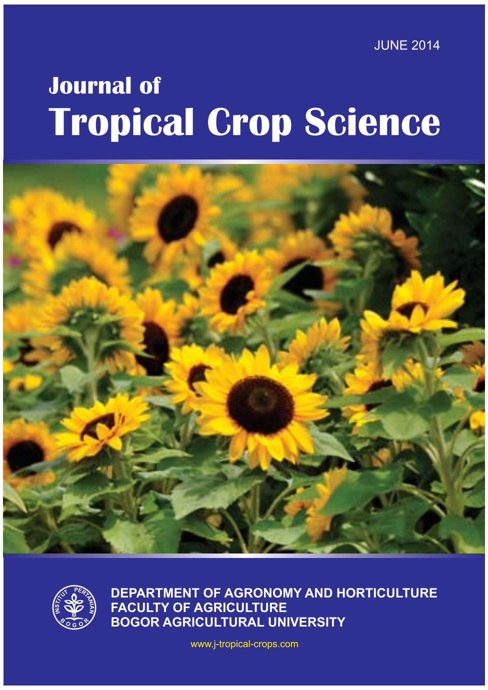

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Different Growth Partitioning and Shoot Production of *Talinum triangulare* Treated with Organic and Inorganic Fertilizer

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Abstract *Talinum triangulare* or waterleaf is an underutilized tropical plant, mostly found as weeds, and has been used more as medicinal plant than as vegetable in Indonesia. The study of *Talinum triangulare* cultivation has been explored to increase the shoot production as functional vegetables. The effects of organic fertilizer applications at 0.50, 0.75, 1.00, 1.25 and 1.50 of the standard rate on waterleaf growth were tested in a Leuwikopo research station, Bogor, West Java, Indonesia. Standard rate of organic fertilizer consisted of 12.3 t..ha^{-1} of cow manure, 226.8 kg. .ha^{-1} of guano, and 5.5 t.ha^{-1} of rice hull ash that is equal to 100 kg urea, 60 kg SP-36 and 100 kg KCl.ha^{-1}. Net assimilation rate (NAR) of the organic fertilizer-treated plants was lower than the inorganic fertilizer-treated with plant at two to four weeks after planting (WAP). However, the plants treated with 0.75-1.25 organic fertilizer had a higher NAR than those treated with inorganic fertilizer at four to six WAP. Plants treated with 0.75 rate of organic fertilizer had similar relative growth rate (RGR) to plants treated with the inorganic fertilizer at two to four WAP, whereas plants treated with 1.00, 1.25 and 1.50 standard rate had higher RGR than plants treated with inorganic fertilizer at 4-6 WAP. Plants treated with 1.50 organic fertilizer rate had 34.55% more marketable shoots compared to those treated with inorganic fertilizer whereas those treated with 0.50 rate of organic fertilizer had 179.54% at 6 WAP. The percentage of marketable shoots to total fresh weight of the organic fertilizer-treated plants was lower than the inorganic fertilizer-treated plants.

Keywords: *Talinum triangulare*, leafy vegetables, organic

Introduction

Talinum triangulare or waterleaf is an underutilized tropical plant from Portulacacea family found mostly as weeds, and has been used more as medicinal plant than as vegetable in Indonesia. The name of waterleaf came from the high water content of the plant, which is 95-98 % (Susanti et al., 2008; Mualim et al., 2009). Waterleaf is classified into functional vegetables. The edible part of the plants are the leaves which contain primary metabolites such as protein and vitamin C, and secondary metabolites such as phenolic compounds that have high anti-oxidant activities (Yang et al., 2006; Andarwulan et al., 2010). Phytochemical study by Aja et al. (2010a) reported that each 100g dry weight of waterleaf contain flavonoid (0.070%), alkaloid (0.056%), saponin (0.001%), tannin (0.001%) and a total phenol of 0.489 mg eq galic acid (GAE).g^{-1} fresh weight with lipid peroxidation inhibition of 97.1%. DPPH, ABTS and FRAP tests showed trolox equivalen (TE) values of 7.4, 1.03 and 28.3 TE/ g. ha^{-1} fresh weight, respectively (Andarwulan et al., 2010). Waterleaf methanol extract showed TEAC test value of 79 µmol TE/g (Yang et al., 2006). The leaves of waterleaf contains carbohydrate (10.87 mg.g^{-1}), steroid (106.61 mg.g^{-1}), protein (35.20 mg.g^{-1}), fat (35.20 mg.g^{-1}), β-karoten (114.15 mg.g^{-1}), and crude fiber (120 mg.g^{-1}) (Aja et al., 2010 b).

