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DISTRIBUTION OF NITROGEN, PHOSPHORUS, POTASSIUM AND ZINC CONTENT IN MANGO GROWN ACIDIC SOILS OF JHARKHAND

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ABSTRACT

The mango orchards grown in acidic soils of Jharkhand were evaluated for pH, organic carbon (OC), available macro- (N, P and K) and DTPA-micronutrient (Zn) content in the soil profile. Soil samples were collected from 27 different mango orchards comprised of three health levels (unhealthy, medium and healthy) and three age groups (1-3 year, 4-5 year and 6-7 year). The pH of the surface soil was low and gradually increased with increase in depth of soil profile. The pH was lowest in unhealthy (4.96) as well as in 1-3 year old orchard (4.72). The organic carbon content was highest of 5.40 and 5.57 g kg^{-1} in healthy and 6-7 year old orchard, respectively in 0-30cm depth. The available nitrogen content varied from 67.2-139.4 kg ha^{-1} among the health levels of orchard. Among the age levels of orchard, the available nitrogen content varied from 82.8-128.2 kg ha^{-1}. The available phosphorus content varied from 1.8-7.3 and 0.8-5.7 kg ha^{-1} among health levels and age levels of orchard, respectively. The exchangeable potassium content was highest of 309.5 and 334.3 kg ha^{-1} in healthy and 6-7 year old orchards, respectively in 0-30cm depth. The DTPA-extractable Zn content varied from 0.27-0.48 and 0.24-0.40 mg kg^{-1} among health levels and age levels of orchard, respectively. The soils of different orchards were low in organic carbon, available nitrogen and available phosphorus; sufficiency in exchangeable K and DTPA-extractable zinc was critically low.

KEY WORDS
Alfisols
Mango orchard
Nitrogen
Phosphorus, Potassium, Zinc

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INTRODUCTION

Soil acidity is a major factor limiting crop yield in highly weathered and leached soils in both tropical and temperate regions of the world (Von Uexküll and Mutert, 1995). Out of the 328 million hectares of geographical area of India nearly about 89.94m ha area is covered by acid soils (Sharma and Sarkar, 2005) of which 6.19 m ha is strongly acidic showing pH below 4.5 while about 24.81 m ha is moderately acidic with pH between 4.5 and 5.5 and 58.94 m ha is slightly acidic with pH between 5.5 and 6.5. In India, acid soils occur in the Himalayan region, the Eastern and North-eastern plains, peninsular India and coastal plains under varying topography, geology, climate and vegetation. Most of these soils belong to the soil order, Ultisols, Alfisols, Mollisols, Spodosols, Entisols and Inceptisol. The acid soils are mostly distributed in Assam, Manipur, Tripura, Meghalaya, Mizoram, Nagaland, Sikkim, Arunachal Pradesh, West Bengal, Jharkhand, Odisha, Madhya Pradesh, Himachal Pradesh, Jammu and Kashmir, Andhra Pradesh, Karnataka, Kerala, Maharastra and Tamilnadu.

The acid soils have coarse soil texture with high infiltration rate, low water holding capacity, high permeability, soil crust formation, excessive leaching of nutrients and high bulk density. In acidic soils, the nutrient deficiencies of phosphorus, calcium and magnesium are pronounced, and the presence of phytotoxic substances like soluble aluminium and manganese. The practice of liming acid soils by applying lime in order to raise soil pH and precipitate exchangeable aluminium as insoluble hydroxy aluminium has long been recognized as necessary for optimum crop production (Haynes, 1984).

Among the fruit crops, mango is widely cultivated in the state of Jharkhand. At present, the total land area under mango cultivation is about 50,000 ha in the Jharkhand state (Kumar, 2011). The productivity of fruits in the state is around 9.8 t ha^{-1} which is less than the national average of 11.9 t ha^{-1}. It has been observed that most of the mango plantations (1st year to 6th year) are unhealthy and having low yield. It is necessary to have proper soil fertility evaluation before expansion of area under fruit based cropping system. The soil fertility evaluation can forecast for suitable fruit based cropping system in the state. Considering all these above points, the present investigation was undertaken with the objective to investigate the distribution of nitrogen, phosphorus, potassium and zinc content in different mango orchards grown in acid soils of Jharkhand.

