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Deficiency of Iron in Eucalyptus Plantations of Variable Age in Punjab and its Amelioration

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ABSTRACT

The experiment was conducted during March, 2018 to March, 2020 at Research Farm of Punjab Agricultural University, Ludhiana and a few villages in Ludhiana district of Punjab, India to standardize the application of iron (Fe) in eucalyptus plantations varying from one to five years of age to eradicate Fe deficiency in these plantations. The treatments (g plant^{-1}) consisted of plants without Fe application, 100 g S+100 g $FeSO_4.7H_2O$, 200 g S+200 g $FeSO_4.7H_2O$, 300 g S+300 g $FeSO_4.7H_2O$, 50 g Fe EDTA (iron chelate), 100 g Fe EDTA, 200 g Fe EDTA, 300 g Fe EDTA and 400 g Fe EDTA. The diameter at breast height (DBH) and height of plants were measured at the time of fertilizer application and one year after application. The DBH and height one year after application improved over increase in control by 6.86 and 7.13% respectively in first year plants with 50 g plant^{-1}, 8.58 and 10.16% respectively in second year plants and 9.41 and 10.2% respectively in third year plants with 100 g plant^{-1}, and 10.85 and 11.21% respectively in fourth year plants and 10.27 and 11.87% respectively in fifth year plants with 200 g plant^{-1} Fe EDTA alongwith correction of Fe deficiency completely. Therefore, the deficiency of Fe can be corrected by application of 50 g plant^{-1} Fe EDTA to first year plantations, 100 g plant^{-1} Fe EDTA to second and third year plantations and 200 g plant^{-1} Fe EDTA to fourth and fifth year plantations of eucalyptus.

KEYWORDS: Deficiency symptoms, Fe EDTA, growth parameters, iron chelate

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1. INTRODUCTION

Eucalyptus is one of the fast growing tree species that has been adopted under farm forestry in Punjab. It is being grown in block plantations at a spacing of 4×2 m or 3×3 m or on field boundaries at a spacing of 2 m. Its wood is used for furniture, crates, packing cases, pulp wood and in plywood industry (Amer et al., 2021). The species is fast growing and has ability to grow successfully under different soil and climatic conditions. Earlier it was being raised through seeds but during recent years, the genetically improved high yielding fast growing clones of eucalyptus have been introduced (Dhillon et al., 2019). Average productivity of 20 to 25 m^3 ha^{-1} $year^{-1}$ has been achieved under unirrigated conditions in Andhra Pradesh from these clonal materials. Many farmers have achieved a record high of 50 m^3 ha^{-1} $year^{-1}$ from clonal plants under limited irrigation as compared to yield of 6 to 10 m^3 ha^{-1} $year^{-1}$ from normal seedlings (Lal, 2004).

Plants require adequate nutrition for the production of food, fibre and fuel but soil conditions often limit the ability of plants to acquire mineral nutrients (Akin et al., 2020; Esteves et al., 2021). To address this, mineral nutrients can be applied as inorganic or organic fertilizers to the soil or as liquid fertilisers to foliage (White et al., 2014; Kumar and Sharma, 2017). Foliar application of micronutrients has been found to be more beneficial than the soil application (Paikra et al., 2018; Saha et al., 2023). The growth of trees depends upon spacing, moisture, nutrients and other cultural practices (Shukla and Kasera, 2004; Singh and Sharma, 2007; Henderson and Jose, 2010). A significant increase in growth of eucalyptus has been observed with application of N, P and K than the plants without nutrient application (Singh et al., 2018; Silva et al., 2020; Medeiros et al., 2021; Singh et al., 2021). However, the deficiency symptoms of iron have been observed in plantations of eucalyptus in Punjab. It is unavailable to plants due to the poor solubility of Fe containing minerals and it undergoes a series of plant-induced reactions that can alter its mobility as well as availability, resulting in its deficiency (Yadav et al., 2011; Murgia et al., 2022). Fe deficiency is exacerbated further as the farmers do not apply it externally but it is mined. Iron deficiency leads to specific changes in plant metabolism which gives rise to chlorosis. Faded tree branches, interveinal yellowing of leaves, dry leaves, fruit falling during the growing stage and a lower rate of fruiting are all signs of Fe deficiency in plants (Siddique et al., 2020; Sherefu and Zewide, 2021). Its deficiency is most common in soils with a coarse texture, high pH, higher free $CaCO_3$ content and low organic matter content (Poonia et al., 2022). Soil is a major source of supply of most of the essential plant nutrients and several soil factors such as, soil texture, pH, organic matter, calcium carbonate and type of clay minerals determine the availability of nutrients in the soil (Chatterjee and Bandyopadhyay, 2014; Singh et al., 2020; Kaur and Singh, 2024). In addition, nutrients are present in soils in various forms that differ in their availability to plants (Nisab and Ghosh, 2023; Bincy et al., 2023).