To date there is still no available information on the effects of organic fertilizer application on waterleaf growth partitioning and shoot production. Organic farming is believed to produce better quality vegetables over conventional farming that uses inorganic fertilizers. Organically produced vegetables had a higher concentration of polyphenol antioxidants (Carbonaro et al., 2002; Young et al., 2005; Benbrook et al., 2008; Abu-Zahra et al., 2007), vitamin C, Fe, Mg, and P than those produced by conventional systems (Worthington, 2001). In addition, organic farming products had high sugar content (Stert, 2005; Hallmann and Rembialkowska, 2007). Vegetable quality is indicated by the content of vitamin, antioxidant, minerals and functional components including pigments and polyphenols (Ali et al., 2009). Studies on the effect of manure (Ibeawuchi et al., 2006; Susanti et al., 2008), and NPK (Mualim et al., 2009; Mualim and Aziz, 2011) on waterleaf growth has been reported. Application of 5 ton chicken manure.ha^{-1} resulted in high phytochemical waterleaf quality (Susanti et al., 2009). Potassium was reported to be the limiting factor in waterleaf anthocyanin production; the highest anthocyanin (39.60 mol.plant^{-1}) was obtained from application of 100 kg SP-36.ha^{-1} dan 100 kg KCl.ha^{-1} (Mualim et al., 2009). The aims of this study were (1) to determine the relative growth rate (RGR) and net assimilation rate (NAR); (2) to determine if application of organic fertilizer can increase marketable shoots; (3) to investigate the effects of organic and inorganic fertilizer application on the proportion of marketable shoots to other part of the waterleaf.

Materials and methods

Treatments

The experiment was set in randomized block design with five rates of organic fertilizer treatment, i.e. 0.50, 0.75, 1.00 (the standard rate), 1.25 and 1.50 of the standard rate, which is 12.3 $t.ha^{-1}$ of cow manures + 226.8 $kg.ha^{-1}$ of guano + 5.5 $t.ha^{-1}$ of hulls. One rate of organic fertilizer treatment equals to 100 kg urea, 60 kg SP-36 and 100 kg $KCl.ha^{-1}$ and was set as control. Plant spacing was 100 cm x 50 cm. Rice hull charcoal at 2 $t.ha^{-1}$ was applied at the same time with the organic fertilizer treatment application (Mualim et al., 2009). Net assimilation rate (NAR) and relative growth rate /RGR (South, 1995) were measured at two, four and six WAP, and shoot harvesting at six WAP. Marketable shoots are shoots of a minimum of 15-cm length with leaf buds and were harvested at six WAP. Data obtained from organic and inorganic fertilizer treatments were compared using t-Dunnet test.

Results

The experiment was conducted at Leuwikopo experimental farm of Bogor Agricultural University, Indonesia (GPS). The soil type is latosol with flat topography, light intensity of 302 cal/cm^2/minute, average temperature of 25.8°C, and rainfall intensity of 6.5 mm per week. Soil pH (H2O) and (KCl) was 4.6 (acidic) and 4.1 (very acidic), respectively, C/N ratio of 15 (low), CEC of 8.97 Cmol(+)/kg, soil base saturation of 57%, and soil texture consisting of sand, loam, and clay of 19%, 13% and 68%, respectively.

Talinum plants flowered at three to six WAP. The C-organic and N levels of the organic vs inorganic fertilizer-treated leaves at six WAP were 49.3 vs 50.3% and 1.81 vs 2.42%, ($P<0.01$), respectively; the P and K levels were 0.27 vs 0.21 and K 5.56 vs 4.92% ($P<0.05$), respectively.

Organic fertilizer-treated plants had a lower plant biomass (Figure 1A) and leaf photosynthetic activity (Figure 2A) than inorganic fertilizer-treated plants up to four WAP, and the plants treated with a half rate of organice fertilizer had the lowest of both. However, the biomass of the organic fertilizer-treated plants showed an increase at four to six WAP (Figure 1B). At six WAP the plants treated with a standard, 1.25, and 1.5 standard rates of organic fertilizer had a greater biomass than those treated with inorganic fertilizer (Figure 1B).

