

GROWTH, YIELD AND UPTAKE OF NUTRIENTS IN RED AMARANTH IN RESPONSE TO APPLICATION OF TEXTILE EFFLUENT

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Abstract

To investigate the effects of textile effluent on growth, yield and nutrient uptake of amaranth, a field experiment was carried out. The different treatments were T₁: Control, T₂: 100% RDF (recommended dose of fertilizer) + 0% effluent, T₃: 50% RDF + 25% effluent, T₄: 50% RDF + 50% effluent, T₅: 50% RDF + 75% effluent, and T₆: 50% RDF + 100% effluent. T₂ (100% RDF) had the tallest plants (86.6 cm), the largest bases diameter (18.2 mm), the maximum number of leaves (28.3), the highest yield (38.18 t/ha), and the highest levels of N, P, K, S, Ca, and Mg uptake. Although T₂ had the highest values, the results did not show much statistical difference between T₂ and T₄ treatments. The findings of the current studies suggest that in areas with limited freshwater resources, irrigation with a mixture of 50% RDF and 50% textile effluent may be employed to increase amaranth yield and nutrient uptake.

Key words: Growth, Yield and uptake, Red amaranth, Textile effluent.

Introduction

Due to its rapid growth and availability throughout the year, amaranth is eaten as a leafy vegetable. Amaranth includes secondary plant metabolites in addition to macro- and micronutrients, which may be important in the human diet due to their potential health benefits (Tang, 2017). Other significant nutrients included in amaranth leaves are dietary fiber, vitamins and vitamin precursors (ascorbic acid, riboflavin, tocopherols, and carotenoids), as well as minerals (Ca, Fe, Mg, K, Cu, Zn, and Mn). Compared to those found in various cereals and green leafy vegetables, their contents are higher in amaranth (Rastogi *et al.* 2013, Valencia *et al.* 2009, Venskutonis and Kraujalis 2013). Amaranth is becoming more popular as a food ingredient due to its nutrient composition, especially in the creation of gluten-free goods (Alvarez *et al.* 2010, Conte *et al.* 2019). Other than reusing wastewater discharged by textile and dyeing factories, farmers in urban and periurban areas of developing countries like Bangladesh have no other sources of irrigation water for agriculture. The main advantages of using wastewater include increased soil fertility, which improves crop production by increasing the content of organic matter (OM), macronutrients, and micronutrients (Pereira *et al.* 2011), as well as environmental advantages like decreased groundwater uptake and decreased direct discharge of residual waters (Muyen *et al.* 2011, Toze 2006). Heavy metals in the soil can pose a serious hazard to both human health and ecological integrity. However, relatively few studies of dietary exposure to heavy metals from eating green plants have been found in Bangladesh (Jolly *et al.* 2013, Alam *et al.* 2003, Al-Rmalli *et al.* 2012). Therefore, the purpose of this study is to evaluate the yield and nutrient uptake of red amaranth as a result of irrigation with textile effluent.

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Material and Methods

A field experiment was carried out at the Bangladesh Jute Research Institute in Dhaka. Treatments were T₁: Control, T₂: 100% RDF (recommended dose of fertilizer) + 0% effluent, T₃: 50% RDF + 25% effluent, T₄: 50% RDF + 50% effluent, T₅: 50% RDF + 75% effluent, and T₆: 50% RDF + 100% effluent. Experiment was set up using three-replications using a randomized complete block design (RCBD). There were 18 plots, and each one was 3 m × 3 m in size. There was one meter of space between each plot, each block, and the field itself. Final land preparation included basal applications of all P as triple super phosphate (TSP), all K as muriate of potash (MoP), all S as gypsum, and half of N as urea. In moist soil conditions, the remaining N was top dressed at the 15 day after sowing. Red amaranth plants were harvested before flowering. Base diameter and plant height of ten randomly selected uprooted amaranth plants were taken with a slide calipers and meter scale, respectively. Then the plant roots, shoots and leaves were separated and their fresh and dry weights were taken.

Table 1. Some physicochemical properties of the soil.