Eucalyptus is grown in Punjab on the soils having variable texture, pH, organic matter content as well as other properties. Deficiency of Fe has been observed in many plantations of eucalyptus grown on such sites. Therefore, this study was conducted to investigate the nature of iron deficiency symptoms and standardization of iron application for amelioration of iron deficiency in eucalyptus plantations.

2. MATERIALS AND METHODS

2.1. Selection of plantations and soil properties

The study was conducted during March, 2018 to March, 2020 on clonal eucalyptus plantations on farmers' fields in Ludhiana district of Punjab and at Forestry Research Area of Punjab Agricultural University (PAU), Ludhiana, India. The sites are located at around 244 metre above the sea level with a latitude of 30° 56' North and a longitude of 75° 52' East. Eucalyptus plantations of variable age were selected which were showing deficiency symptoms of iron. The plantations in 1st, 2nd and 3rd year of their age were selected at villages namely Ayali Kalan, Bhatha Dhua and Kila Raipur, respectively and plantations in 4th and 5th year were at PAU Forestry Research Area (Table 1). The important physico-chemical properties and available nutrient status of soils of these sites are given in table 1. The physico-chemical properties of the soil and available N, P and K contents were determined by standard methods (Jackson, 1973). Available iron (Fe) in the soil was extracted with DTPA extractant (Lindsay and Norvell, 1978) and estimated on an atomic absorption spectrophotometer. As per the rating limits of different properties and available nutrients for different crops, the soils of these sites have loamy sand to sandy loam texture, alkaline pH (7.82–8.13) normal EC (0.18–0.41 dS m^{-1}), low to medium organic carbon (2.7–5.2 g kg^{-1}), low $CaCO_3$ (0.41–0.78%), low available N (156–241 kg ha^{-1}), low to medium available P (8.3–15.2 kg ha^{-1}), sufficient available K (164–234 kg ha^{-1}) and low to medium available Fe (8.15–15.22 kg ha^{-1}).

2.2. Treatments and growth parameters

Seven treatments were applied in plants having age less than one year and nine treatments in plants having age more than one year. Three plants having symptoms of iron deficiency were selected for application of each treatment in each plantation. The treatments included plants without Fe application or control (T_1), 100 g S+100 g $FeSO_4.7H_2O$ (T_2), 200 g S+200 g $FeSO_4.7H_2O$ (T_3), 300 g S+300 g

Table 1: Physico-chemical properties of the surface layer (0–15 cm) of the experimental sites

Age (years)	Plantation Site	Texture	pH	EC (dS m^{-1})	OC (g kg^{-1})	$CaCO_3$ (%)	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})	Available Fe (kg ha^{-1})
1	Ayali Kalan	Sandy loam	7.91	0.41	3.7	0.54	157	13.1	234	13.23
2	Bhatha Dhua	Loamy sand	8.13	0.18	3.1	0.78	185	8.30	203	10.36
3	Kila Raipur	Sandy loam	7.83	0.37	5.2	0.61	241	15.2	229	15.22
4	PAU	Loamy sand	8.04	0.28	3.4	0.46	162	13.5	164	8.15
5	PAU	Loamy sand	7.82	0.23	2.7	0.41	156	10.3	188	8.46

$FeSO_4.7H_2O$ (T_4), 50 g Fe EDTA (T_5), 100 g Fe EDTA (T_6), 200 g Fe EDTA (T_7), 300 g Fe EDTA (T_8) and 400 g Fe EDTA (T_9). Ferrous sulphate heptahydrate ($FeSO_4.7H_2O$) contained 19% Fe whereas Fe EDTA (iron chelate) contained 12% Fe. Elemental sulphur (S) was added along with $FeSO_4.7H_2O$ to increase the availability of Fe due to acidic effect of S in the soil. The treatments were applied in 0.5 m diameter ring to the plants in 1st year, 1 m diameter ring to the plants in 2nd and 3rd year and in 1.5 m diameter ring to the plants in 4th and 5th year of age. Each treatment was applied to three plants in each plantation. The fertilizer was mixed thoroughly in the soil and the plants were watered so that plants could take the applied nutrient element. The plants were observed periodically to know the condition of deficiency symptoms. The diameter at breast height (DBH) and height of plants were measured at the time of fertilizer application and one year after application. The average (of three plants) increase in growth parameters in each treatment within a year and increase (%) in each treatment over control were calculated.

