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Response of *Coriandrum sativum* with variable soil pH of Typic Haplustalfs and Typic Heplustepts

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Abstract

Some of the crops traditionally adopted by the farmers in a certain area and later on those areas recognized as bowl or hot spots for a particular crop. Still there is a scope to achieve more yield in non-traditional areas than the potential yield in traditional area. Therefore, present study was conducted under controlled conditions to evaluate the coriander under various soil pH levels (6.0, 6.5, 7.0, 7.5, 8.0 and 8.5 $\pm$ 0.35). Data revealed that most of the growth and yield parameter were at par up to pH 7.0 and reduced thereafter. Biomass accumulation was increased with increase in pH up to neutral level and reduced thereafter. Seed produced by the Ajmer coriander-1 was 5-6 time lower with the alkaline pH then the neutral to slight acidic pH. Harvest index was at par with pH acid to neutral and was lowest at pH 7.0. N and P content in seed and straw decreased with increase in pH. However, potassium content in seed increased with higher levels of pH. Iron content in seed and straw increased with increasing levels of pH. However, zinc content in seed increased with increase in pH and reduced down in straw with higher pH. Copper and Manganese content in seed and straw decreased with increasing soil pH. The uptake of N and K was also increased up to pH 7.0 and reduction took place beyond pH 7.5. However, P uptake was remained at par up to pH 7.0 and reduced after pH 7.5. The total removal of iron and zinc increased up to pH 7.0 and lower down thereafter. Moreover, manganese and copper accumulation decreased with increasing in soil pH. Chlorophyll content a, b and total decreased with increase in soil pH. Beyond the pH 9.0, plant could not complete the life cycle and showed chlorosis. Therefore, soil pH is one of the important factors to harvest yield potential of coriander. It can also inference that variety ACr-1 is most suitable in slight acid to neutral pH soils than neutral to alkaline soil pH.

Key words: Ajmer coriander-1, *Coriandrum sativum,* growth, nutrient uptake, Soil pH, yield.

Introduction

Worldwide 60 per cent land area on earth occupied by the acid soil. In all the thermal belt of the Earth, these arises under humid climatic conditions. In India, total area under degraded and wastelands is 147.75 mha and the extent of area under chemical degradation particularly by acidification (pH < 4.5 -5.5) was estimated at 16.03 M ha (ICAR, 2010). According to different possible classes with different stake holders, the extent of this chemically degraded area has been estimated as 10.71 M ha. In the Jharkhand state, soils mainly developed on granite gneiss (32.6%) and granite schists (14.2 %). Soil acidity problem (pH < 5.5) is acute in 4 lakh hectare of cultivated area. Soil acidification takes place by depletion of calcium and magnesium by leaching process and uptake by crops. Low pH and lower levels of organic carbon, K, *Ca,* Mg and in some places micronutrients also are the major constraints for growing general crops in these soils. Such soil chemical reaction turn influences both microbial and biochemical processes in soil as well as chemical composition of plants. Liming in these soils play a crucial role for enhancing their productivity. Liming is an expensive management measure and some time it does not work properly. Selection of crops tolerant to acidity is an effective tool to counter this soil problem and breeding of such varieties is of specific importance for attaining higher productivity particularly in the areas where liming is not economical. Mandal *et al*. (1975) suggested some of the crop like maize, sorghum, wheat, barley, millets, rice, oats, field beans, soybeans, pea, lentil, *berseem,* groundnut, sugarcane, cotton and potato for acid soils. However, none of the information available on seed spices like coriander. To take the initiative for sustainable and eco-friendly management of these soils, non-traditional crops like coriander may be tried to grow for their evaluation in relation to tolerance level to soil acidity. Moreover, coriander shows lime induced chlorosis in