Characteristics	Values	Characteristics	Values
Particle size analysis a		Magnesium (Mg) Cmol(+)K ⁻¹	0.93
Sand (%)	42	Available phosphorus (P) mgkg ⁻¹	26.51
Silt (%)	45	Available Sulphur (S) mgkg ⁻¹	29.11
Clay (%)	13	Available copper (Cu) mgkg ⁻¹	0.74
Textural class	Loam	Available iron (Fe) mgkg ⁻¹	199.80
pH b	6.2	Available manganese (Mg) mgkg ⁻¹	2.42
EC (dSm ⁻¹)	1.3	Available zinc (Zn) mgkg ⁻¹	20.15
Organic matter % c	2.42	Available lead (Pb) mgkg ⁻¹	29.78
Total Nitrogen % b	0.121	Available cadmium (Cd) mgkg ⁻¹	0.238
Potassium(K) Cmol(+)K ⁻¹	0.31	Available nickel (Ni) mgkg ⁻¹	23.48
Calcium(Ca) Cmol(+)K ⁻¹	3.27	Available chromium (Cr) mgkg ⁻¹	31.12

a. Boyoucos (1962), b. Jackson (1973), c. Walkley and Black (1934)

Table 2. Chemical characteristics of textile effluent.

Characteristics	Values	Characteristics	Values
pH	7.2	Phosphorus (mgkg ⁻¹)	40.27
EC (dSm ⁻¹)	2.43	Sulphur (mgkg ⁻¹)	70.48
TDS (mgkg ⁻¹)	805	Copper (mgkg ⁻¹)	1.73
DO (mgkg ⁻¹)	4.2	Iron (mgkg ⁻¹)	1.11
BOD (mgkg ⁻¹)	13.4	Manganese (mgkg ⁻¹)	0.069
Color	brownish	Zinc (mgkg ⁻¹)	0.10
Total Nitrogen (%)	0.6	Lead (mgkg ⁻¹)	0.0001
Potassium (mgkg ⁻¹)	0.61	Cadmium (mgkg ⁻¹)	0.0032
Calcium (mgkg ⁻¹)	0.73	Nickel (mgkg ⁻¹)	0.351
Magnesium (mgkg ⁻¹)	0.25	Chromium (mgkg ⁻¹)	0.152

Majority textile mills are located in Gazipur areas, from where textile effluent was collected for irrigation. Following land preparation, samples of the 0 to 15 cm plough layer were taken. For chemical analysis, one kilogram of each composite soil sample was collected in a plastic container. In addition, in a plastic bottle containing one liter of textile waste water was collected. Physical and chemical characteristics were determined using standard procedures:

Results and discussion

Plant height: Red amaranth plant height increased significantly ($P \leq 0.05$) under textile effluent irrigation than under control (Fig. 1). Highest plant height (86.6 cm) was recorded in T_2 (100% RDF) and the lowest plant height (70.03 cm) was found in control. Plant height increased until irrigation of 50% effluent and then gradually decreased. The findings showed that T_4 (50 % RDF + 50 % effluent) demonstrated the strongest positive effect on plant height within the effluent-treated plots. Red amaranth with T_2 and T_4 have similar plant heights with no apparent differences. On the other hand, the plant height of red amaranth with T_4 has no significant difference with the plant height of treatment T_5 and T_6 .

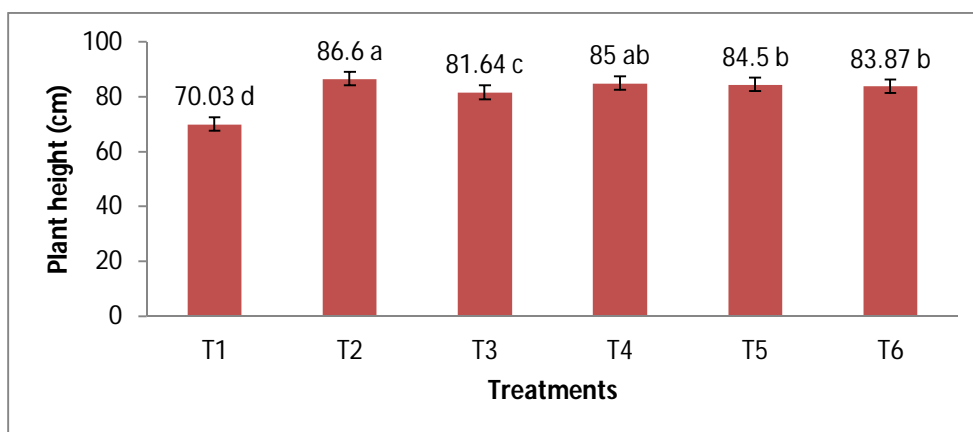


Fig. 1. Effect of textile effluent on red amaranth plant height.

