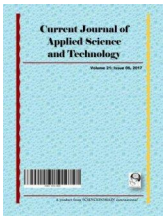

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Performance of Terrestrial Water Spinach (*Ipomoea reptans)* through Biofortification under Different Mode and Source of Iron Nutrition

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Authors' contributions

This work was carried out in collaboration between all authors. Author PD designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author RKT managed the analyses of the study. Author SKS managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Micronutrient malnutrition is a major health problem in India. Indian children and women suffer from anemia, deficiency of iron which creates an adverse effect on health. One of the main reasons for such situation is lack of availability of iron rich food. In such circumstances, it's essential to enhance the availability of iron rich food in India. Thus the field experiment was laid out in a split plot design with nine treatments and three replications during summer season of 2016 and 2017 at Instructional Farm, Faculty of Horticulture, Uttar Banga Krishi Viswavidyalaya, to find out the most viable mode and source of iron fertilizer for growth, yield and iron accumulation in *Ipomoea reptans*. For this purpose, three source of Fe solutions (Fe-EDTA, $FeSO_4$. $7H_2O$ and Fe_2 $(SO_4)_3$ were applied in three different modes, i.e., 100% recommended dose through soil application, 100%

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recommended dose through foliar spray at 4 weeks after sowing and 50% of recommended dose through soil application + 50% recommended dose through foliar at 4 weeks after sowing. It was noticed that growth and yield parameters increased with the treatment combination of $FeSO_4$. $7H_2O$ (containing 16% iron) as 100% of recommended dose through foliar spray (0.5 g/ L of water) at 4 weeks after sowing, secondly the iron content of plant (mg/100g) was found maximum with the treatment combination of $FeSO_4$. $7H_2O$ (containing 16% iron) as 50% of recommended dose through soil application + 50% recommended dose through foliar spray at 4 weeks after sowing. Treatment combination $FeSO_4$. 7H2O (containing 16% iron) as 100% of recommended dose through foliar spray produced maximum yield. Application of $FeSO_4$. $7H_2O$ as 50% of recommended dose through soil application + 50% recommended dose through foliar at 4 weeks after sowing can also be suggested.

Keywords: Ipomoea reptans; biofortification; malnutrition; iron nutrition; foliar spray; soil application.

1. INTRODUCTION

Water spinach (*Ipomoea reptans*) is a herbaceous perennial, aquatic and semi aquatic plant commonly cultivated crop in all the south Asian countries. Water spinach occurs in both wild and cultivated forms in India. Water spinach is also a rich source of minerals and vitamins, being especially rich in iron, Vitamin A (carotene 2.9 g/100 g), B_1, B_2 and C (45 mg/100 g) [1,2]. In India, about 89 million children are anaemic. The prevalence of anaemia is 70% in children aged 6-59 months [3]. The highest prevalence of anaemia is seen in children <10 years, especially in those <5 years [4]. Iron deficiency is one of the most common causes of anaemia [5]. Macronutrients as well as micronutrients are of primary importance in our agriculture system but due to rapid area expansion under hybrid or high yielding varieties of vegetables and unawareness of our farmers, Indian soils are becoming deficient in micronutrients which, results in poor yields and reduced nutritional quality. Deficiencies of micronutrient drastically affect the growth, metabolism and reproductive phase in plants, animal and human beings [6]. Being the fourth most abundant element in the lithosphere, iron is generally present in high quantities in soils; however, its bioavailability in aerobic and neutral pH environments is limited. Iron plays an important role in metabolic processes such as DNA synthesis, protein metabolism, respiration, and photosynthesis [7].

The best ways for increasing iron status and its bioavailability in daily diet in commonly grown leafy vegetables are through agronomic practices such as increasing iron levels through supplementation of iron-containing fertilizer, agronomic biofortification, biofertilizer or microbial inoculants, and breeding approaches. Foliar fertilization of micronutrients is a visible economic way to supplement the plants nutrients for more efficient fertilization [8]. In calcareous soils, for example, Fe availability is usually very low and Fe deficiency is widespread. Foliar spraying under these conditions could be much more efficient than any other applications of Fe to the soil. Biofortification is the process of increasing the natural content of nutrients in edible part of crop plants [9]. It is regarded as one of the strategies to address the persistent burden of micronutrient malnutrition. To date, no systematic review has been conducted to assess this type of complex public health intervention that combines agriculture and nutrition. In order to improve the growth and yield parameters, the chemicals like $FeSO_4$, $7H_2O$, Fe_2 $(SO_4)_3$, $4H_2O$ and Fe-EDTA were applied to water spinach.

