05$ level, treatments means were separated using Duncan's New Multiple Range Test (DNMRT). Data were analyzed following standard procedure using SPSS software.

Trial II

Design. In trial II, the extract used was the purified one that showed the best result (the most effective) in trial I. The experiment was arranged in two factors CRD replicated three times. First factor was concentrations of extract: F1 (control), F2 (100 mg/L crude extract), F3 (0.4 mg/L purified extract), F4 (0.8 mg/L purified extract), and F5 (1.6 mg/L purified extract). Second factor was application frequency: (T1) once (at 15 DAP) and (T2) twice (15 and 30 DAP).

Preparation of Purified Extract. Purified extracts were prepared from the most effective extract in increasing vegetative growth of maize in the first stage. Preparation of purified extract was meant to obtain the major compounds from crude extract by discarding some other compounds. Purified extract from cassava leaves crude extract was prepared by adding ethanol and screened, then filtrate was steamed in vacuo and purified extract was formed (Bakhtiar et al., 1994). Purified extract from crude fern leaves extract was prepared by adding ethanol and then screened. The filtrate formed was steamed in vacuo, then the purified extract was formed (Bakhtiar et al., 1994; Jubahar et al., 2006). The one from *C. asiatica* crude extract was prepared by adding active carbon and screened, then filtrate was steamed in vacuo, and purified extract was formed (Singh et al., 2012). Purified extract from mangosteen fruit shell crude extract was prepared by adding ethyl acetate and screened, and filtrate was steamed and then was added with hexane, precipitation formed was screened and dried until purified extract was formed (Orozco & Failla, 2013). Purified extract from stem bark of *A. scholaris* was prepared by adding HCl 2M and ethyl acetate and then screened. Water and ethyl acetate fractions were added with NH_4OH then steamed, and purified extract was formed (Marliana & Ismail, 2011).

Phytochemical Analysis. Phytochemical analysis on crude extract was done qualitatively using thin layer chromatography (TLC) plate. Phytochemical screening on secondary metabolites such as flavonoid, terpenoid, steroid, alkaloid, phenolic and saponin was done using standard laboratory method (Harborne, 1973; Trease & Evans, 1983).

Confirmation on the content of purified extracts using TLC for flavonoid content was done using stationary phase with Silica Gel 60 $F_{254}$and mobile phase with *n* butanol:ethyl acetate:water (3:1:1), and for terpenoid it was done using stationary phase with Silica Gel 60 F_{254} and chloroform:metanol (4:1) at mobile phase.

Application of Extracts. Extracts were diluted in organic solvent, *dimethyl sufoxide* (DMSO), and then diluted with 1-L water. Crude and purified extracts, ±25 mL per plant, were sprayed evenly on maize leaves 2 weeks after planting. Application of crude extracts was carried out in morning when relative humidity was close to saturation (Kalaivanan et al., 2012).

Measurement of Growth and Yield Parameters. Previously mentioned growth parameters were measured from early vegetative phase to harvest. Fresh and dry weight of shoot and roots, length and diameter of cob as well as 100 grains weight were recorded at harvest.

Statistical Analysis. The analysis of variance (ANOVA) for various growth characters was performed following *F* test. When *F* was significant at the $p < 0.05$ level, treatments means were separated using DNMRT. Data were analyzed following standard procedure using SPSS software.

RESULTS AND DISCUSSION

Trial I

The growth parameter of maize such as plant height and leaf area were significantly influenced by the interaction effect of different crude extract and concentration. The plant height was found in A2B4 where crude extract of *G. linearis* leaves 100 mg/L were used, which was statistically similar to A2B3 (*G. linearis* leaves 50 mg/L). The lowest plant height was recorded in A4B3 (crude extract of pericarp of mangosteen 50 mg/L). The highest leaf area was found in A2B4, which was significantly higher than the other treatments. The lowest leaf area was recorded in A4B2 (crude extract of stem bark *A. scholaris* 25 mg/L) (Table 2). The interaction effect of crude extract and concentration were not significant. The number of leaves, fresh and dry weight of shoot were significantly influenced by the different concentration of crude extracts.