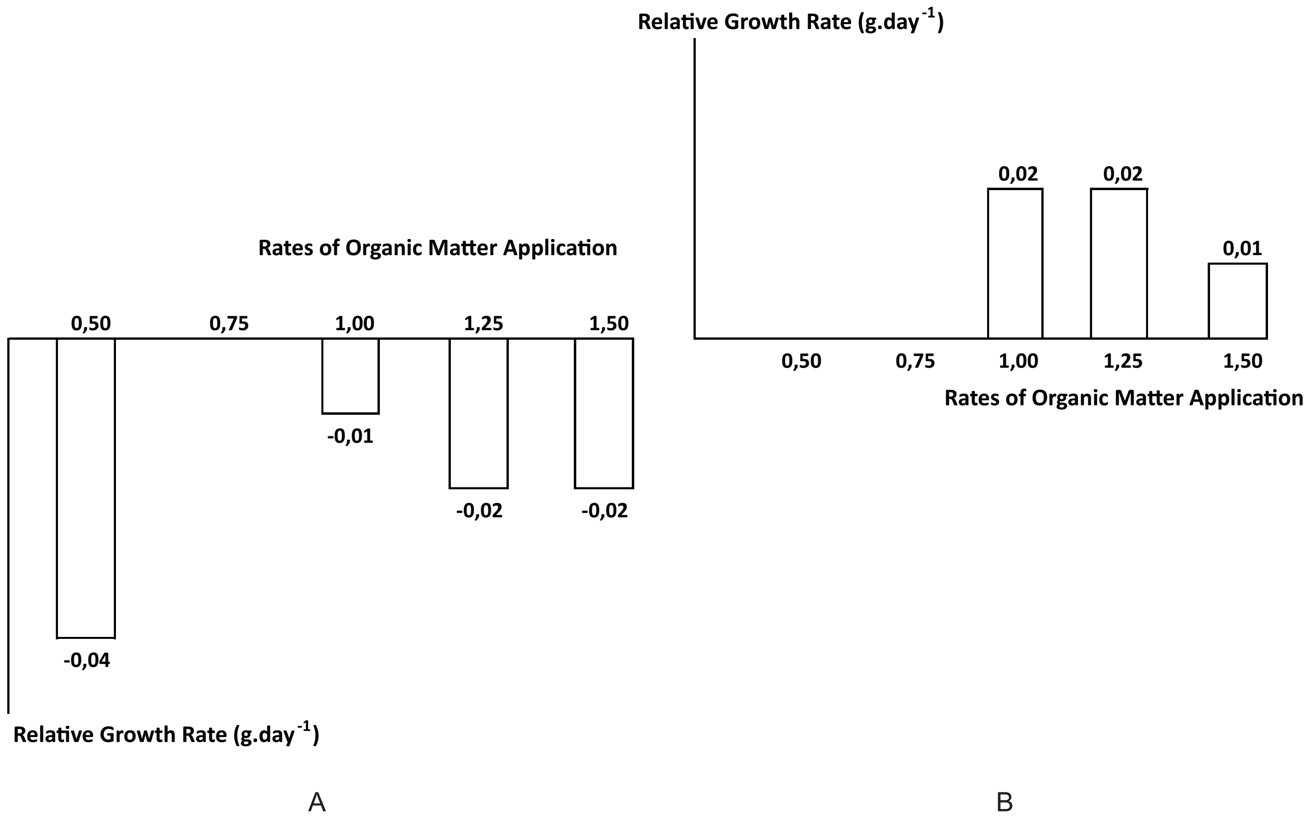
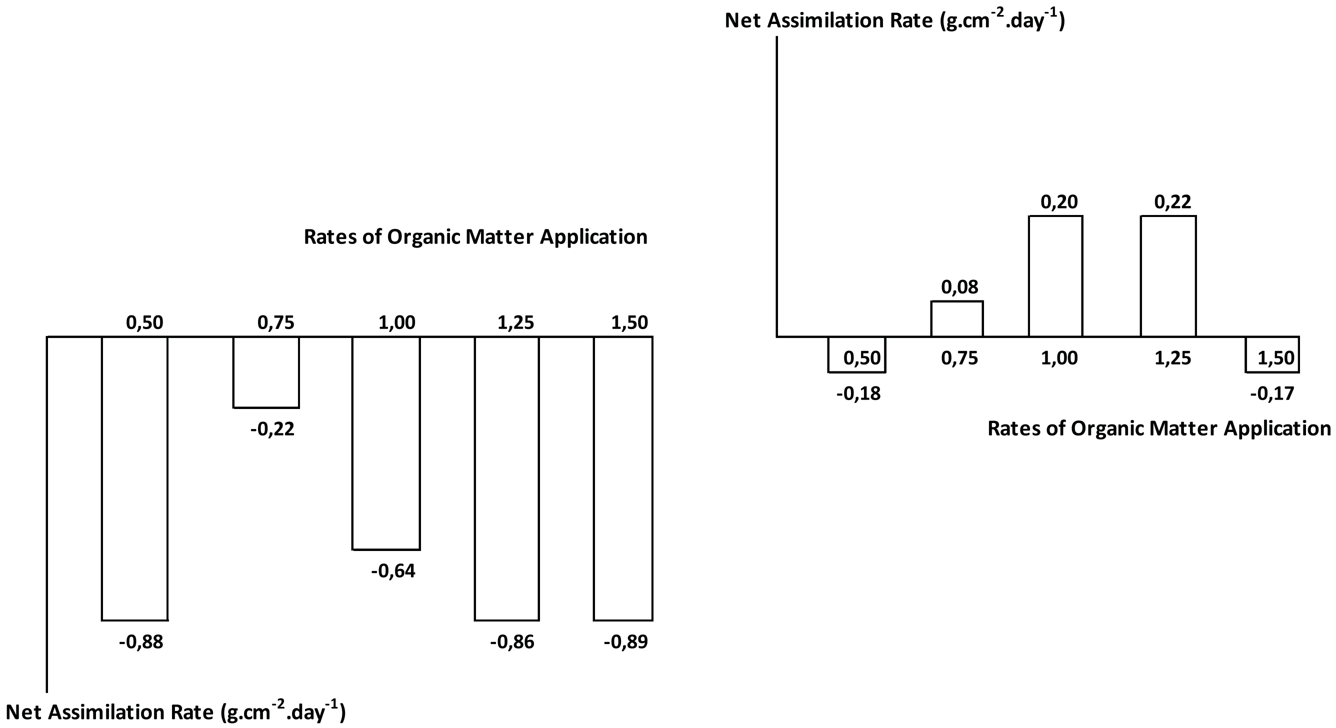