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calcareous soil having pH more than 8.5 and its severity further aggravated with high temperature particularly in summer season (Aishwath and Anwer, 2010). In some other reports, it has stated that 70 per cent seed spices production comes from Rajasthan and North Gujarat and called as seed spice bowl (Malhotra, and Vashishtha, 2008). This resulted a mind-set that geographical situations of this area is most suited for seed spice cultivation. It has also been reported that coriander comes well with the soil pH 6.5-8.0 in well drained loams or sandy soils (Aishwath *et al.*, 2010). However these crops are having the most ecological significance and can be grown under various adversities. Besides coriander as a spice, it also an aromatic and medicinal herb used for garnishing food and various parts of coriander possess Diuretic, Antioxidant, Ant-diabetic Anti-convulsant, Sedative Hypnotic, Anti-microbial, Anti mutagenic and Anthelmintic activities. Though this is a very important seed spice crop occupying largest area (557870 ha) and production (532947 tonnes) in the country among the seed spices under various agro-ecological regions. Yet, there is no specific research findings available for the degree of tolerance of coriander to acidity. Therefore, it is imperative to evaluate the crops under these soils so as to diversify the crop in these chemically degraded soil for their management via economic and sustainable way.

Materials and methods

Location and climate

The field experiments were carried out under the Typic Haplustepts and Haplustalfs during *Rabi* season of 2010-2011 and 2011-2012 at ICAR-National Research Centre on Seed Spices, Tabiji, Ajmer, Rajasthan, India. This was laid out between 74° 35'39" to 74° 36' 01"E longitude and 26° 22'12" to 26° 22' 31" N latitude. Climate of the Ajmer area characterized as semi-arid. The average annual rainfall of the area is 536 mm and most of it (85-90%) received between June to September. July and August are most rainy months contributing 60.0% of the average rainfall. The moisture control section remains dry for more than 90 cumulative days and hence moisture regime classified as Ustic. The mean annual temperature is 24.5 to 25.0°C. January is the coolest month of the season and temperature remain around 7.0°C. Currently frost is also occurring in this month with changing climatic pattern (Singh and Shyampura, 2004).

Treatments and cultural practices

The treatments consisted soil pH 6.0, 6.5, 7.0, 7.5, 8.0 and 8.5 (± 0.35) with four replication. The soil pH of TypicHaplustalfs raised by application of lime and beyond the neutral pH, natural gradient available at ICAR-NRCSS farm soil (TypicHeplustepts) were used directly in pot culture study. The fertility of the soil maintained by adding manures and fertilizers for the comparison only for the pH. All the six treatments were arranged in a Randomized Block Design (RBD). The coriander varieties Ajmer Coriander-1 (ACr-1) was taken as a test crop for the study. Seeds of the coriander variety ACr-1 were sown during winter season and plant population per pot maintained by thinning in pots. Cultural practices were uniformly followed during the growing seasons in both the years and crop was irrigated as and when required. The crop was harvested, when it matured during both the years. After harvest, seeds were separated from the stover by hand rubbing and blown out of straw.

Soil analysis

Soil samples were collected from the surface (0-15 cm depth) before sowing of seed during both year crops. Samples were air dried and powdered with wooden mortar and pestle and passed through a 2 mm stainless steel sieve. Experimental soil was analysed for physicochemical properties ie EC and pH (Richards, 1954), organic carbon content by rapid chromic titration (Walkley and Black, 1934), available N by alkaline permanganate (Subbiah and Asija, 1956), available P by 0.5 M $NaHCO_3$ extractable P (Olsen, *et al.*, 1954) and Bray and Kurtz (1945), available K by 1N NH_4OAc extracts method (Jackson, 1973) and available micro-nutrients (Fe, Zn, Mn & Cu) by DTPA (Lindsay and Norvell, 1978).

Texture of experimental soil was sandy loam. Soil organic carbon was 0.31%. However, soil available N, P and K were 135, 14.2 and 244 kg ha^{-1}, respectively. Micronutrient status like iron, zinc, manganese and copper of the soil was 88.1, 5.9, 72.04 and 8.1 kg ha^{-1}, respectively

Plant analysis

The plant samples were collected after the harvest of crop. These samples were successively washed with tape water and then 0.1 M HCl followed by distilled water and thereafter dried at 70°C. After proper drying samples were powdered in wily mill and passed through the 20 mesh stainless steal sieve. Nitrogen was estimated by Kjeldahl method (Piper, 1966). The samples were digested in nitric and perchloric acid (10:4) for the estimation of P by Venado-molybdo yellow colour method (Chapman, and Pratt, 1962) and K by flame photometer. Iron, zinc, manganese, and copper were estimated by Atomic Absorption Spectrophotometer and carbon by CHNS Analyser (Thermo Scientific make).