2. MATERIALS AND METHODS

The experiment was carried out at Instructional Farm of the Faculty of Horticulture, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal (26^0 19′ N latitude and $89^0$23′ E longitude at an elevation of 43 meter above sea level (masl) during the year 2016 and 2017 in a split plot design with three replications and nine treatments. The local variety of water spinach was selected for investigation. The experimental site is under tropical humid climate with range of average temperature of 27.49ºC- 31.38ºC during experimental period of February to May. The plot size of 1.5m × 1.5m each with a spacing of 30 cm × 15 cm was demarcated. All the plots under study received recommended uniform dose of fertilizers (N: P_2O_5: K_2O-75:50:50 kg ha^{-1}) along with farmyard manure (15 t ha^{-1}). The treatment combination used was as follows:**A_1**- 100% of recommended dose through soil application, **A_2**- 100% of recommended dose through foliar spray at 4 weeks after sowing and **A_3** -50% of recommended dose through soil application + 50% recommended dose through foliar at 4 weeks after sowing. The source of iron fertilizers

included **B_1**- Fe-EDTA (Chelated iron-8% Fe), **B_2**-$FeSO_4$, $7H_2O$ (Ferrous sulphate heptahydrate- 16% Fe) and **B_3**- $Fe_2(SO_4)_3$, $4H_2O$ (Ferric sulphate-23% Fe). The soil application for Fe-EDTA was 5.0 kg ha^{-1}, for $FeSO_4$, $7H_2O$ was 2.50 kg $ha^{-1}$and for $Fe_2(SO_4)_3$, $4H_2O$ was 2.0 kg $ha^{-1}$and the recommend dose of foliar spray for Fe-EDTA (Chelated iron) was 1 g L^{-1} water for $FeSO_4$, $7H_2O$ (Ferrous sulphate heptahydrate) was 0.5 g L^{-1} water and for $Fe_2(SO_4)_3$, $4H_2O$ (Ferric sulphate) was 0.5 g L^{-1}. Available iron content of plant was estimated with the help of Atomic Absorption Spectrometer. The data were statistically analyzed using standard statistical procedures [10].

3. RESULTS AND DISCUSSION

3.1 Vine Length (cm)

The different mode and source of iron nutrition on vine length had no significant effects (Table 1). The maximum length of 33.26 cm, 34.82 cm and 37.43 cm from 1st, 2nd and 3rd harvesting were obtained from 100% of recommended dose through foliar spray at 4 weeks after sowing (A_2). Similarly, with the different source of treatments the maximum vine length of 33.62 cm, 34.82 cm and 36.26 cm from 1st, 2nd and 3rd harvesting respectively were obtained from the plot treated with ferrous sulphate heptahydrate ($FeSO_4,7H_2O$) (B_2).The interaction effects (Table 1) of different mode and source of treatments produced 34.01 cm, 35.78 cm and 38.70 cm from 1st, 2nd and 3rd harvesting with treatment combination of 100% of recommended dose through foliar spray at 4 weeks after sowing (A_2) using ferrous sulphate heptahydrate ($FeSO_4,7H_2O$) as source of iron fertilizer (B_2). Samira et al. [11] reported that foliar spray of 500 and 1000 mg $FeSO_4$ solutions were found to be most effective for enhancing physiological and yield parameters of tomato.

Table 1. Effect of mode and source of iron fertilization on vine length of water spinach