The highest number of leaves per plant (10.3) was found in cassava leaves at 25 mg/L. The highest fresh weight of shoot was found at concentration 25 mg/L (540.50 g) that was statistically similar to concentration 50 mg/L (526.73 g), and the highest dry weight of shoot was found in concentration 100 mg/L (188.28 g). However, the highest fresh weight of root was found in crude extract of *G. linearis* leaves extract (104.83 g).

Application of 100 mg/L crude extract of *G. linearis* was the most effective in increasing plant height and leaf area, 243.4 cm and 655.43 cm^2, while controls were 174.1 cm and 447.96 cm^2. Crude extract of *C. asiatica* was effective in increasing plant height, number of leaves, and fresh weight of maize plant shoot. Application of crude extract of *C. asiatica* at concentration 25 mg/L was able to increase plant height (216.3 cm) and number of leaves (11 per plant) and showed the highest fresh weight of shoot (618.33 g). Crude extract of mangosteen fruit pericarp was effective in increasing plant height, number of leaves, fresh and dry weight of maize canopies.

Application of crude extracts of mangosteen fruit pericarp at concentration 100 mg/L was able to increase plant height (213.3 cm), number of leaves (10.0 per plant) and showed the highest fresh weight (616.00 g) and dry weight (224.51 g) of shoots.

The result of this research in contrast with Zakiah et al. (2017), vegetative growth of soybean (*Glicine max*) was inhibited by a crude extract of *G. linearis* leaves, mangosteen fruit pericarp and *A. scholaris* stem bark, but crude extract of *C. asiatica* promoted height and leaf area. Ummah et al. (2017) reported that the application of crude extracts of mangosteen fruit pericarp significantly increased the plant height and fresh weight of root of upland rice (*Oryza sativa*). On the other hand, crude extract of *G. linearis* leaves and stem bark of *A. sholaris* decreased vegetative growth. Other studies also showed that the response of plant species to crude extracts was different from one other . Phiri (2010) reported that extract of moringa leaf increased radical length of maize but reduced radical of rice. Shikur (2015) showed that the water extracts of alfalfa (*Medicago sativa*) influenced the root length and yield of beetroot (*Beta vulgaris*).

The effects of crude extracts five plant species on the growth of maize might be due to the content of secondary metabolites in the crude extracts. Secondary metabolites contained in crude extract of *G. linearis* leaves were flavonoid, terpenoid, phenolic, and saponin compounds. Organic compounds of *C. asiatica* were steroid, terpenoid, and polar phenolic. Those of mangosteen fruit pericarp were terpenoid, phenolic, and saponin compounds (Ummah et al., 2017). Terpenoid and terpenoid saponin from the plant extracts might have a role to promote plant growth. Terpenoid is a compound that engages in plant growth and development (Kabera, Semana, Mussa, & He, 2014). Some hormones are terpenoid such as giberelin and abscisic acid. Saha, Walia, Kumar and Parmar (2010) reported that saponin triterpenoid isolated from seed and pericarp of *Sapindus mucorossi* and *Diploknema butyracea* fruits showed the activity to promote growth of maize and rice.

Stem bark extract of *A. scholaris* containing steroid, terpenoid, and saponin that can promote growth also contains alkaloid, phenolic compounds that are toxic to plants. Acording to Ummah et al. (2017), the cassava leaf extract contained terpenoid, flavonoid, and phenolic compound. Flavonoid can inhibit auxin transport that results in decreasing plant height and stem diameter (Brown et al., 2001). Some phenolic compounds inhibit seed germination (Colvas, Ono, Rodriques, & de Sauza Passos, 2003). Polar phenolic compound is more toxic and inhibits cell devision (Zhao-Hui, Qiang, Xiao, Cun-De, & De-An, 2010). Generally, alkaloid group has allelopathic effect that can inhibit growth of monocotyle and dicotyle plants (Shao, Huang, Zhang, & Zhang, 2013).