Statistical Analysis

The data of both the years were analyzed by ANOVA and treatment differences were expressed for Least Significant differences (LSD) at 5% probability to determine the significance among the treatment means (Cochran and Cox, 1987).

Results and Discussion

Growth and yield

Data revealed that plant height was at par up to pH 7.0 and reduced thereafter (Table 1). Plant height reduced about 42% at pH 8.5 as compared to neutral pH. No of primary branches were more with neutral pH than the lower and higher pH, whereas secondary branches were only lower at pH 8.0 and 8.5 and rest of the pH remained at par. No of umbel plant^{-1}, number of umbelets plant^{-1} and number of seed umbel^{-1} were at par with neutral to acid side and reduced above the neutral pH. Straw accumulation was increased with increase in pH up to neutral level and reduced thereafter. Seed produced by the Ajmer coriander-1 was 5-6 time lower with the alkaline pH then the neutral to slight acidic pH. Harvest index was at par with pH acid to neutral and was lowest at pH 7.0. This might be due to more nutrient availability at lower pH gave higher yield of crop (Lanyon, *et al* 1977).

Chlorophyll content, nutrient content and uptake

Chlorophyll content a, b and total decreased with increase in soil pH. Beyond the pH 9.0, plant could not complete the life cycle and showed chlorosis (Fig. 1). Availability of micronutrients is more at low pH and are the integral part of chlorophyll, hence the chlorophyll content was more at low pH (Aishwath and Dravid, 2004). At higher pH lime induced chlorosis occurs in coriander causes loss of chlorophyll (Aishwath and Anwer, 2010)

Nitrogen and phosphorus content in seed and straw decreased with increase in pH (Fig. 2-7). However, potassium content in seed increased with each successive levels of pH, while it was at par in straw up to pH 7.0 and increased thereafter. Higher pH suppressed the ionic uptake leads to lower content and uptake of macronutrients. Nitrogen (N), from urea fertilizers or mineralized from organic matter, is in the form of ammonium (NH_4^+). In alkaline soils, NH_4^+ becomes ammonia (NH_3), and can be volatilized (lost as a gas). In acid soils, the additional H helps maintain NH_4^+ concentrations, which can adsorb to the CEC. Uptake of nitrate (NO_3^-) by plants is best at a lower pH, while NH_4^+ is absorbed more efficiently at a neutral pH. Optimum P availability is at pH 6.5. Below 6.5, P becomes insoluble Al/Fe minerals or absorbs to oxides and clay. Above 6.5, P bonds with Ca to form solid minerals similar to Ca-phosphate fertilizers. Relatedly, Ca-phosphate fertilizers added to acid soils will readily dissolve and release P, but will have limited solubility in alkaline soils (Pagani and Mallarino, 2014).

Iron content in seed and straw increased with increasing levels of pH (Fig. 7-11). However, zinc content in seed increased with increase in pH and reduced down in straw with higher pH. Copper and Manganese content in seed and straw decreased with increasing soil pH. The uptake of N and K was also increased up to pH 7.0 and reduction took place beyond pH 7.5. However, P uptake was remained at par up to pH 7.0 and reduction observed after pH 7.5. The total removal of iron and zinc increased up to pH 7.0 and lower down thereafter. Moreover, manganese and copper accumulation decreased with increasing in soil pH. Micronutrient availability is highly dependent on soil pH and lower the higher pH by the lower availability. All the known micronutrients decrease