3. RESULTS AND DISCUSSION

3.1. *Symptoms of Fe deficiency*

The deficiency symptoms of Fe initially appear on younger leaves which further extend to lower leaves. The deficiency is visually exhibited by yellowing or chlorosis of new or younger leaves initially followed by lower or older leaves (Plate 1). Under acute deficiency conditions, there is bleaching of the affected leaves. With time, the affected leaves become necrotic and ultimately die. Yellow leaves indicate a lack of chlorophyll, the green pigment responsible for photosynthesis in plants. Reduction in chlorophyll during the growing season can reduce plant growth. It has been reported earlier that the deficiency of various essential nutrient elements in the soil affects the growth of tree species and leads to visual deficiency symptoms. These symptoms are distinct and specific for each element, such as restricted growth, yellowing of particular (younger or older) leaves, necrotic spots on leaves, etc. (Kaul et al., 1966; Mishra, 2004; Siddique et al., 2020). Iron is immobile in the plants and its deficiency symptoms appear initially in

Plate 1: Different stages of iron deficiency in eucalyptus

the younger leaves as the element cannot move from the older to the younger leaves having active growth and higher demand of nutrients for their metabolic activities (Sherefu and Zewide, 2021). Coarse texture, low organic carbon, high pH and low Fe content of the soils under study might have led to improper nutrition of trees and appearance of the Fe deficiency symptoms (Bincy et al., 2023; Kaur and Singh, 2024). Many reactions govern iron availability and contribute to the complexity of iron chemistry in soil. Iron chlorosis frequently occurs in soils that are alkaline and that contain lime. Most soils contain abundant levels of iron; however, deficiencies develop because soil chemical reactions render this iron unavailable to plants. At high soil pH, iron rapidly forms reaction products in combination with oxygen, hydroxide and carbonate ions (Goswami et al., 2009). These forms of iron are not water-soluble and cannot be absorbed by plant roots. Such iron will be tied up indefinitely unless soil conditions change (Paikra et al., 2018).

3.2. *Growth parameters*

During first year growth of plants, deficiency was ameliorated completely in the treatments having ≥50 g $plant^{-1}$ Fe EDTA after about 1.5 months of its application whereas the application of $FeSO_4.7H_2O$ along with sulphur had no effect on the deficiency symptoms. The negligible effect of ferrous sulphate and sulphur might be due to alkaline nature of these soils which makes the applied Fe insoluble (Poonia et al., 2022). In plants in the first year, DBH and height at the time of application of iron fertilizers varied from 1.87 to 2.11 cm and 3.16 to 3.35 m, respectively (Table 2). The DBH and height one year after application of iron increased to 6.12 to 6.66 cm and 7.25 to 7.72 m, respectively in different treatments. Increase in these growth parameters over control indicated not much difference with the application of different levels of $FeSO_4.7H_2O$ along with sulphur. The increase in DBH and height in these treatments over control varied from 1.89 to 2.60% and 1.72 to 1.97%, respectively. However, 50 g plant^{-1} or more application of Fe EDTA led to a considerable increase in DBH (6.86% with 50 g application) and height (7.13% with 50 g application) over control. Therefore, 50 g plant^{-1} Fe EDTA being the lowest dose, should be sufficient for first year plants to control Fe deficiency and for optimum effect on growth parameters.