Based on the result of trial I, application of 100 mg/L crude extract of *G. linearis* leaves showed the most effective effect in increasing plant height and leaf area, that is 1.39 times than the control plant (243.4 cm:174.1 cm) and 1.46 times of control leaf area (655.43 cm^2:447.96 cm^2). Therefore, crude extract of *G. linearis* leaves was continued to test its effects on growth and yield of maize at trial II.

Trial II

The yield contributing characters of maize were significantly influenced by the interaction effect of different concentration of extract and application time. The leaf area was found in F2T1 where crude extract of *G. linearis* leaves 100 mg/L was applied once at 15 DAP, which was statistically similar to F5T1 (purified extract of *G. linearis* leaves 1.6 mg/L was applied once at 15 DAP). The lowest leaf area was recorded in F4T1 (0.8 mg/L PE + 15 DAP) (Table 2). The highest fresh dry weight of shoot was also found in F2T1. The lowest fresh weight of shoot was recorded in F5T1 while the lowest dry weight of shoot was found in F5T2 (purified extract of *G. linearis* leaves 1.6 mg/L was applied twice at 15 and 30 DAP). The highest fresh weight of root, dry weight of root and weight of 100 grains were found in F2T2 (crude extract of *G. linearis* leaves 100 mg/L was applied twice at 15 and 30 DAP). The lowest fresh weight of root was recorded in F5T1, and the lowest dry weight of root and weight of 100 grains were found in F5T2.

Crude and purified extracts of *G. linearis* leaves significantly influenced the leaf area, fresh and dry weight of shoot, fresh and dry weight of roots, length of cob, and weight of 100 grains weight. The highest leaf area (250.95 cm^2), fresh weight of shoot (495.6 g), and dry weight of shoot (114.78 g) were found in 100 mg/L crude extract applied once at 15 DAP. The highest fresh weight (77.7 g) and dry weight (36.3 g) of roots, and weight of 100 grains (177.00 g) were observed in 100 mg/L crude extract applied twice at 15 and 30 DAP.

Mvumi, Tgwira and Chiteka (2013) reported that the application of moringa leaf extract in field treatment significantly increased the grain yield of maize, but in greenhouse condition it was not significant on all parameters. Spraying moringa extract once at 2 weeks after germination increased the grain yield by 59%, while spraying every 2 weeks until physiological mature increased grain yield by 128%.

The lower effect of purified extracts on growth and yield of maize compared to crude ones, and even lower than the one in control, presumably due to the content of purified extract contains kaempferol (R_f^2 = 0.41) and other flavonoid (R_f^1 = 0.15) groups (Figure 1). According to Samanta, Das and Das (2011), flavonoids are the low molecular weight polyphenolic secondary metabolic compounds, and function as allelopathic compounds. Allelopathy flavonoid can inhibit cell growth by inhibiting the production of ATP and the function of auxin (Mierzeak, Kostyn, & Kulma, 2014).

Based on crude extract potential of *G. linearis* leaves, it was able to increase fresh and dry fresh of roots, and weight of 100 grain, while two groups of flavonoid of purified extract was decreased leaf area, fresh weight of shoot. Further studies are needed to evaluate the bioactivity of terpenoid and saponin of purified extract to promote growth and yield of maize. According to Saha et al. (2010), activity of saponin and terpenoid was indicated to promote growth of maize and rice.

