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The effects of external iron concentration on the growth, yield and nodulation in Chick Pea (Cicer arietinum L. cv.H-208)

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Abstract:

As trace elements several metals like copper, iron, manganese, molybdenum, nickel and zinc are essential for the growth of the plants. Rapid industrialization, mining and use in agriculture have resulted in the increased concentrations of these metals in the soil causing phytotoxicity. The present study was undertaken to study the effects of the soil with different concentrations of the iron ranging from acute deficiency to excess, on the growth and nodule formation in Cicer arietinum L. cv.H-208. This cultivar was found to respond in a different way in terms of various growth parameters studied as well as in the formation of root nodules when grown on the soil amended with 10mg/kg and 50mg/kg iron concentrations as compared to the soil not amended with Fe.

Key words: *Trace elements, metals, nodule formation, iron, Cicer arietinum, growth, phytotoxicity*

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Introduction

Years of mining, industrial processing and the use in agriculture have led to the accumulation of various metals in the environment creating pollution (Arzoo et al.,2014, Nazir et.al.,2015). Though some metals like copper, iron, manganese, molybdenum, nickel and zinc are essential for the growth of the plants in traces, elevated concentrations of both essential and non-essential elements result in growth inhibition and toxicity symptoms. (Tchounwou et. al.,2014, Dixit et. al.,2015, Rout and Sahoo, 2015). Iron is an essential nutrient for plants and is a constituent of many enzymes and proteins (Marschner, 2011). The essential role of Fe in plant biochemistry include the mechanisms of photosynthetic electron transfer, influencing chlorophyll formation, nucleic acid metabolism, and redox reactions of chloroplasts, mitochondria and peroxisomes amongst others (Li et al., 2016). Fe deficiency affects several physiological processes and therefore, retards plant growth as well as plant yield (Kennelly, 2012, Trejo-Téllez and C. Gómez-Merino, 2014, Sokolov et.al.,2015). Application of Fe in low doses promotes growth and yield (G. Libralato et al., 2016). Legumes, which develop a symbiosis with nitrogen-fixing bacteria, have an increased demand for iron. Iron is required for the synthesis of iron-containing proteins in the host, including the highly abundant leghemoglobin, and in bacteroids for nitrogenase and cytochromes of the electron transport chain. Deficiencies in iron can affect initiation and development of the nodule (Brear et al., 2013). Experimental results have shown that both Fe and Mo applied alone or combined significantly increased number of nodules in lentils over control (Nasar and Shah, 2017).

Despite its importance as essential micronutrient, iron is toxic when high levels accumulate (Rout and Sahoo, 2015). The presence of high Fe concentration have known to result in stunted shoot growth, brown necrotic patches on leaves, die-back of leaves, stunted root growth and lack of branching of roots in plants like geranium and marigold (Broschat and Moore, 2004) . Peña-Olmos

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et. al (2014) reported that the exposure of Brassica oleracea var. Italica plants to high Fe^{2+} levels in the substrate negatively affects the general function of these plants. Excess of Fe also reduces the uptake of nutrients like phosphate into plant tissues resulting in nutrient deficiency (Batty and Younger, 2003). Hence, the present study was undertaken to evaluate the effects of soil application of Fe on the growth, yield and nodulation in one of the important food crop, Cicer arietinum L. cv.H-208.

Materials and Methods

The seeds of Cicer arietinum L. cv.H-208 were procured from Government Horticulture Research Station and Training Centre, Saharanpur and the soil taken from the experimental plots of this research station was amended with Ferric oxide as to make the final concentration 10mg Fe/kg and 50 mg Fe/kg soil. Two kg each of Fe- amended soil and blank soil were filled in polythene bags. The seeds of Cicer arietinum L. cv.H-208 were sown in these polythene bags in the month of November and grown under field conditions with irrigation whenever necessary.

Plant samples for growth analysis were taken at 30th and 60th day of seedling emergence. The day of 75 to 100% emergence was taken as the starting day. Root/Shoot length, fresh weight and dry weight, nodule number, fresh and dry weight of nodules per plant were recorded. Yield parameters like number of pods per plant, weight of pod cover, number and weight of seeds per plant were recorded.

Results and Discussion:

Table 1 indicates that in general growth of Cicer arietinum, Linn. Cultivar H208 increases in the presence of 10mg Fe/kg soil and declines in the presence of 50 mg/kg soil as compared to control soil. Results show that 10 mg/kg Fe amended soil is promontory to plant growth. Thus, at 30th day root and shoot lengths are 167.7% and 134.2% of control, respectively, whereas, these values at 60th day are 146.9% and 145.6% of control respectively. This indicates both root and shoot growth is equally promoted in presence of

10mg/kg iron amended soil, which acts as nutrient. Table further indicates that 50 mg/kg Iron amended soil is deleterious for plant growth at all stages; however, the extent of inhibition is more marked in the above ground part at later phase of growth.