In the plants in their second and third year of growth, the Fe deficiency was cured completely in the treatments having application of ≥100 g plant^{-1} Fe EDTA after about 1.5 months of its application whereas the lower dose (50 g plant^{-1}) of Fe EDTA could not correct the deficiency completely and the application of $FeSO_4.7H_2O$ along with sulphur had no effect on the deficiency symptoms. The DBH and height of plants in second year varied from 5.40 to 6.14 cm and 7.08 to 7.56 m, respectively and those of plants in third year from 10.25 to 10.69 cm and 12.35 to 13.05 m, respectively at the time of application of treatments (Tables 3 and 4). The DBH and height one year after application of iron increased to 10.53 to 11.50 cm and 13.52 to 14.40 m, respectively in second year plants and 13.71 to 14.42 cm and 16.38 to 17.06 m, respectively in third year plants in different treatments. Application of different levels of $FeSO_4.7H_2O$ and sulphur did not affect much to these parameters over control. The increase in DBH and height in these treatments over control varied from 2.20 to 2.59% and 1.56 to 2.34%, respectively in second year and 1.47 to 2.35% and 2.30 to 3.57%, respectively in third year plants. However, 100 g plant^{-1} or more application of Fe EDTA led to a marked increase in DBH and height over control. The increase in DBH and height with this dose was 8.58% and 10.16%, respectively in second year plants and 9.41% and 10.2%, respectively in third year plants. Therefore, 100 g plant^{-1} Fe EDTA can successfully control the deficiency symptoms in plants in second and third year of their growth.

Table 2: Growth parameters of plants in first year under different levels of iron fertilizers

Treatments (per plant)	Diameter at breast height (DBH)				Plant height			
	At application (cm)	After one year (cm)	Increase in one year (cm)	Increase over control (%)	At application (m)	After one year (m)	Increase in one year (m)	Increase over control (%)
Control (T_1)	1.89	6.12	4.23	-	3.18	7.25	4.07	-
100 g S+100 g $FeSO_4.7H_2O$ (T_2)	1.92	6.25	4.33	2.36	3.16	7.31	4.15	1.97
200 g S+200 g $FeSO_4.7H_2O$ (T_3)	1.87	6.21	4.34	2.60	3.34	7.48	4.14	1.72
300 g S+300 g $FeSO_4.7H_2O$ (T_4)	1.96	6.27	4.31	1.89	3.24	7.39	4.15	1.97
50 g Fe EDTA (T_5)	1.91	6.43	4.52	6.86	3.16	7.52	4.36	7.13
100 g Fe EDTA (T_6)	2.11	6.66	4.55	7.57	3.19	7.57	4.38	7.62
200 g Fe EDTA (T_7)	1.95	6.49	4.54	7.33	3.35	7.72	4.37	7.37

In the plants in fourth and fifth year of growth, Fe deficiency was corrected completely in treatments having application of ≥200 g plant^{-1} Fe EDTA after about 1.5 months of its application whereas the lower doses of 50 and 100 g plant^{-1} Fe EDTA did not correct the deficiency completely and the application of $FeSO_4.7H_2O$ along with sulphur had not much effect on the deficiency symptoms. The DBH and height of plants in fourth year varied from 12.21 to 13.12 cm and 14.36 to 15.02 m, respectively and those of plants in fifth year from 15.43 to 16.23 cm and 16.43 to 17.05 m, respectively at the time of application of treatments (Tables 5 and 6). The DBH and height one year after application of iron increased to 16.03 to 17.18 cm and 18.76 to 19.72 m, respectively in fourth year plants and 18.14 to 19.01 cm and 19.27 to 19.92 m, respectively in fifth year plants in different treatments. Application of different levels of $FeSO_4.7H_2O$ and sulphur did not affect much to these parameters over control. However, 200 g plant^{-1} or more application of Fe EDTA led to a significant increase in DBH and height over control. The increase in DBH and

Table 3: Growth parameters of plants in second year under different levels of iron fertilizers

Treatments (per plant)	Diameter at breast height (DBH)				Plant height			
	At application (cm)	After one year (cm)	Increase in one year (cm)	Increase over control (%)	At application (m)	After one year (m)	Increase in one year (m)	Increase over control (%)
Control (T_1)	5.67	10.68	5.01	-	7.12	13.52	6.40	-
100 g S+100 g $FeSO_4.7H_2O$ (T_2)	5.62	10.74	5.12	2.20	7.15	13.65	6.50	1.56
200 g S+200 g $FeSO_4.7H_2O$ (T_3)	6.14	11.28	5.14	2.59	7.08	13.63	6.55	2.34
300 g S+300 g $FeSO_4.7H_2O$ (T_4)	5.40	10.53	5.13	2.40	7.16	13.69	6.53	2.03
50 g Fe EDTA (T_5)	5.75	11.01	5.26	4.99	7.56	14.32	6.76	5.63
100 g Fe EDTA (T_6)	5.49	10.93	5.44	8.58	7.19	14.24	7.05	10.16
200 g Fe EDTA (T_7)	6.05	11.50	5.45	8.78	7.21	14.31	7.10	10.94
300 g Fe EDTA (T_8)	5.55	11.03	5.48	9.38	7.22	14.34	7.12	11.25
400 g Fe EDTA (T_9)	5.67	11.14	5.47	9.18	7.34	14.40	7.06	10.31