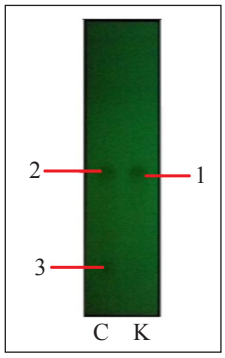

Figure 1. Elucidation of purified extract of *G. linearis* by TLC: Mobile phase: *n*-hexane:ethyl acetate (1:1); stationary phase: silica gel 60 F_{254}; detection: UV_{254}; C = purified extract of *G. lineris* leaf; K = kaempferol as standard; 1 = spot of standard kaempferol (R_f = 0,41); 2 = spot of kaempferol of purified extract (R_f =0.41 =); 3 = spot of other flavonoid group of purified extract (R_f =0.15)

Table 1
Effect of crude extract of several plants with different level of concentration on plant height, number of leaves, leaf area, fresh and dry weight of shoot and root of maize

Crude extracts	Concentrations				Average
	Control	25 mg/L	50 mg/L	100 mg/L	
			Plant height (cm)		
Cassava leaves	174.80efg	176.20efg	176.00efg	166.30efg	173.33
G. linearis leaves	174.10efg	231.70ab	240.50a	243.40a	222.43
C. asiatica	178.00defg	216.30abc	157.00fg	198.50bcde	187.45
Fruit pericarp of mangosteen	176.60defg	193.10cdef	148.80h	213.30abcd	182.95
Stem bark *A. scholaris*	171.20efg	178.80defg	184.80cdefg	159.00fg	173.45
Average	174.94	199.22	181.42	196.10	
			Leaf area (cm^2)		
Cassava leaves	486.70bc	392.26cd	391.55cd	429.90bcd	425.10
G. linearis leaves	447.96bcd	498.18bc	427.18bcd	655.43a	507.19
C. asiatica	453.97bcd	513.59bc	394.47cd	451.43bcd	453.37
Fruit pericarp of mangosteen	423.02bcd	422.47bcd	493.20bc	525.48b	466.04
Stem bark *A. scholaris*	487.01bc	351.81d	486.23bc	426.87bcd	437.98
Average	459.73	435.66	438.53	497.82	

Table 1 *(continue)*

Crude extracts	Concentrations				Average
	Control	25 mg/L	50 mg/L	100 mg/L	
	Number of leaves/plant				
Cassava leaves	9.30ns	10.70ns	10.30ns	10.30ns	10.15A
G. linearis leaves	9.00	10.30	10.00	10.70	10.00A
C. asiatica	9.00	11.00	8.70	9.30b	9.50AB
Fruit pericarp of mangosteen	8.7	9.70	8.00	10.00	9.10B
Stem bark *A. scholaris*	9.30	9.70	8.70	9.00	9.18B
Average	9.06 B	10.28 A	9.14 B	9.86 A	
	Fresh weight of shoot (g/plant)				
Cassava leaves	456.67ns	566.67ns	405.00ns	440.00ns	467.09ns
G. linearis leaves	420.00	615.00	637.50	635.00	576.88
C. asiatica	456.67	618.33	290.00	489.33	463.58
Fruit pericarp of mangosteen	363.33	542.50	276.67	616.00	449.63
Stem bark *A. scholaris*	463.33	360.00	496.67	453.33	443.33
Average	432.00 B	540.50 A	421.17 B	526.73A	
	Dry weight of shoot (g/plant)				
Cassava leaves	171.88ns	173.74ns	167.48ns	157.05ns	167.54ns
G. linearis leaves	186.29	233.20	141.59	195.19	189.07
C. asiatica	141.25	208.11	145.55	192.99	171.98
Fruit pericarp of mangosteen	139.83	155.33	117.07	224.51	159.19
Stem bark *A. scholaris*	145.58	139.37	161.59	171.68	154.56
Average	156.97 AB	181.95 A	146.66 B	188.28 A	
	Fresh weight of root (g/plant)				
Cassava leaves	71.67ns	75.00ns	71.67ns	82.33ns	75.17B
G. linearis leaves	84.33	103.33	111.67	120.00	104.83A
C. asiatica	65.00	70.00	53.33	70.00	64.58A
Fruit pericarp of mangosteen	62.50	87.50	46.67	97.50	73.54A
Stem bark *A. scholaris*	76.67	55.67	111.67	80.00	81.00AB
Average	72.03ns	78.30	79.00	89.97	
	Dry weight of root (g/plant)				
Cassava leaves	26.37ns	15.25ns	14.98ns	25.30ns	20.48ns
G. linearis leaves	22.34	34.99	28.69	22.10	27.03
C. asiatica	15.52	24.26	13.63	20.09	18.38
Fruit pericarp of mangosteen	19.64	29.64	16.26	33.23	24.69
Stem bark *A. scholaris*	27.41	17.50	27.29	19.07	22.82
Average	22.26ns	24.33	20.17	23.96	