Base diameter: Base diameter of the red amaranth plant rose significantly ($P \leq 0.05$) after applying several combinations of effluent compared to the control (Fig. 2). The results showed that the T_2 treatment (100 % RDF + 0% effluent) had the largest base diameter, 18.2 mm, which was also significantly ($P \leq 0.05$) different from the other treatments. The T_4 (50 % RDF + 50 % effluent) treatment had the second-highest base diameter of the red amaranth plant (16mm) and it significantly ($P \leq 0.05$) differed from the other treatments. Additionally, T_1 was used to determine that the plant's minimal base diameter was 12.1 mm (control). Base diameter gradually decreased with increasing effluent concentration more than 50% during irrigation.

Number of leaf: Red amaranth plants produced considerably ($P \leq 0.05$) more leaves per plant than the control (Fig. 3). The results also demonstrated that the number of leaves per plant increased until watering with 25% textile effluent, after which it declined steadily.

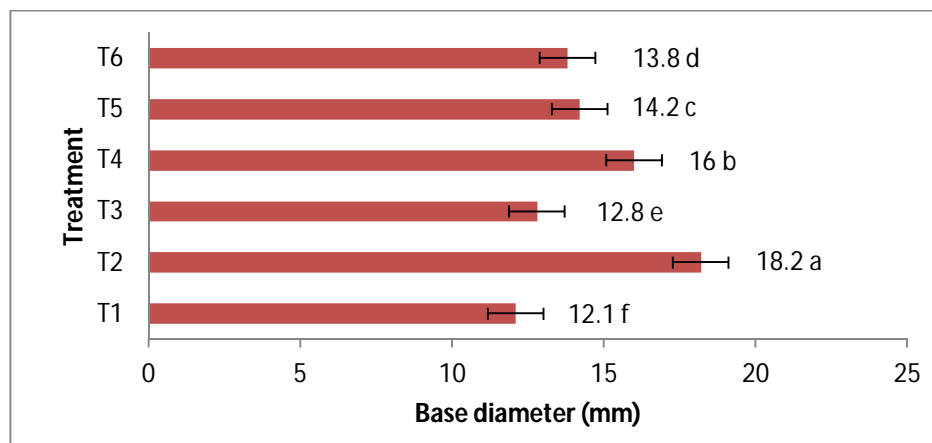


Fig. 2. Effect of textile effluent on base diameter of red amaranth.

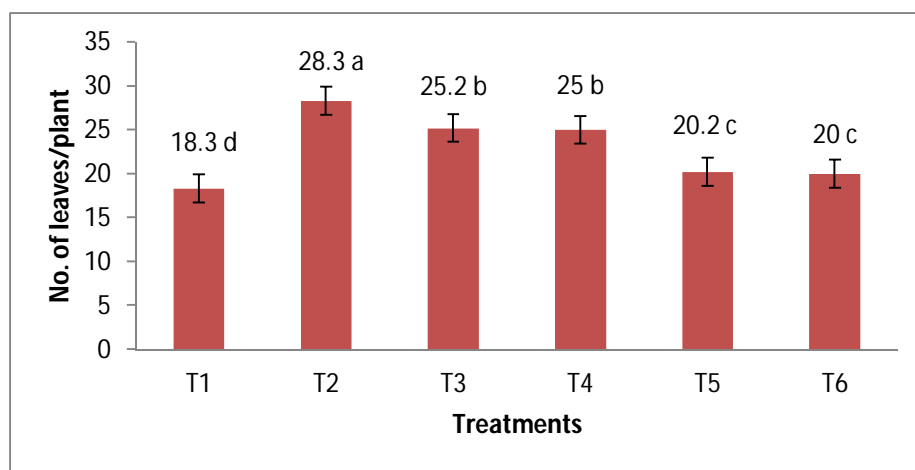


Fig. 3. Effect of textile effluent on the number of leaves per plant of red amaranth.