Table 4: Growth parameters of plants in third year under different levels of iron fertilizers

Treatments (per plant)	Diameter at breast height (DBH)				Plant height			
	At application (cm)	After one year (cm)	Increase in one year (cm)	Increase over control (%)	At application (m)	After one year (m)	Increase in one year (m)	Increase over control (%)
Control (T_1)	10.34	13.74	3.40	-	12.46	16.38	3.92	-
100 g S+100 g $FeSO_4.7H_2O$ (T_2)	10.37	13.84	3.47	2.06	12.46	16.52	4.06	3.57
200 g S+200 g $FeSO_4.7H_2O$ (T_3)	10.26	13.71	3.45	1.47	13.05	17.06	4.01	2.30
300 g S+300 g $FeSO_4.7H_2O$ (T_4)	10.45	13.93	3.48	2.35	12.58	16.63	4.05	3.32
50 g Fe EDTA (T_5)	10.36	13.95	3.59	5.59	12.84	17.02	4.18	6.63
100 g Fe EDTA (T_6)	10.25	13.97	3.72	9.41	12.35	16.67	4.32	10.20
200 g Fe EDTA (T_7)	10.69	14.42	3.73	9.71	12.56	16.85	4.29	9.44
300 g Fe EDTA (T_8)	10.67	14.36	3.69	8.53	12.45	16.73	4.28	9.18
400 g Fe EDTA (T_9)	10.26	13.99	3.73	9.71	12.54	16.85	4.31	9.95

height with this dose was 10.85% and 11.21%, respectively in fourth year plants and 10.27% and 11.87%, respectively in fifth year plants. Therefore, 200 g plant^{-1} Fe EDTA can successfully ameliorate the deficiency symptoms of Fe in plants in fourth and fifth year of their growth.

The application of ferrous sulphate along with sulphur was not able to correct the deficiency of iron. The application of ferrous sulphate alone in the soil is not effective as its soluble iron is transformed into insoluble forms after its reaction with the soil components (Goswami et al., 2009; Yadav et al., 2011; Poonia et al., 2022). Therefore, it was applied along with sulphur which would increase soil acidity and maintain iron in a form that can be absorbed by plant roots. But in our study, their applied doses may not have increased the acidity in the soil to the extent where sufficient iron becomes available for the plants. However, application of Fe EDTA was effective in correcting iron deficiency and improving the growth of the plants. Fe EDTA is an iron chelate and is an

Table 5: Growth parameters of plants in fourth year under different levels of iron fertilizers

Treatments (per plant)	Diameter at breast height (DBH)				Plant height			
	At application (cm)	After one year (cm)	Increase in one year (cm)	Increase over control (%)	At application (m)	After one year (m)	Increase in one year (m)	Increase over control (%)
Control (T_1)	12.25	16.03	3.78	-	14.39	18.76	4.37	-
100 g S+100 g $FeSO_4.7H_2O$ (T_2)	12.21	16.06	3.85	1.85	14.36	18.89	4.53	3.66
200 g S+200 g $FeSO_4.7H_2O$ (T_3)	13.08	16.91	3.83	1.32	14.38	18.92	4.54	3.89
300 g S+300 g $FeSO_4.7H_2O$ (T_4)	12.67	16.51	3.84	1.59	15.01	19.51	4.50	2.97
50 g Fe EDTA (T_5)	12.34	16.33	3.99	5.56	14.45	19.13	4.68	7.09
100 g Fe EDTA (T_6)	13.12	17.18	4.06	7.41	15.02	19.72	4.70	7.55
200 g Fe EDTA (T_7)	12.45	16.64	4.19	10.85	14.56	19.42	4.86	11.21
300 g Fe EDTA (T_8)	12.68	16.85	4.17	10.32	14.78	19.63	4.85	10.98
400 g Fe EDTA (T_9)	12.36	16.54	4.18	10.58	14.37	19.19	4.82	10.30