Note: In a column and row, within treatment, same letter(s) indicate do not differ significantly according to DNMRT ($p < 0.05$). ns :nonsignificant.

Table 2

Effect of crude and purified extract of G. linearis *leaves and application frequency on growth and yield of maize*

Treatments		Plant height (cm)	No. of leaves/ plant	Leaf area (cm^2/plant)	Fresh weight of shoot (g/plant)	Dry weight of shoot (g/plant)	Fresh weight of root (g/plant)	Dry weight of root (g/ plant)	Length of cob (cm)	Diameter of cob (cm)	100 grains weight (g)	No. of cob/ plant
Concentration (mg/L)	Application frequency											
Control	1×	156.83ns	8.3ns	225.87bc	420.7d	82.40d	60.6e	32.4b	17.0ns	4.6ns	138.33f	1ns
	2×	156.83	8.3	171.57d	456.7b	102.18b	64.3d	26.9efg	15.2	4.3	136.67g	1
100 mg/L CE	1×	159.83	8.7	250.95a	495.6a	114.78a	64.7d	25.9fg	17.3	4.9	167.00b	1
	2×	161.00	9.0	216.90c	457.6b	97.40b	77.7a	36.3a	17.7	4.5	177.00a	1
0.4 mg/L PE	1×	153.67	9.0	185.00d	381.0e	83.72d	63.6d	27.8def	15.8	4.5	142.33e	1
	2×	156.67	8.3	134.34e	431.0c	81.11d	62.3de	29.5cd	16.8	4.6	150.50d	1
0.8 mg/L PE	1×	145.17	8.0	131.98e	389.7e	93.45c	67.3c	28.8cde	17.0	4.5	120.83i	1
	2×	161.67	8.3	188.28d	345.3f	93.60c	62.7de	30.7bc	16.8	4.2	157.00c	1
1.6 mg/L PE	1×	167.00	8.7	238.48a	443.0bc	76.31e	57.3f	25.3gh	15.3	4.3	104.53j	1
	2×	164.00	8.7	142.31e	323.7g	103.8b	70.7b	23.5h	16.0	4.9	132.23h	1

Note: CE: crude extract; PE: purified extract

Different letters within each same column indicate significant differences according to DNMRT ($p < 0.05$)

ns: nonsignificant

CONCLUSION

Crude extract of *G. linearis* leaves at the rate of 100 mg/L was the most effective in increasing plant height (243.4 cm) and leaf area (655.43 cm^2), followed by 50 mg/L of crude extract to plant height (240.5 cm) and 25 mg/L to leaf area (498.18 cm^2) , while in controls they were 174.1 cm and 447.96 cm^2. In the second trial, crude extract was more effective than the purified one. Growth and yield of maize treated with purified extract were lower than the ones of control. The highest fresh weight (77.7 g) and dry weight (36.3 g) of roots, and weight of 100 grains (177.00 g) were found in 100 mg/L crude extract applied twice at 15 and 30 DAP. The application of crude extract of *G. linearis* leaves could be used as biostimulants to increase growth and yield of maize.

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