MATERIALS AND METHODS

The different mango orchards of Gumla district of Jharkhand state were evaluated for nitrogen, phosphorus, potassium and zinc status during 2011-2012. The different mango orchards have been classified based on age (1-3, 4-5 and 6-7 year old) and health (Unhealthy, medium and healthy) comprised of 27 different orchards for the study. The experiment was set up in a randomized block design with factorial concept. The soils of the region were dominated by red and lateritic soils belong to the order alfisols. The soils were collected at different depths of 0-30, 30-60, 60-90 and 90-120 cm from different soil profiles. The soil samples were then air-dried, powdered and sieved through an 80 mesh nylon sieve and analised for its different chemical properties. The soil organic carbon content was determined by Walkley and Black method (1934). The following methods were used to determine available nutrient contents: the method of Subbiah and Asija (1956) for N, that of Bray and Curtz (1945) for P and the flame photometric method (Jackson, 1973) for K. The DTPA-extractable Zn was measured with an atomic absorption spectrophotometer by following the method of Lindsay and Norvel (1978). All the data were analysed by analysis of variance (ANOVA). Multiple comparisons were performed with Duncan's multiple range tests using the MSTATC statistical computer programme (version 5; Michigan State University, East Lansing, MI, USA).

RESULTS AND DISCUSSION

pH and organic carbon of the soil

The pH in the surface soils (0-30 cm) of all the orchards is very low and gradually increased with increasing depth of soil profile (Fig. 1). The pH of 5.5 was conducive for the growth of mango (Bopaiah and Srivastava, 1984) and this critical pH was observed only in healthy orchard throughout the depth of soil profile. The pH of healthy orchard soil was significantly better than medium and unhealthy orchard up to 60 cm depth of soil profile. The pH in the surface soil of healthy orchard was 5.5 and resulted in 11% higher over unhealthy orchard. The pH in the different age group of orchard soil varied from 4.72 to 5.48 in the surface soils and thereafter gradually increased with soil profile depth. The pH of higher age orchard (4-5 year and 6-7 year old) soil was significantly better than younger age orchard (1-3 year old) throughout the soil profile depth. The pH of 6-7 year old orchard soil was 5.48 and resulted in 16% higher than younger age orchard. The increased pH with increasing depth of soil profiles was ascribed to the deposition of exchangeable bases at lower depth of soil profiles due to heavy rainfall in the region during rainy season (Balpande *et al.*, 2007).

The organic carbon content (Fig. 2) of unhealthy, medium and healthy orchard varied from 4.2 to 5.4 g kg^{-1} in the surface soils and thereafter gradually decreased with increase in soil depth. The organic carbon content of healthy and medium orchards was significantly better than unhealthy orchards. All the soils of different orchards were having organic carbon below the critical concentration of 5 g kg^{-1} except healthy orchard at 0-30 cm depth. The healthy orchards registered 28.5 and 11.8 % increase in organic carbon over unhealthy and medium orchards, respectively in the surface soils. The organic carbon content in the different age group of orchard soils varied from 3.6 to 5.57 g kg^{-1} in the surface soils and thereafter gradually decreased with increasing soil depth. The organic carbon content of 6-7 year old orchard was significantly higher than 4-5 and 1-3 year old orchard soils throughout the depth of soil profile. The organic carbon content in different age group of orchard soils was highest of 5.57 g kg^{-1} in the surface soils of 6-7 year old orchard and registered 54.7 % increase over 1-3 year old orchard. It has been observed that, the organic carbon content in surface soil of 4-5 and 6-7 year old orchards were above critical concentration. Higher build up of soil organic carbon on surface layers under the higher age orchard may be attributed to the accumulation of litter fall of fruit trees on soil surface. The subsequent decomposition and incorporation of litter into the soil would have helped in raising the organic carbon status of soil. The results of the present investigations were in agreement with the findings of Gill *et al.* (1987) and Kumar *et al.* (1998).