Results also show that in this legume, yield of plant grown in 10 mg/kg Fe amended soil is also promoted. Thus, in 10 mg/kg Fe amended soil grown plant, Pod number/plant, Pod weight, seed number/plant and seed weight are 140.2%, 130.0% and 136. 3% and 252.3% of control respectively. Table 1 further shows that higher iron concentration is inhibitory to various yield parameters studied in this crop.

As the nodulation is the part of productivity in the legumes, the effects of iron on nodulation was also studied. There is also a promotion in nodulation in this cultivar in presence of 10mg/kg Fe concentration. Thus, in 10 mg/kg Fe amended soil at 20th day nodule number, fresh weight and dry weight are 196.5%, 126.3% and 120.8% of control respectively whereas, these values in the same concentration of Iron at 40th day are 128.6%, 113.3% and 141. 6% of control respectively, in presence of same lower concentration of Iron.

Results also show that in this legume, yield of plant grown in 10mg/kg Fe amended soil is also promoted. Thus, in 10mg/kg Fe amended soil grown plant, pod number/plant, pod weight, seed number/pod and seed weight per plant are 140.2%, 130.0%, 136.3% and 252.3% of control respectively.

The observations indicate that the iron at lower concentration is an essential micronutrient but is

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highly toxic to growth and yield when present in excess. Iron toxicity in plants has also been reported by other workers (Shahid et. al., 2014, Peña-Olmos et.al., 2014 and Wu et.al., 2016). The present work clearly indicates the nutrient and hazardous nature of metal iron. Iron is an essential trace element for plants, and species differ greatly in how much Fe they require for optimal growth. (Li et al .2015). As iron is frequently limiting, iron deficiency is more commonly studied than toxicity arising from excess iron exposure. Therefore, further research in understanding the mechanisms underlying excess Fe toxicity is essential.

Table 1

GROWTH CHARACTERISTICS AND YIELD OF *Cicer arietinum* Linn. CV. H208 ON SOIL WITHOUT (CONTROL) AND WITH IRON CONCENRTRATION (10 & 50 mg Fe/kg soil)

Growth Parameters per Plant (± SD)	**DAYS OF EMERGENCE**								
		30			60			90	
	CONCENTRATION OF IRON, mg/kg soil								
	0	10	50	0	10	50	0	10	50
1. **Root**									
Length, cm	12.40 ±1.16	20.80 ±1.45	10.00 ±1.40	26.40 ±2.40	38.80 ±2.66	20.80 ±1.80			
Fresh Wt. g	00.58 ±0.02	0.84 ±0.03	0.41 ±0.01	00.84 ±0.04	1.087 ±0.03	0.65 ±0.04			
Dry Wt. g	0.098 ±0.014	0.206 ±0.018	0.062 ±0.01	0.240 ±0.018	0.456 ±0.018	0.21 ±0.01	0.35 ±0.01	0.51 ±0.01	306 ±0.01
2. **Shoot**									
Length, cm	18.10 ±1.18	24.30 ±1.18	10.90 ±1.60	26.40 ±2.10	38.45 ±2.80	23.50 ±1.20			
Fresh Wt. g	1.84 ±0.06	2.08 ±0.70	1.38 ±0.04	2.40 ±0.08	3.60 ±0.048	2.96 ±0.34			
Dry Wt. g.	0.215 ±0.018	0.36 ±0.018	0.18 ±0.014	0.43 ±0.065	0.88 ±0.40	0.34 ±0.036	1.60 ±0.073	2.4 ±0.044	1.2 ±0.02
3. **Nodule**									
Number	16.46 ±1.80	26.80 ±1.80	12.26 ±1.40	28.60 ±1.10	38.40 ±2.18	20.30 ±1.1			
Fresh Wt. g	0.14 ±0.004	0.24 ±0.006	0.11 ±0.002	0.27 ±0.005	0.309 ±0.008	0.21 ±0.004			
Dry Wt. g.	0.048 ±0.006	0.084 ±0.007	0.03 ±0.004	0.08 ±0.006	0.106 ±0.008	0.06 ±0.004			
4. **Pod**									
Number/Plant							8.4 ±0.42	16.40 ±0.88	6.0 ±0.06
Wt. of Pod Cover							0.408 ±0.06	0.818 ±0.04	306± ±0.04
Wt. of Seed/Pod							1.20 ±0.18	2.1 ±0.46	0.90 ±0.30
5. **Seeds**									
Number/Pod							2.0 ±0.12	3.1 ±0.1	1.45 ±0.1
Weight. g							0.080 ±0.12	0.097 ±0.0.44	0.040 ±0.04
Weight/plant.g							1.344 ±0.42	4.93 ±0.42	0.348 ±0.04

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