Figure 1. Relative growth rate ($g.day^{-1}$) of organic fertilizer-treated vs to inorganic fertilizer-treated plants at (A) two to four WAP (0.09$g.day^{-1}$); (B) four to six WAP (0.02$g.day^{-1}$).

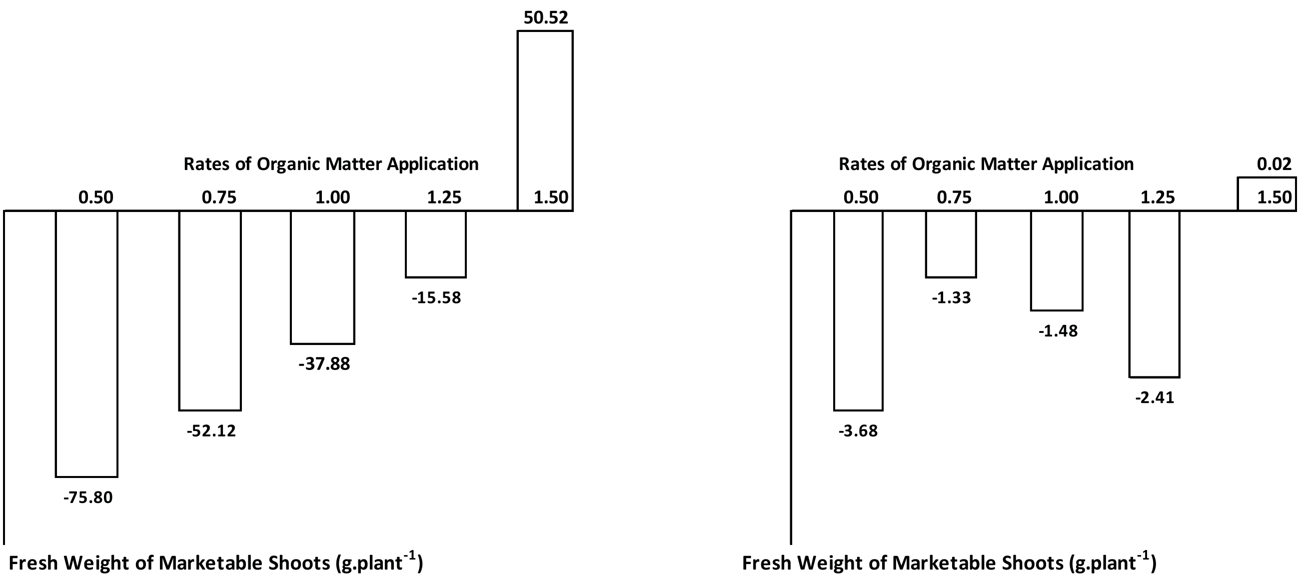
Plants treated with 1.5 standard rate of organic fertilizer had the greatest fresh weight of marketable shoots at six WAP (Figure 3A). However, the dry weight was lower than those treated with the inorganic fertilizer (Figure 3B). This indicated that the plants treated with 1.5 standard rate of organic fertilizer had the highest water content.