Available macronutrients

The available N content (Fig. 3) in unhealthy, medium and healthy orchard soils varied from 115.7 to 139.4 kg ha^{-1} in the surface soils and thereafter gradually decreased with increasing depth of soil profile. The healthy orchard soils recorded

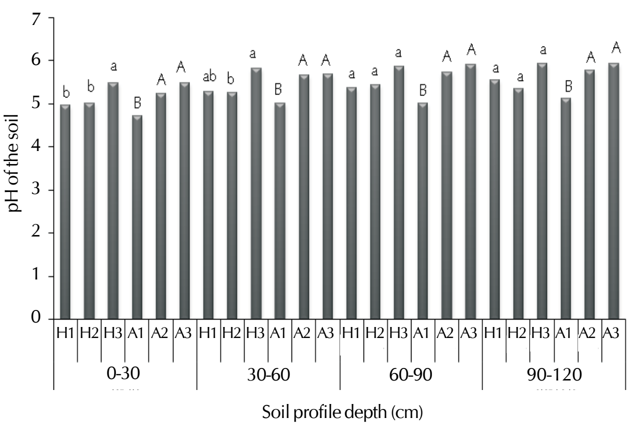

Figure 1: pH status of soils of different mango orchards in acid soils. Bars followed by the same letter are not significantly different at the 0.05 level of probability by Duncan's Multiple Range Test (DMRT). (H1: Unhealthy orchard, H2: Medium orchard, H3: Healthy orchard, A1: 1-3 year old orchard, A2: 4-5year old orchard, A3: 6-7 year old orchard)

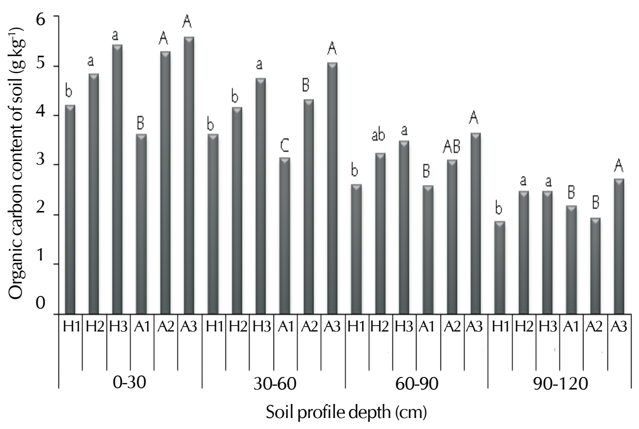

Figure 2: Organic carbon content in soils of different mango orchards in acid soils. Bars followed by the same letter are not significantly different at the 0.05 level of probability by Duncan's Multiple Range Test (DMRT)

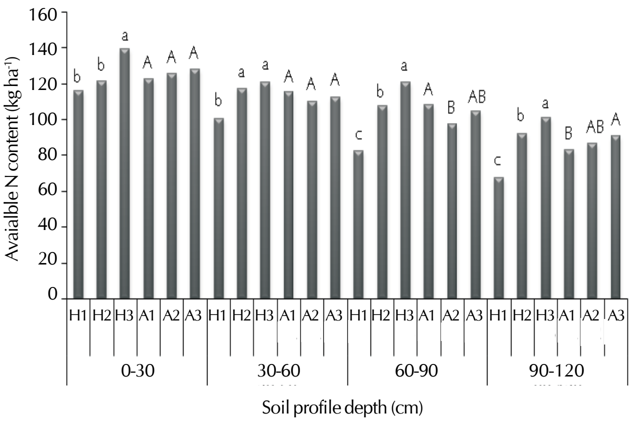

Figure 3: Available nitrogen content in soils of different mango orchards in acid soils. Bars followed by the same letter are not significantly different at the 0.05 level of probability by Duncan's Multiple Range Test (DMRT)