Table 1. Effect of soil pH on growth yield and their parameters of coriander

Treatment (Soil pH)	Plant height	No of primary branches	No of secondary branches	No of umbel plant^{-1}	No of umbelets umbel^{-1}	No of seed umbel^{-1}	straw (g pot^{-1})	Seed (g pot^{-1})	Harvest index (%)
6.0	37.5	2.8	2.8	6.0	5.8	7.3	8.1	6.5	44.6
6.5	38.0	3.5	3.5	6.5	6.0	7.8	8.9	7.2	44.6
7.0	39.0	4.0	3.5	6.8	6.8	8.3	9.7	7.7	44.0
7.5	35.5	4.0	2.8	4.5	5.5	6.8	5.7	2.5	30.4
8.0	28.3	2.8	1.3	3.5	5.0	6.5	2.4	1.8	42.8
8.5	27.5	2.3	1.3	3.3	4.8	6.0	2.0	1.3	40.0
CD at 5%	3.2	1.1	1.0	1.0	0.7	1.0	0.4	0.6	3.7

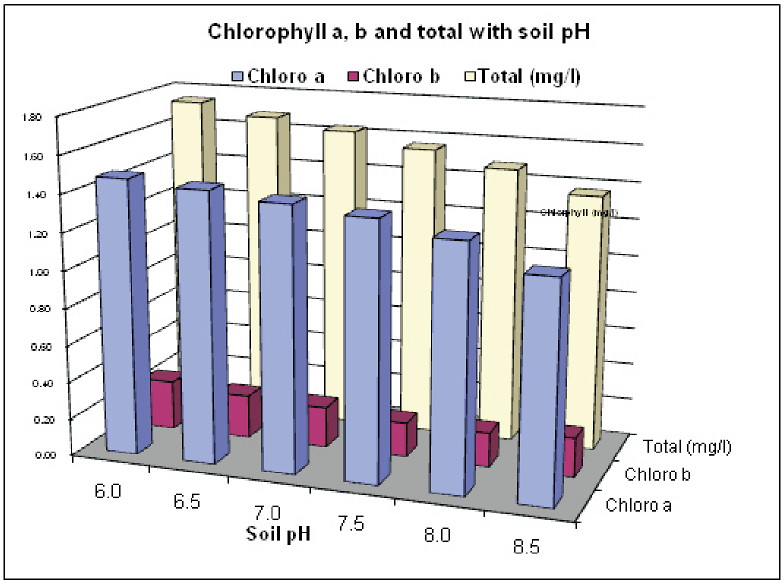

Fig. 1. Effect of soil pH on chlorophyll content in coriander

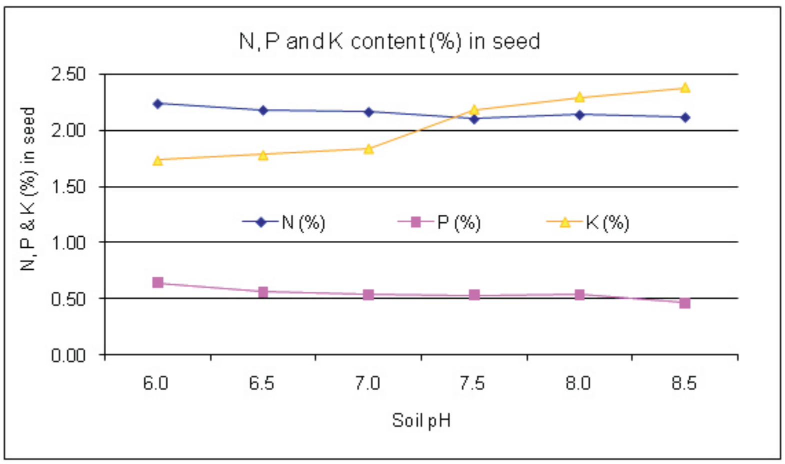

Fig. 2. Effect of soil pH on N, P and K content in coriander seed

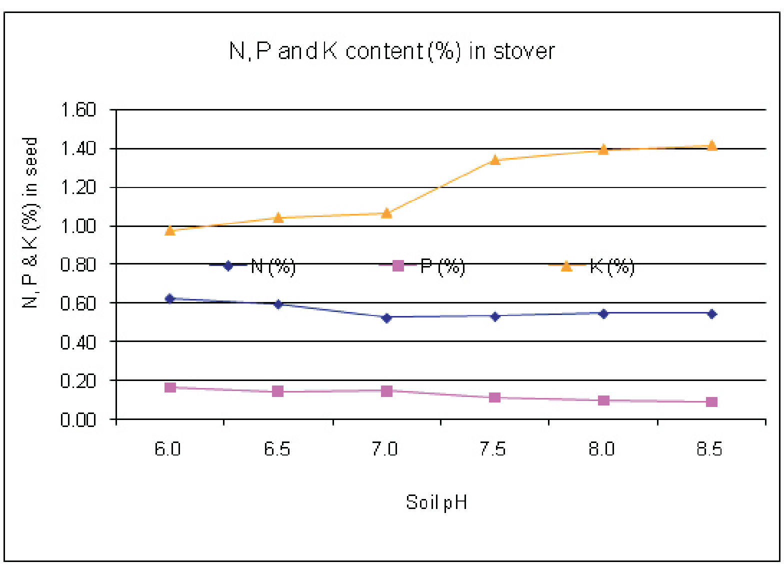

Fig. 3. Effect of soil pH on N, P and K content in coriander stover

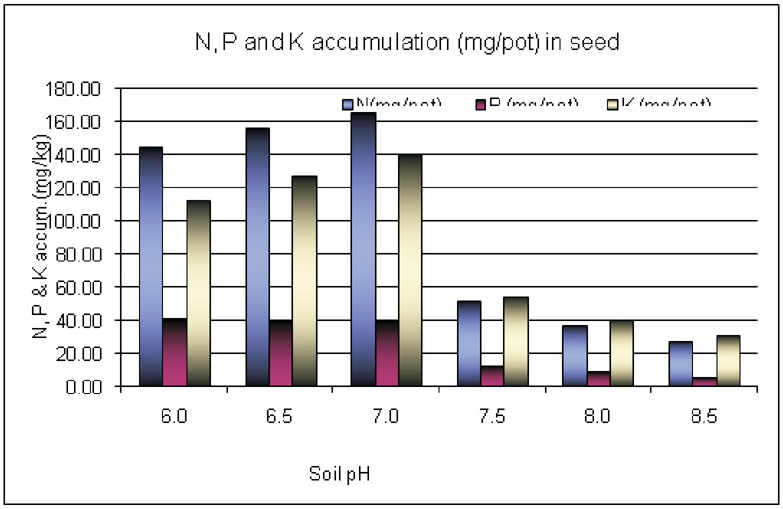