The organic fertilizer-treated plants had a higher percentage of marketable shoots to the total biomass than the inorganic fertilizer-treated at four WAP; and plants treated with the standard rate had the highest (Figure 4B), i.e. 20.42% higher than inorganic fertilizer-treated. At two and six WAP the proportion was dominated by other parts of the plant.



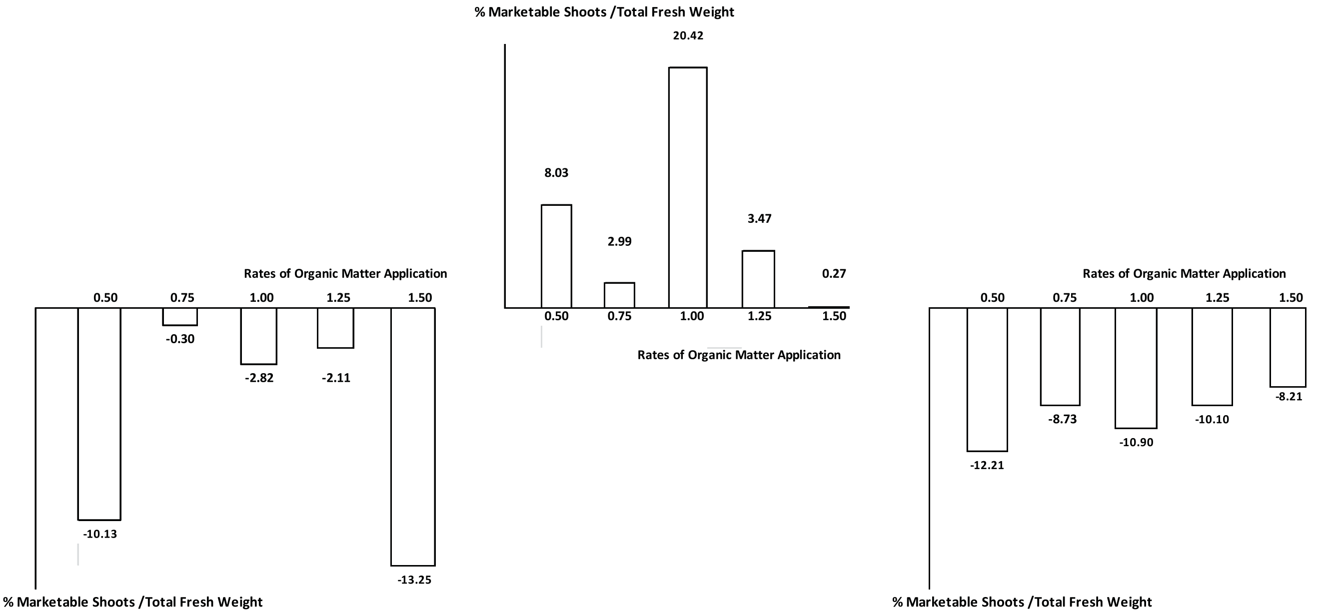
A B

Figure 2. Net assimilation rate (g.cm^{-2}.day^{-1}) of organic fertilizer-treated compared to inorganic fertilizer-treated plants at (A) two to four WAP (1.22 g.cm^{-2}.day^{-1}) and (B) at four to six WAP (0.5 g.cm^{-2}.day^{-1})



A B

Figure 3. (A) Fresh weight of marketable shoots (g.plant^{-1}) of the organic fertilizer-treated plants compared to those treated with inorganic fertilizer (146.22 g.plant^{-1}) at six WAP; (B) Dry weight of marketable shoot weight of plants treated with organic fertilizer compared to those treated with inorganic fertilizer (9.06 g.plant^{-1}) at six WAP.



A B C

Figure 4. Percentage of marketable shoots to total biomass (fresh weight) of the organic fertilizer-treated vs inorganic-fertilizer treated plants at (A) two WAP; (B) four WAP; and (C) six WAP.