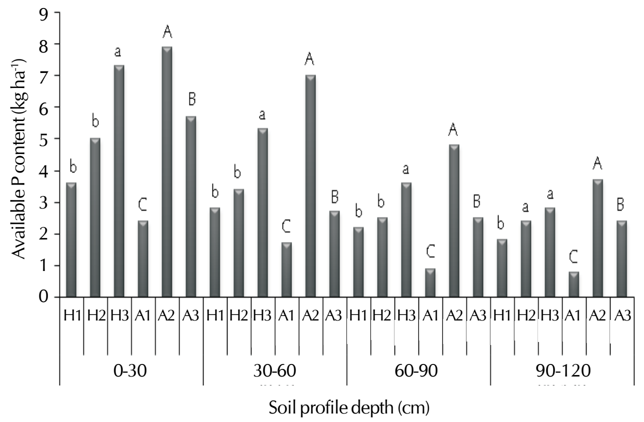

Figure 4: Available phosphorus content in soils of different mango orchards in acid soils. Bars followed by the same letter are not significantly different at the 0.05 level of probability by Duncan's Multiple Range Test (DMRT)

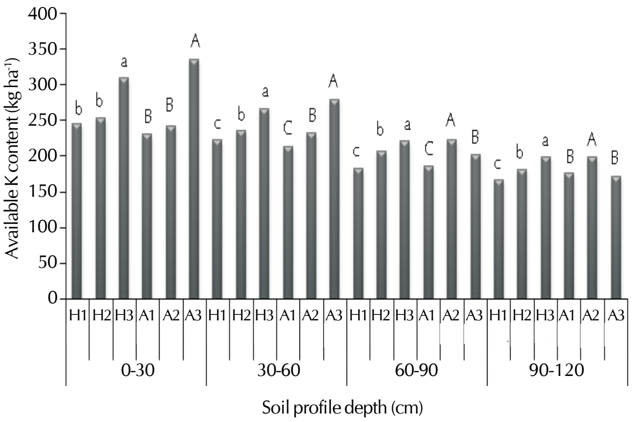

Figure 5: Available potassium content in soils of different mango orchards in acid soils. Bars followed by the same letter are not significantly different at the 0.05 level of probability by Duncan's Multiple Range Test (DMRT).

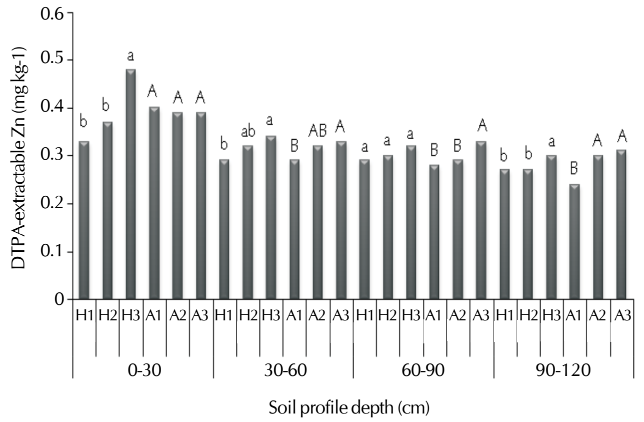

Figure 6: DTPA-extractable zinc content in soils of different mango orchards in acid soils. Bars followed by the same letter are not significantly different at the 0.05 level of probability by Duncan's Multiple Range Test (DMRT).

significantly higher available N content over medium and unhealthy orchard. The available N content of all the orchards was below the critical concentration of 280 kg ha^{-1} (Subbiah and Asija, 1956). The highest available N content among the health levels of orchard was 139.4 kg ha^{-1} in healthy orchard and registered 20.5 and 15 % increase over unhealthy and medium orchards respectively in the surface soils. The available N content of different age orchards (unhealthy, medium and healthy) was statistically at par throughout the entire depth of soil profile. The highest available N content was 128.2 kg ha^{-1} in healthy orchard soils in surface layer. With increasing depth of soil, the available N content gradually decreased, which is due to decreasing trend of organic carbon with depth. The data showed that all samples contained low N as compared with the values reported by Subbiah and Asija (1956). The low N concentrations in the soils might be due to N leaching and surface runoff in the undulating topography of different orchards.