	Vine length (cm)								
	First harvesting			Second harvesting			Third harvesting		
	Y1	Y2	Pooled	Y1	Y2	Pooled	Y1	Y2	Pooled
Mode									
A_1	32.91	31.93	32.42	34.22	33.19	33.70	34.95	35.31	35.13
A_2	32.75	33.77	33.26	34.62	35.01	34.82	36.76	38.09	37.43
A_3	32.49	33.28	32.88	34.46	33.73	34.09	34.62	35.79	35.20
S Em±	0.64	0.49	0.31	0.32	0.62	0.30	0.18	0.53	0.29
CD at 5%	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
Source									
B_1	33.27	32.22	32.74	32.85	33.68	33.26	36.21	34.89	35.55
B_2	33.05	34.20	33.62	35.39	34.25	34.82	35.87	36.64	36.26
B_3	33.00	31.40	32.20	33.89	35.15	34.52	35.66	36.24	35.95
S Em±	0.31	0.50	0.44	0.49	0.47	0.20	0.52	0.66	0.34
CD at 5%	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
Interaction									
A_1B_1	33.40	30.57	31.98	34.23	33.18	33.70	35.31	33.90	34.61
A_1B_2	32.97	31.33	32.15	34.34	33.22	33.78	34.09	35.28	34.69
A_1B_3	32.33	31.59	31.96	32.64	31.98	32.31	33.87	35.05	34.46
A_2B_1	33.44	32.87	33.16	35.00	34.00	34.50	35.14	37.07	36.11
A_2B_2	33.40	34.62	34.01	35.40	36.16	35.78	38.15	39.24	38.70
A_2B_3	33.38	31.56	32.47	34.70	33.30	34.01	34.31	36.53	35.42
A_3B_1	33.10	34.28	33.69	35.67	33.52	34.59	35.12	37.53	36.33
A_3B_2	33.00	34.55	33.78	34.71	35.23	34.97	36.63	37.89	37.26
A_3B_3	31.75	33.23	32.49	33.97	34.41	34.19	35.28	36.18	35.73
S Em±	1.11	0.86	0.53	0.56	1.07	0.52	0.31	0.93	0.50
CD at 5%	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S

Treatment details: A_1 – 100% of recommended dose through soil application, A_2 – 100% of recommended dose through foliar spray at 4 weeks after sowing, A_3 – 50% of recommended dose through soil application + 50% recommended dose through foliar at 4 weeks after sowing, B_1 – Fe-EDTA (Chelated iron-8% Fe), B_2 – $FeSO_4,7H_2O$ (Ferrous sulphate heptahydrate- 16% Fe), B_3– $Fe_2(SO_4)_3$, $4H_2O$ (Ferric sulphate-23% Fe)

3.2 Number of Leaves/Plant

Number of leaves produced by *Ipomoea reptans* under the treatment condition were influenced significantly. The number of leaves per plant (33.55, 52.15 and 83.17) were highest throughout the three harvests with 100% of recommended dose through foliar spray at 4 weeks after sowing (A_2) using ferrous sulphate heptahydrate ($FeSO_4,7H_2O$) as source of iron fertilizer (B_2) (Table 2). Huda et al. [12] reported that leaf number is considered as an important factor in growth, responsible for photosynthesis and ultimately affecting the flower yield and quality indicating that $FeSO_4$ is one of the factors controlling the induction and growth of shoots.

3.3 Leaf Area Index

The different mode of treatments on leaf area index (LAI) of water spinach produced significant results (Table 3). The maximum LAI of 2.01, 2.50 and 1.48 in 1st, 2nd and 3rd were recorded from 100% of recommended dose through foliar spray at 4 weeks after sowing (A_2) and the lowest was obtained from 100% of recommended dose through soil application (A_1) similarly with the different source of treatment the maximum of 2.18, 2.76 and 1.61 were obtained with the application of ferrous sulphate heptahydrate ($FeSO_4.7H_2O$) (B_2). The combination of 100% recommended dose through foliar spray at 4 weeks after sowing (A_2) and ferrous sulphate heptahydrate ($FeSO_4.7H_2O$) as source of iron fertilizer (B_2) showed maximum leaf area index of 2.37, 2.99 and 1.65. The results of the experiment were in accordance with Chopde et al. [13] who also recorded significantly maximum vegetative growth in respect of plant height and leaf area index. Similar results were also found by Hamzeh [14].

Table 2. Effect of mode and source of iron fertilization on number of leaves/plant of water spinach