Table1. Growth and Shoot Production of *Talinum triangulare* treated with organic and inorganic fertilizer

Cultivar	WAP	Rate of Organic Fertilizer					Inorganic fertilizer
		0.5	0.75	1.00	1.25	1.50	
Plant height (cm)	2	24.79	27.81	24.89	28.98	26.33	24.90
	3	31.41b	35.07ab	33.67ab	35.50ab	37.71a	34.53
	4	40.49c	43.09bc	43.14bc	44.60b	47.89a+	41.43
	5	47.41b	48.93b	49.25b	49.81b	54.85a+	46.47
	6	49.52c	53.12abc	53.17abc	56.57ab	58.73a	50.67
Shoot diameter (cm)	2	30.15	30.69	34.12	31.87	34.14	32.59
	3	36.89b	40.67ab	43.57a	42.65a	44.03a	41.29
Marketable shoot weight (g)	6	70.38b	94.10b	108.34b	130.64b	196.74a	146.22
Stem weight (g)	6	26.75b	26.57b	25.52b	46.51a	45.84a	31.68
Leaf fresh weight (g)	2	38.42	34.00	48.98	78.70	37.11	40.12
	4	218.05	229.67	252.19	209.19	266.56	230.42
	6	124.91	140.42	166.26	208.89	296.99	205.61
Shoot fresh weight (g)	2	155.41	95.73	109.00	131.18	211.59	94.31
	4	460.30	520.80	547.90	464.90	596.50	515.10
	6	296.20	343.70	430.40	498.10	702.20	402.00
Root dry weight (g)	2	0.85	0.60	0.51	0.65	0.88	0.63
	4	1.66	3.00	1.88	2.05	2.34	2.14
	6	1.63	1.94	2.77	2.30	2.60	2.11
Stem dry weight (g)	2	2.56	2.33	1.84	2.23	2.13	2.86
	4	6.33	4.37	3.98	4.13	5.51	4.04
	6	3.87	4.41	4.55	5.14	4.30	4.26
Leaf dry weight (g)	2	5.55	4.21	4.96	4.89	6.18	4.78
	4	13.91	12.65	14.53	11.12	14.52	14.94
	6	11.00	13.00	14.65	12.51	15.18	18.05
Shoot dry weight (g)	2	8.67	6.28	7.52	8.06	9.46	7.52
	4	22.51	27.93	29.33	19.20	31.90	31.23
	6	32.22	34.79	44.13	38.82	42.72	42.56

Note: values followed by different letters in the same row indicate significant differences by Duncan's Multiple Range test, $P<0.05$;
value followed by (+) indicate significant difference by t-Dunnet test

Plants treated with 1.50 standard rate of organic fertilizer had better performance than plants treated with inorganic fertilizers or with other rates of organic fertilizer for all other variables. This treatment also produced 34.55% more marketable shoots than the inorganic fertilizer treatment, and 179.5% of the 0.50 organic fertilizer treatment (Table 1). The total marketable shoots of the organic fertilizer-treated plants were similar to those treated with inorganic fertilizer.

Discussions

The low RGR and NAR at two to four WAP might be related to the slow availability of the nutrients from the decomposing organic fertilizer, and to the fact that the plants had reached the generative phase. This condition showed that waterleaf had a good access to nutrients from the inorganic fertilizer at two to four WAP. The leaf C-organic and nitrogen content of the inorganic fertilizer-treated plants were initially lower than the organic fertilizer-treated, i.e. 49.3 vs 50.3%, and 1.81 vs 2.42% respectively ($P<0.01$). However, at four to six WAP the nutrient accessability from organic fertilizer increased. P and K levels of the organic fertilizer-treated leaves were significantly higher ($P<0.05$) than the inorganic fertilizer-treated leaves at six WAP.

Conclusions

Out of all rates of organic fertilizers tested plants treated with 0.75 rates had similar RGR to the inorganic fertilizer-treated plants at two to four WAP. Plants treated with 1.00, 1.25 and 1.50 fertilizer rates had higher RGR than inorganic fertilizer at four to six WAP. Marketable shoots from 1.50 organic fertilizer-treated plants was 25.67% greater than those treated with inorganic fertilizer, and it was 179.54% of those treated with 0.50 rate of organic fertilizer at six WAP. All plants treated with organic fertilizer produced more marketable shoots than those treated with inorganic fertilizer.

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