Fig. 4. Effect of soil pH on N, P and K accumulation in coriander seed

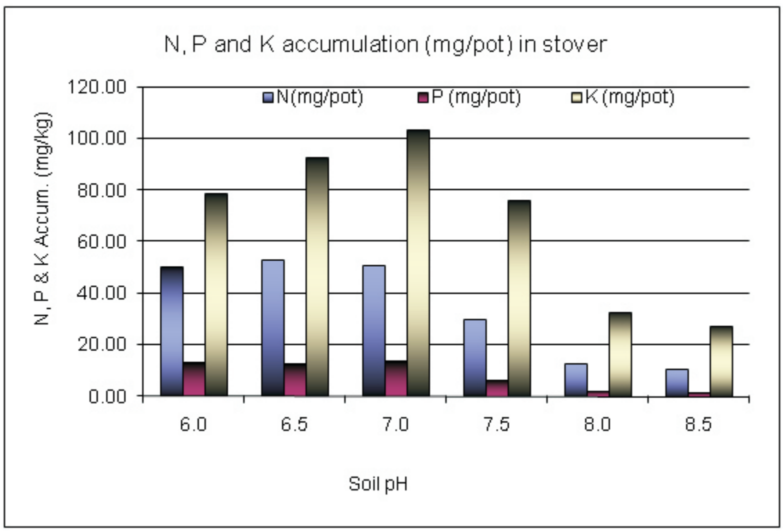

Fig. 5. Effect of soil pH on N, P and K accumulation in coriander stover

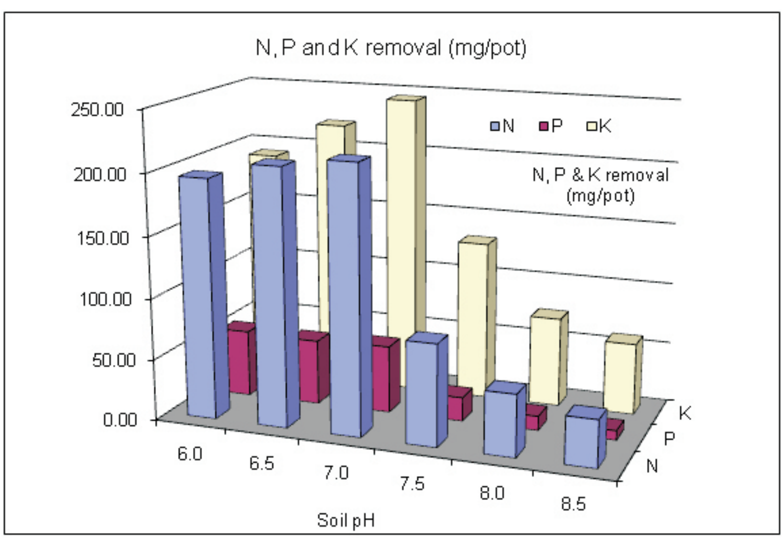

Fig. 6. Effect of soil pH on N, P and K removal by coriander

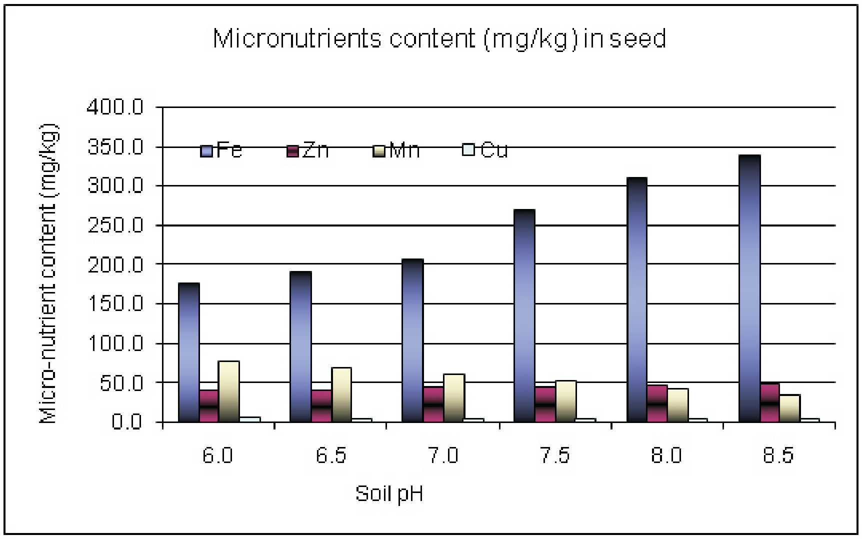

Fig. 7. Effect of soil pH on micronutrient content in coriander seed

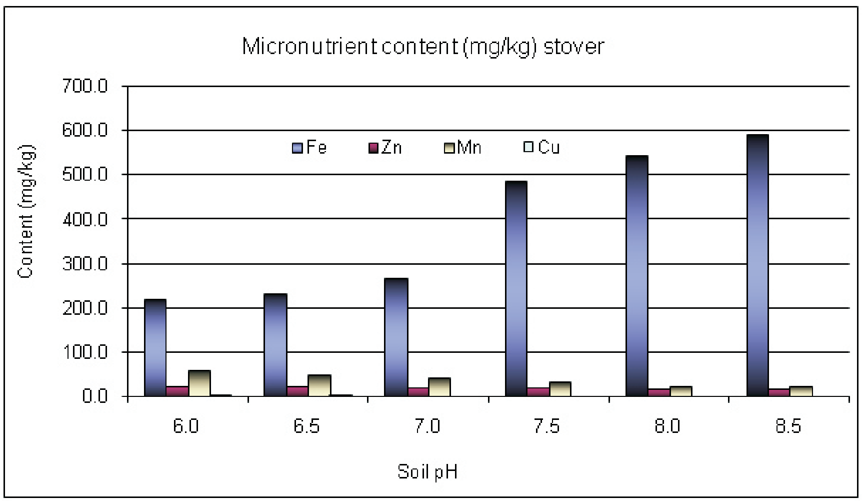

Fig. 8. Effect of soil pH on micronutrient content in coriander stover