Table 6: Growth parameters of plants in fifth year under different levels of iron fertilizers

Treatments (per plant)	Diameter at breast height (DBH)				Plant height			
	At application (cm)	After one year (cm)	Increase in one year (cm)	Increase over control (%)	At application (m)	After one year (m)	Increase in one year (m)	Increase over control (%)
Control (T_1)	15.51	18.14	2.63	-	16.49	19.27	2.78	-
100 g S+100 g $FeSO_4.7H_2O$ (T_2)	15.56	18.24	2.68	1.90	16.43	19.32	2.89	3.96
200 g S+200 g $FeSO_4.7H_2O$ (T_3)	15.75	18.45	2.70	2.66	16.45	19.33	2.88	3.60
300 g S+300 g $FeSO_4.7H_2O$ (T_4)	16.15	18.84	2.69	2.28	17.05	19.92	2.87	3.24
50 g Fe EDTA (T_5)	16.23	19.01	2.78	5.70	16.62	19.62	3.00	7.91
100 g Fe EDTA (T_6)	15.53	18.35	2.82	7.22	16.55	19.53	2.98	7.19
200 g Fe EDTA (T_7)	15.43	18.33	2.90	10.27	16.65	19.76	3.11	11.87
300 g Fe EDTA (T_8)	15.45	18.37	2.92	11.03	16.43	19.56	3.13	12.59
400 g Fe EDTA (T_9)	15.67	18.61	2.94	11.79	16.77	19.92	3.15	13.31

organic combination of iron with EDTA (ethylene diamine tetraacetic acid) where iron remains soluble and is not converted to insoluble products after its reaction with the soil components. So, the plants applied with Fe EDTA can take Fe easily from the soil and thus the deficiency symptoms are cured. As elaborated in the results, the sufficient dose of Fe EDTA was 50 g plant^{-1} for first year plants, 100 g plant^{-1} for second and third year plants and 200 g plant^{-1} for fourth and fifth year plants for curing the deficiency symptoms and increasing the growth of the plants. Many research workers have observed a significant effect of fertilizer application on tree growth. Singh (2001) reported a significant increase in plant growth attributes of *Populus deltoides* due to application of N, P and K fertilizers. Albaugh et al. (2015) conducted a nutrient dose and application frequency study in *Eucalyptus grandis* stands. Fertilization began when trees were 11–24 months old and they examined volume growth response three years after study initiation. Three years after treatment initiation, the maximum absolute response was 142 m^3 ha^{-1} (91% increase) and 116 m^3 ha^{-1} (56% increase) for sites 1 and 4, respectively. Sites 1 and 4 reached maximum volume response at cumulative nitrogen doses of 360 and 480 kg ha^{-1}, respectively. Poonia et al. (2022) observed that the application of $FeSO_4$ both as basal and foliar spray along with citric acid and FYM application produced the best results in improving the yield of groundnut in dry ecologies of western Rajasthan.

There was not much increase in growth parameters as the dose was increased beyond 50 g $plant^{-1}$ Fe EDTA in first year plants, 100 g $plant^{-1}$ Fe EDTA in second and third year plants and 200 g $plant^{-1}$ Fe EDTA in fourth and fifth year plants. Therefore, there is no use of adding higher rates than these doses because those have not improved much the growth parameters of plantations than the lower levels despite involving the higher cost. A significant influence of 0.02% zinc sulphate on height of *Acacia catechu* was observed by Raina et al. (1990). Singh et al. (2009) observed that the deficiency of zinc in poplar could be corrected by soil application of 25 g $plant^{-1}$ Zn (through $ZnSO_4.7H_2O$) in one year old plants, 40 g $plant^{-1}$ Zn in two-year-old plants whereas application of 20 kg ha^{-1} Zn was sufficient for eradicating Zn deficiency in nurseries.

4. CONCLUSION

The deficiency symptoms of iron in eucalyptus plantations could be cured by application of 50 g $plant^{-1}$ Fe EDTA (iron chelate) in 0.5 m diameter ring to first year plants, 100 g $plant^{-1}$ Fe EDTA in 1 m diameter ring to second and third year plants and 200 g $plant^{-1}$ Fe EDTA in 1.5 m diameter ring to fourth and fifth year plants of eucalyptus.

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