The highest number of leaves per plant was 28.3 and the second highest number of leaves per plant was 25.2 in T₂ and T₃, respectively. And the lowest number of leaves per plant 18.3 was found with the treatment T₁ (control). The results revealed that treatment T₃ (50% RDF + 25% effluent) and T₄ (50% RDF + 50% effluent) showed the similar effect on number of leaves of red amaranth, which have no significant difference between each other. On the other hand, treatment T₅ (50% RDF + 75% effluent) and T₆ (50% RDF + 100% effluent) also showed the similar effect on the number of leaves of red amaranth, which have no significant difference between each other.

Begum *et al.* (2018) found that applying various combinations of textile effluent had a favorable impact on the jute plant's height, number of leaves, and overall leaf weight. Results confirmed and agreed with the accomplishments of this research investigation. Yaseen *et al.* (2017) observed that applying waste and canal water in a 50:50 ratio increased field mustard plant

height, pod quantity, and pod length. Instead of disposing of the textile wastewater in lakes and rivers, Kanan *et al.* (2005) and Khan *et al.* (2003) put it to agricultural fields and recorded that crops grow better due to the presence of many nutrients like N, P, Ca, Mg, *etc.* Muhammad *et al.* (2013) found that vegetative growth of Sorghum assessment found that plant height was better in control (0% TWW) and T4(100% TWW), had the least height among all treatments. Khandaker *et al.* (2013) found that growth and yield performance of amaranth irrigated with different less polluted textile wastewater increased the number of leaves, leaf length and leaf width, stem diameter, plant weight, and also plant height.

Yield: Irrigation of different dose of textile effluent significantly ($P \leq 0.05$) increased red amaranth yield as compared with T₁ (control). Results revealed that yield of red amaranth increased with the concentration of textile effluent increased up to 50%, then decreased. The highest yield of red amaranth was 38.18 t/ha, which was found with the treatment T₂ (100% RDF + 0% effluent) and the second highest yield of red amaranth was 36.78 t/ha, which was achieved with T₄ (50% RDF + 50% effluent). The lowest yield of red amaranth was 23.75 t/ha, which was found with T₁ (control). The outcomes also showed that yield of red amaranth with all treatments varied significantly ($P \leq 0.05$) with each other treatment. The yield was increased 60.76% with treatment T₂ and 54.86% with treatment T₄ over control.

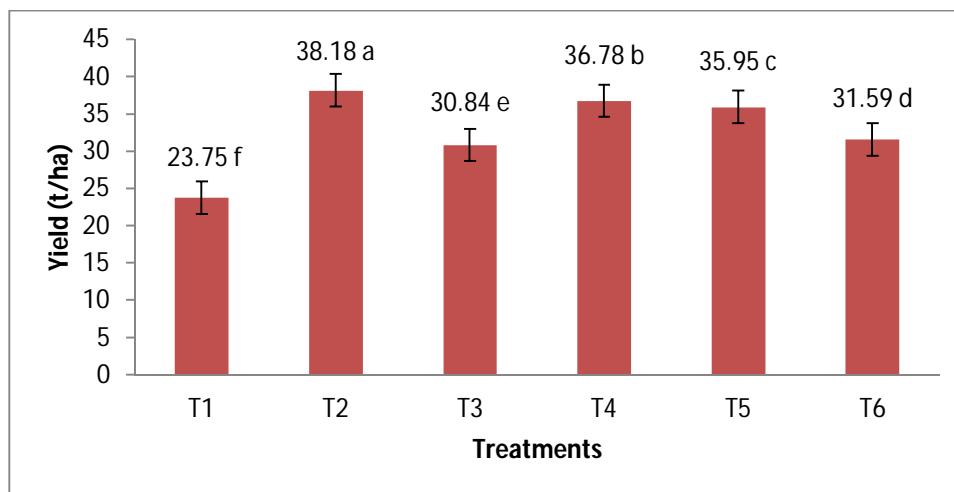


Fig. 4. Effect of textile effluent on yield of red amaranth.