	Number of leaves/plant								
	First harvesting			Second harvesting			Third harvesting		
	Y1	Y2	Pooled	Y1	Y2	Pooled	Y1	Y2	Pooled
Mode									
A_1	29.25	31.64	30.44	49.48	50.99	50.23	67.87	65.79	66.83
A_2	30.58	31.41	30.99	49.78	51.26	50.52	80.15	79.49	79.82
A_3	30.05	29.07	29.56	50.83	49.85	50.34	67.24	68.94	68.09
S Em±	0.45	0.46	0.65	1.12	0.97	0.54	0.98	2.07	0.54
CD at 5%	1.27	1.30	1.87	3.19	2.82	1.53	2.82	6.08	1.55
Source									
B_1	30.55	31.54	31.04	49.84	50.97	50.40	72.67	71.58	72.12
B_2	30.79	31.85	31.32	49.89	51.28	50.59	75.62	76.83	76.23
B_3	28.14	29.13	28.64	50.37	49.84	50.11	67.01	65.78	66.39
S Em±	0.68	0.53	0.32	1.02	0.76	0.49	0.90	0.54	0.72
CD at 5%	1.95	1.47	.87	2.94	2.17	1.36	2.61	156	2.05
Interaction									
A_1B_1	25.20	28.69	26.95	48.00	50.59	49.30	62.44	63.42	62.93
A_1B_2	28.46	29.64	29.05	50.00	48.74	49.37	64.00	65.22	64.61
A_1B_3	26.47	27.04	26.76	46.44	47.67	47.06	55.52	57.46	56.49
A_2B_1	30.49	32.22	31.35	52.33	50.34	51.34	76.39	77.23	76.40
A_2B_2	32.30	34.80	33.55	51.48	52.83	52.15	84.66	81.68	83.17
A_2B_3	31.08	30.05	30.57	49.67	50.97	50.32	68.83	63.77	66.30
A_3B_1	30.67	32.78	31.73	50.00	53.00	51.50	81.67	79.32	80.50
A_3B_2	32.61	31.80	32.21	52.33	51.52	51.93	82.13	83.02	82.58
A_3B_3	30.25	31.42	30.84	50.67	49.99	50.33	72.33	70.18	71.26
S Em±	0.78	0.80	0.79	1.93	1.68	0.88	1.70	2.58	0.94
CD at 5%	2.26	2.31	2.23	5.53	4.89	2.52	4.96	7.58	2.73

Treatment details: A_1 – 100% of recommended dose through soil application, A_2 – 100% of recommended dose through foliar spray at 4 weeks after sowing, A_3 – 50% of recommended dose through soil application + 50% recommended dose through foliar at 4 weeks after sowing, B_1 – Fe-EDTA (Chelated iron-8% Fe), B_2 – $FeSO_4,7H_2O$ (Ferrous sulphate heptahydrate- 16% Fe), B_3– $Fe_2(SO_4)_3, 4H_2O$ (Ferric sulphate-23% Fe)

Table 3. Effect of mode and source of iron fertilization on leaf area index of water spinach

	Leaf area index								
	First harvesting			Second harvesting			Third harvesting		
	Y1	Y2	Pooled	Y1	Y2	Pooled	Y1	Y2	Pooled
Mode									
A_1	2.03	1.88	1.96	1.65	3.17	2.41	1.27	1.50	1.38
A_2	2.35	1.66	2.01	1.30	3.70	2.50	1.21	1.76	1.48
A_3	2.16	1.65	1.91	1.93	2.94	2.44	1.62	1.14	1.38
S Em±	0.13	0.04	0.14	0.19	0.09	0.35	0.13	0.17	0.08
CD at 5%	0.36	0.09	0.38	0.51	0.24	0.97	0.34	0.46	0.19
Source									
B_1	2.42	1.75	2.08	1.65	3.35	2.50	1.12	1.79	1.45
B_2	2.50	1.85	2.18	1.89	3.64	2.76	1.34	1.87	1.61
B_3	1.31	1.92	1.61	1.35	2.83	2.09	1.02	1.34	1.18
S Em±	0.18	0.07	0.17	0.18	0.10	0.12	0.13	0.14	0.03
CD at 5%	0.51	0.18	0.48	0.50	0.27	0.31	0.36	0.38	0.07
Interaction									
A_1B_1	1.35	1.92	1.64	1.75	2.58	2.17	1.42	1.09	1.25
A_1B_2	2.15	1.33	1.74	1.63	2.74	2.19	1.54	0.96	1.25
A_1B_3	1.65	1.20	1.42	2.24	1.48	1.86	0.80	1.02	0.92
A_2B_1	1.73	2.58	2.15	1.58	3.72	2.65	1.31	1.82	1.57
A_2B_2	3.13	1.60	2.37	1.54	4.45	2.99	1.34	1.95	1.65
A_2B_3	2.01	1.54	1.78	1.61	2.81	2.21	1.20	1.58	1.39
A_3B_1	2.61	1.81	2.21	1.63	3.74	2.69	1.43	1.81	1.62
A_3B_2	2.68	1.79	2.24	2.43	3.43	2.93	1.27	1.98	1.62
A_3B_3	2.23	1.94	2.08	1.69	3.03	2.36	1.23	1.71	1.47
S Em±	0.23	0.06	0.24	0.32	0.16	0.61	0.22	0.29	0.13
CD at 5%	0.61	0.16	0.67	0.91	0.44	1.72	0.61	0.84	0.37