The available P content (Fig. 4) of unhealthy, medium and healthy orchard soils varied from 3.6 to 7.3 kg ha^{-1} in the surface layer and thereafter gradually decreased with increasing soil depth. The healthy orchard soils recorded significantly higher available P content over medium and unhealthy orchard throughout the depth of soil profile. The highest available P content among the health levels of orchard soils was 7.3 kg ha^{-1} and registered 103 and 46 % increase over unhealthy and medium orchard respectively in the surface layer. All the orchards soils had below the critical concentration of available P (34 kg ha^{-1}) (Bray and Curtz, 1945) throughout the soil profile. Further, the different age group of orchards soil recorded low available P content throughout the depth of soil profile. The available P content in 4-5 and 6-7 year old orchard soil was significantly higher over 1-3 year old orchard throughout the depth of profile. Among the age level of orchards, 4-5 year old orchard recorded highest available P of 7.9 kg ha^{-1} and registered 229 and 38.6 % increase over 1-3 and 6-7 year old orchard, respectively in the surface soils. The low P concentrations in the soils of different orchard might be due to fixation of released phosphorus by oxides of iron and aluminium (Haynes, 1984; Thangasamy *et al.*, 2005). The fixed-

P can be made plant available form by applying native phosphate solubilizing fungi (Naik *et al*., 2012).

The available K content of unhealthy, medium and healthy orchard soil varied from 245 to 309.5 kg ha^{-1} in the surface soils and thereafter gradually decreased with increasing depth of soil profile (Fig. 5). The available K status in all the orchards was found to be in sufficiency range. The medium and healthy orchard soil recorded significantly higher available K over unhealthy orchard. The highest available K among health levels of orchard soil was 309.5 kg ha^{-1} in healthy orchard soil and resulted in 26.3 and 22% increase over unhealthy and medium orchard, respectively at 0-30 cm depth of profile. The available K content of different age group of orchards varied from 231.3 to 334.3 kg ha^{-1} in the surface soil and thereafter consistently decreased with increasing depth of profile. The 4-5 and 6-7 year old orchard recorded significantly higher available K over 1-3 year old orchard in the profile up to depth of 90 cm. The highest available K among age levels of orchard soil was 334.3 kg ha^{-1} in 6-7 year old orchard and resulted in 44.5 and 37.8 % higher over 1-3 and 4-5 year old orchard, respectively in the surface soils.

The higher content of available nutrients (N, P and K) on surface layers under different orchards was attributed to accumulation and decomposition of litterfall on the soil surface and subsequent nutrient release pattern was influenced by climatic factor (Bhalawe *et al*., 2013). During mineralization process organic-N and P from the litter released into the soil. Uma *et al*. (2011) observed that decomposition of leaflitter released the nutrients into the surface soils was in the order of N>Ca>Mg>K>Na>P>Zn>Cr>Fe. Higher availability of K at surface layers under different orchards was attributed to liberation of K from decomposition of litterfall as well as solubilization of insoluble forms of K present in soil due to organic decomposition products. Contractor and Badanur (1996) and Mathew *et al*. (1997) observed that availability of N, P and K was higher on surface layers than subsurface horizons under different tree species and it decreased gradually with depth.

DTPA-extractable zinc

The DTPA-extractable Zn content among health levels of orchard varied from 0.33 to 0.48 mg kg^{-1} in the surface soils and thereafter gradually decreased with increasing depth of soil profile (Figure 6). The DTPA-extractable Zn content in all the orchards was below the critical limit of 0.6 mg Zn kg^{-1} (Lindsay and Norvell, 1978) throughout the entire depth of soil profile. The healthy orchard recorded significantly higher DTPA-Zn content over medium and unhealthy orchard throughout the entire depth of soil profile. The highest DTPA-extractable Zn content was 0.48 mg kg^{-1} in healthy orchard soil and registered 45.5 and 29.7 % higher over unhealthy and medium orchard, respectively in the surface soil. The DTPA-extractable Zn content varied from 0.39 to 0.4 mg kg^{-1} in the surface soils among the different age group of orchard. Among the age levels of orchard, the DTPA-extractable Zn content was statistically at par in the surface soil. The DTPA-Zn consistently decreased with increasing depth of soil profile. The DTPA-extractable Zn in 6-7 year old orchard soils was significantly better than 1-3 year old orchard from 30-120 cm depth of profile. The low Zn concentrations in the orchard soils might be due to the fixation of Zn with sesquioxides (Mandal *et al*., 2000).

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