According to Nagajyothi *et al.* (2009) and Nath *et al.* (2009), irrigation with textile effluent increases crop growth and yield. The results are consistent with those for the soil watered with textile effluent that were previously published by Kumar *et al.* (2018). Ramana *et al.* (2002) observed that they were beneficial with the irrigation wastewater on various crops including vegetables.

Nutrient content in different parts of red amaranth: Nutrients content in shoot were higher than roots but lower than leaves in terms of N, P, K, S, Ca, and Mg. The concentration of the N, P, K, S, Ca and Mg of leaves of red amaranth ranged from 3.10 to 3.70%, 0.34 to 0.41%, 0.45 to 0.49%, 0.67 to 0.85%, 0.730 to 0.895% and 0.75 to 0.84%. In shoot it ranged from 0.94 to 1.04%,

0.12 to 0.15%, 0.23 to 0.27%, 0.32 to 0.41%, 0.225 to 0.290% and 0.30 to 0.40%. And in root it ranged from 0.06 to 0.69%, 0.07 to 0.11%, 0.15 to 0.18%, 0.20 to 0.31%, 0.110 to 0.155% and 0.13 to 0.20% with different treatments. Highest N (3.70%), P (0.41%), K (0.49%), S(0.85%), Ca (0.895%) and Mg(0.84%) were found in leaves of red amaranth with T₂ (100% RDF + 0% effluent). The second highest N (3.61%), P (0.38%) and Ca (0.850%) were observed in leaves with T₅ (50% RDF+75% effluent) and the second highest K (0.48%), S (0.82%) and Mg (0.82%) were found with T₄(50%RDF+50% effluent). The findings indicated that all the treatments contained higher nutrient over control. Nutrient content increased with the increasing concentration of textile effluent up to 50% to 75% and over then decreased. The lowest values of N, P, K, S, Ca and Mg in leaf, shoot and root of red amaranth were observed in T₁ (control).

Table 3. Effect of textile effluent irrigation on nutrients content in different parts of red amaranth.

Treatments	Plant parts	Nutrients (%)					
		N	P	K	S	Ca	Mg
T ₁ = control	Leaves	3.10	0.34	0.46	0.67	0.730	0.75
	Shoot	0.94	0.12	0.25	0.32	0.225	0.30
	Root	0.60	0.08	0.16	0.20	0.110	0.13
T ₂ = 100% RDF + 0% effluent	Leaves	3.70	0.41	0.49	0.85	0.895	0.84
	Shoot	1.02	0.15	0.26	0.41	0.290	0.35
	Root	0.65	0.10	0.18	0.30	0.150	0.20
T ₃ =50% RDF + 25% effluent	Leaves	3.21	0.36	0.45	0.78	0.775	0.77
	Shoot	0.96	0.13	0.23	0.35	0.235	0.31
	Root	0.63	0.07	0.18	0.22	0.125	0.14
T ₄ =50% RDF + 50% effluent	Leaves	3.52	0.37	0.48	0.82	0.810	0.82
	Shoot	1.02	0.14	0.27	0.40	0.255	0.40
	Root	0.66	0.11	0.17	0.31	0.155	0.20
T ₅ =50% RDF + 75% effluent	Leaves	3.61	0.38	0.47	0.81	0.850	0.80
	Shoot	1.04	0.15	0.26	0.38	0.265	0.37
	Root	0.69	0.10	0.17	0.20	0.150	0.16
T ₆ =50% RDF + 100% effluent	Leaves	3.37	0.36	0.46	0.80	0.800	0.75
	Shoot	0.97	0.14	0.23	0.36	0.245	0.33
	Root	0.66	0.09	0.15	0.25	0.135	0.16