Treatment details: A_1 – 100% of recommended dose through soil application, A_2 – 100% of recommended dose through foliar spray at 4 weeks after sowing, A_3 – 50% of recommended dose through soil application + 50% recommended dose through foliar at 4 weeks after sowing, B1 – Fe-EDTA (Chelated iron-8% Fe), B_2 – $FeSO_4,7H_2O$ (Ferrous sulphate heptahydrate- 16% Fe), B_3– $Fe_2(SO_4)_3$, $4H_2O$ (Ferric sulphate-23% Fe)

3.4 Iron Content of Plant (mg/100 g)

The iron content of plant of water spinach was significantly influenced by different mode of treatments. In pooled analysis the maximum values of 5.53 mg/100 g, 5.31 mg/100 g and 5.12 mg/100 g respectively, in 1st, 2nd and 3rd harvesting were recorded with application of 50% of recommended dose through soil application + 50% recommended dose through foliar spray at 4 weeks after sowing (A_3). Similarly with the different source of treatments the maximum iron content of 4.72 mg/100 g, 4.58 mg/100 g and 4.32 mg/100 g from 1st, 2nd and 3rd harvesting respectively were obtained from treatments with ferrous sulphate heptahydrate ($FeSO_4$, $7H_2O$) i.e. (B_2) (Table 4). Regarding the interaction effect the treatment combination of 50% of recommended dose through soil application + 50% recommended dose through foliar spray at 4 weeks after sowing (A_3) and ferrous sulphate heptahydrate ($FeSO_4,7H_2O$) as source of iron fertilizer (B_2) showed maximum iron content of plant i.e. 7.52 mg/100 g, 7.39 mg/100 g and 7.28 mg/100 g in 1st, 2nd and 3rd harvesting respectively. In line with the present findings, Aciksoz et al. [15] reported that at a given Fe treatment, in combination with N supply substantially enhanced shoot and grain concentrations of Fe and Zn. Dhaliwal et al. [16] also observed that four foliar sprays of $FeSO_4.7H_2O$ at 0.5% at different stages of wheat resulted in significant increase in Fe concentration in wheat grains.

3.5 Total Green Yield (t ha^{-1})

The values in the interaction effects between different mode and source of treatments in pooled analysis ranged between 24.90- 27.21 t ha^{-1}, where maximum green yield 27.21 t ha^{-1} were recorded with the combination of 100% recommended dose through foliar spray at 4 weeks after sowing (A_2) and ferrous sulphate heptahydrate ($FeSO_4$, $7H_2O$) as source of iron fertilizer (B_2) (Table 5). Zeidan et al. [17] studied the effect of micronutrient foliar application on wheat yield, green yield and quality of wheat

grains and found that grain yield, straw yield, 1000 grain weight and number of grains/spike, Fe, Mn and Zn concentration in flag leaves and grains as well as, protein content in grain were significantly increased by application of these elements. Rawashdeh and Florin [18] stated that foliar and soil application of iron alone or in association with other micronutrients to wheat grown on iron deficient soils enhanced the plant growth, yield quantity and quality, yield components.

Table 4. Effect of mode and source of iron fertilization on iron content of plant (mg/100g) of water spinach