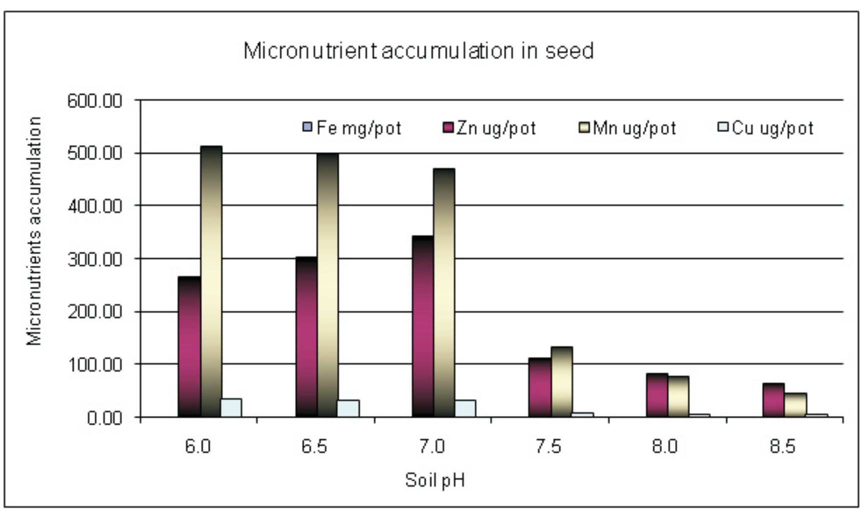

Fig. 9. Effect of soil pH on micronutrient accumulation in coriander seed

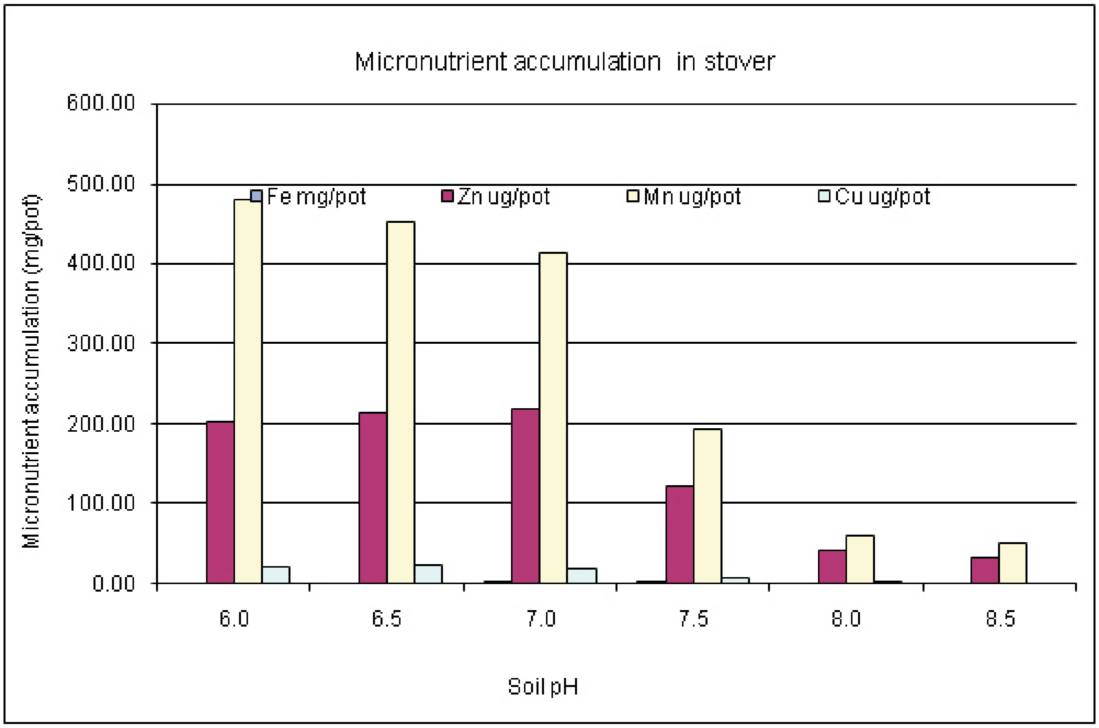

Fig. 10. Effect of soil pH on micronutrient accumulation in coriander stover

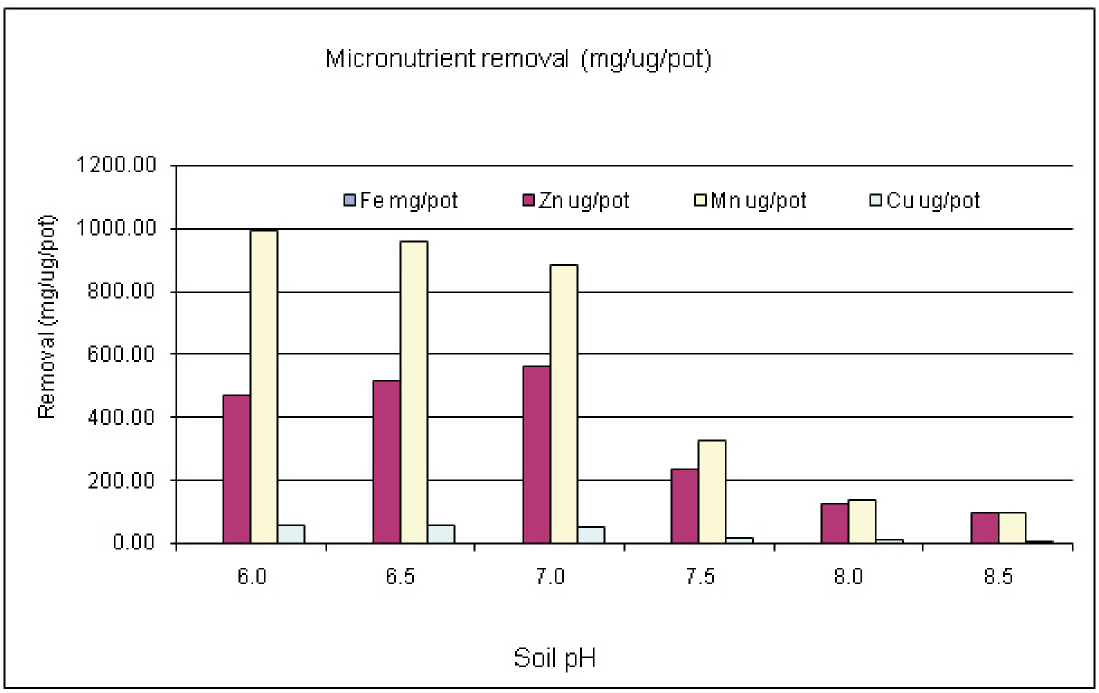

Fig. 11. Effect of soil pH on micronutrient removal by coriander

in availability as pH rises, except for molybdenum (Mo). Zinc (Zn), Cu and Mn decrease 100 fold in concentration with every one unit increase in pH. These nutrients are not lost, but rather preferentially sorb to soil surfaces, where they are not plant available. When concentrations are high (e.g Fe), they will precipitate as solid minerals (Miller, 2016).

Conclusion:

Soil pH is one of the important factors to harvest potential yield of coriander. It can also inference that variety ACr-1 is most suitable in slight acid to neutral pH soils than neutral to alkaline soil pH.

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