Nutrient uptake: In all of treatments, nutrient uptake resulting from irrigation with textile effluent increased significantly ($P \leq 0.05$) in comparison to control. Considerable nutrients were taken up by all the treatments. Total uptake of N, P, K, S, Ca and Mg of red amaranth plants (leaves + shoot + roots) varied from 47.24 to 113.37 kg/ha, 5.64 to 13.95 kg/ha, 9.91 to 19.68 kg/ha, 13.24 to 32.77 kg/ha, 11.00 to 28.71 kg/ha and 12.94 to 29.85 kg/ha, respectively. Highest uptake of N, P, K, S, Ca and Mg of red amaranth 113.37, 13.95, 19.68, 32.77, 28.71 and 29.85 kg/ha, respectively were found with T₂(100% RDF + 0% TWW). And the closest highest uptake of N, P, K, S, Ca and Mg of red amaranth 87.54, 10.56, 16.63, 26.71, 20.79 and 25.75 kg/ha, respectively were observed with T₄ (50% RDF + 50% TWW). Lowest uptake of N, P, K, S, Ca and Mg of red amaranth 47.24, 5.64, 9.91, 13.24, 11.00 and 12.94 kg/ha were found with T₁ (control). Results indicated that the highest nutrients uptake were achieved in 100% RDF along with 0% textile effluent irrigation. Nutrient uptake increased with 50% RDF along with textile

effluent irrigation up to 50% concentration then decreased. In contrast to positive control treatment, Yaseen *et al.* (2017) observed that applying canal water and textile wastewater in a 50:50 ratio increased nutrient uptakes and agronomic efficiency of fertilizers. According to Yagdi *et al.* (2000), the amount of N, P, and K uptake reduced as the amount of polluted water increased.

Table 4. Effect of textile effluent irrigation on nutrient uptake in different parts of red amaranth.

Treatments	Plant parts	Uptake of nutrients (kg/ha)					
		N	P	K	S	Ca	Mg
T ₁ = control	Leaves	22.63	2.48	3.36	4.89	5.33	5.48
	Shoot	20.77	2.65	5.53	7.07	4.97	6.63
	Root	3.84	0.51	1.02	1.28	0.70	0.83
	Total	47.24 d	5.64 f	9.91 f	13.24 f	11.00 f	12.94 f
T ₂ =100% RDF + 0% TWW	Leaves	76.22	8.45	10.09	17.51	18.44	17.30
	Shoot	31.62	4.65	8.06	12.71	8.99	10.85
	Root	5.53	0.85	1.53	2.55	1.28	1.70
	Total	113.37 a	13.95 a	19.68 a	32.77 a	28.71 a	29.85 a
T ₃ =50%RDF +25% TWW	Leaves	42.05	4.72	5.90	10.22	10.15	10.09
	Shoot	24.67	3.34	5.91	9.00	6.04	7.97
	Root	4.03	0.45	1.15	1.41	0.80	0.90
	Total	70.76 c	8.51 e	12.96 d	20.63 e	16.99 d	18.96 d
T ₄ =50%RDF +%50 TWW	Leaves	50.69	5.33	6.91	11.81	11.66	11.81
	Shoot	31.11	4.27	8.24	12.20	7.78	12.20
	Root	5.74	0.96	1.48	2.70	1.35	1.74
	Total	87.54 b	10.56 b	16.63 b	26.71 b	20.79 b	25.75 b
T ₅ =50%RDF +75% TWW	Leaves	45.49	4.79	5.92	10.21	10.71	10.08
	Shoot	32.45	4.68	8.11	11.86	8.27	11.54
	Root	6.14	0.89	1.51	1.78	1.34	1.42
	Total	84.08 b	10.36 c	15.54 c	23.85 c	20.32 c	23.04 c
T ₆ =50%RDF +100% TWW	Leaves	39.77	4.25	5.43	9.44	9.44	8.85
	Shoot	25.22	3.64	5.98	9.36	6.37	8.58
	Root	5.35	0.73	1.22	2.03	1.09	1.30
	Total	70.33 c	8.62 d	12.63 e	20.83 d	16.90 e	18.73 e

Conclusion

According to the above results, amaranth's production and nutrient uptake were improved in both T₂ and T₄. Therefore, it can be suggested that in areas where fresh water irrigation is limited, 50% RDF and 50% diluted textile effluent could be used to increase amaranth's yield and nutrient uptake.

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