	Iron content of plant (mg/100 g)								
	First harvesting			Second harvesting			Third harvesting		
	Y1	Y2	Pooled	Y1	Y2	Pooled	Y1	Y2	Pooled
Mode									
A_1	4.84	3.62	4.23	3.95	4.29	4.12	3.75	4.13	3.94
A_2	4.74	5.38	5.06	5.07	4.65	4.86	4.82	4.56	4.69
A_3	5.35	5.71	5.53	5.08	5.54	5.31	5.29	4.95	5.12
S Em±	1.21	1.08	1.13	1.26	1.17	1.2	1.38	1.08	1.16
CD at 5%	3.42	3.11	3.78	3.34	3.12	3.42	3.39	3.12	3.43
Source									
B_1	4.25	4.61	4.43	4.39	4.09	4.24	3.9	4.26	4.08
B_2	4.86	4.58	4.72	4.37	4.79	4.58	4.16	4.48	4.32
B_3	4.08	3.7	3.89	3.56	3.88	3.72	3.34	3.68	3.51
S Em±	1.13	1.24	1.17	1.11	1.28	1.23	1.08	1.14	1.19
CD at 5%	3.32	3.54	3.42	3.14	3.68	3.51	3.1	3.29	3.46
Interaction									
A_1B_1	4.66	4.12	4.39	4.13	3.61	4.27	3.94	4.34	4.14
A_1B_2	4.83	4.51	4.67	4.28	3.71	4.51	4.11	4.61	4.36
A_1B_3	3.87	4.35	4.11	4.15	4.4	3.98	4.19	3.63	3.91
A_2B_1	6.28	6.78	6.53	6.53	5.62	6.34	5.98	6.38	6.18
A_2B_2	6.71	7.03	6.87	6.89	7.02	6.72	6.87	6.29	6.58
A_2B_3	5.14	4.82	4.98	4.66	4.97	4.81	4.89	4.49	4.69
A_3B_1	6.9	7.32	7.11	6.74	6.93	6.89	6.91	6.53	6.72
A_3B_2	7.35	7.69	7.52	7.58	6.69	7.39	7.04	7.52	7.28
A_3B_3	5.63	5.19	5.41	5.09	4.48	5.26	4.87	5.37	5.12
S Em±	1.48	1.26	1.37	1.52	1.34	1.41	1.33	1.61	1.54
CD at 5%	4.29	3.57	3.97	4.38	3.84	4.07	3.87	4.71	4.42

Treatment details: A_1 – 100% of recommended dose through soil application, A_2 – 100% of recommended dose through foliar spray at 4 weeks after sowing, A_3 – 50% of recommended dose through soil application + 50% recommended dose through foliar at 4 weeks after sowing, B_1 – Fe-EDTA (Chelated iron-8% Fe), B_2 – $FeSO_4,7H_2O$ (Ferrous sulphate heptahydrate- 16% Fe), B_3– $Fe_2(SO_4)_3$, $4H_2O$ (Ferric sulphate-23% Fe)

Table 5. Effect of mode and source of iron fertilization on total green yield of water spinach

	Total green yield (t/ha)		
	Y1	Y2	Pooled
Mode			
A_1	25.33	25.29	25.31
A_2	25.85	26.03	25.94
A_3	26.31	25.45	25.88
S Em±	0.38	0.24	0.27
CD at 5%	1.06	0.67	0.74
Source			
B_1	25.85	25.33	25.53
B_2	25.85	26.55	26.62
B_3	25.85	24.90	24.97
S Em±	0.47	0.25	0.15
CD at 5%	1.36	0.69	0.41

	Total green yield (t/ha)		
	Y1	**Y2**	**Pooled**
Interaction			
A_1B_1	25.24	24.90	25.07
A_1B_2	25.23	24.89	25.06
A_1B_3	24.65	25.14	24.90
A_2B_1	26.05	25.33	25.69
A_2B_2	27.97	26.46	27.21
A_2B_3	25.71	24.76	25.24
A_3B_1	25.87	25.14	25.51
A_3B_2	26.25	26.55	26.40
A_3B_3	25.46	25.19	25.32
S Em±	0.52	0.41	0.47
CD at 5%	1.47	1.17	1.36

Treatment details: A_1 – 100% of recommended dose through soil application, A_2 – 100% of recommended dose through foliar spray at 4 weeks after sowing, A_3 – 50% of recommended dose through soil application + 50% recommended dose through foliar at 4 weeks after sowing, B_1 – Fe-EDTA (Chelated iron-8% Fe), B_2 – $FeSO_4,7H_2O$ (Ferrous sulphate heptahydrate- 16% Fe), B_3– $Fe_2(SO_4)_3$, $4H_2O$ (Ferric sulphate-23% Fe)

4. CONCLUSION

From the experiment it can be concluded that, the best modes of treatment was-100% recommended dose through foliar spray at 4 weeks after sowing and the best source of iron nutrition was ferrous sulphate heptahydrate ($FeSO_4$, $7H_2O$). Thus the treatment combination of ferrous sulphate heptahydrate as 100% recommended dose through foliar spray at 4 weeks after sowing increased growth, yield and yield attributing characters. But in case of increase in iron content of the plant, the combination of $FeSO_4$. $7H_2O$ as 50% of recommended dose through soil application + 50% recommended dose through foliar at 4 weeks after sowing gave maximum results. So, from the results we have concluded that the treatment combination of ferrous sulphate heptahydrate ($FeSO_4$, $7H_2O$) as a foliar spray at 4 weeks after sowing can be suggested to the farmers as it was found superior amongst all other treatment combinations with respect to growth and yield of *Ipomoea reptans.*

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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