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EFFECT OF CROP RESIDUE BURNING ON MICRONUTRIENTS AVAILABILITY IN ARID SOILS OF PUNJAB, INDIA

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ABSTRACT

The study was conducted to assess the effect of crop residue burning on soil micronutrients. Soil samples from unburned and burned fields were collected, dried and prepared for micronutrient analysis. DTPA -extract (pH 7.3) was used for micronutrient extraction and concentration of micronutrients was determined by atomic absorption spectrophotometer. The surface soils (0-15 cm) showed higher content of Fe, Zn, Cu and Mn than sub-surface soils (15-30), which exhibited a decreasing trend with increase in soil depth. The soil heating, due to residue burning increased the DTPA extractable Fe, Zn and Mn content of soil, while the higher temperature reduced the DTPA extractable Cu. The crop stubble burning increased the Fe, Zn and Mn availability by 2.7 -15.8% (Fe) ,8.3-27.3% (Zn) and 10.0-16.7% (Mn) in upper layer, 4.5-9.1% (Fe), 12.0-45.5% (Zn) and 13.0- 22.7% (Mn) in lower layer. While, Cu was decreased by 6.0 -27.8% in upper and 9.0-25.0 % in lower soil layer due to stubble burning. The present study revealed that mostly micronutrients availability was increased due to residue burning. But, the farmers are not advice to burn the crop residue in open field condition, due to serious environmental pollution.

(Key words: Residue burning, Fe-availability, Zn-availability, Cu- availability, Mn-availability)

INTRODUCTION

Micronutrients play many important and complex roles in promoting strong plant growth. Besides increasing yield and improving the harvest quality they also play an important role in improving plant health. Deficiency of micronutrients during the last three decades has grown in both, magnitude and extent because of increased use of high analysis fertilizers, use of high yielding crop varieties and increase in cropping intensity. It was reported that 12 % of soils in India are potentially deficient in Fe, 49 % in Zn, 3 % in Cu, 5 % in Mn (Singh, 2008) and the extent of deficiency in Punjab soils for Fe, Zn, Cu and Mn was reported as 17, 49, 2 and 3%, respectively (Nayyar *et al.,* 1990). The soils of Bathinda district contain low organic carbon (Yadav *et al.,* 2018a) because of the prevailing arid and semi-arid climatic conditions and hence contribution of soil organic matter to available pools of micronutrients (Fe, Zn, Cu, and Mn) is limited. Additionally, the emphasis on increasing the crop production using of high yielding varieties along with intensive application of chemical fertilizers and limited use of organic manures has accentuated the depletion of micronutrients reserves in the soils (Sharma *et al.,* 2004). In India, 110.15 million tones (MT) of rice, 98.38 MT of wheat and 26.26 MT of maize production have been reported during 2016-17 (Anonymous, 2017). But due to poor management the rice residues are mostly burnt in the field which create pollution in the environment (Hiloidhari *et al.,* 2014). As per report of Council on Energy, Environment and Water (Gupta, 2019) according to (Punjab Government 2017) in Punjab, almost 80 per cent of the rice crop is harvested using combine harvesters, which leaves behind large amounts of rice residue - almost 19.7 million metric tons of paddy straw on average, of which almost 15.4 million metric tons are set on fire in open fields. During the burning elements contained in residue or surface soil can be transferred into the atmosphere via non particulate (volatilization) and/or particulate (ash) pathways (Raison *et al.,* 1985). The nutrient loss from the burned site is most likely through volatilization and results in atmospheric pollution (Mc Naughton *et al.,* 1998; Liu *et al.,* 2000). Nutrients in ash can deposited on-site or redistributed to adjacent areas via wind, rainfall, erosion, runoff, and leaching. Many researchers reported, this may have a significant impact on the soil nutrient status (Badia and Marti, 2003).

The effect of burning on soil is very complicated and less studied has been reported in comparison to its above ground effect (De Bano and Neary, 1998). According to Keeley (2009), heat generated during burning effects soil ecosystems depending on heat intensity and duration. The low severity-fires do not substantially affect soils; while, high severity-fires can affect a wide range of soil properties,

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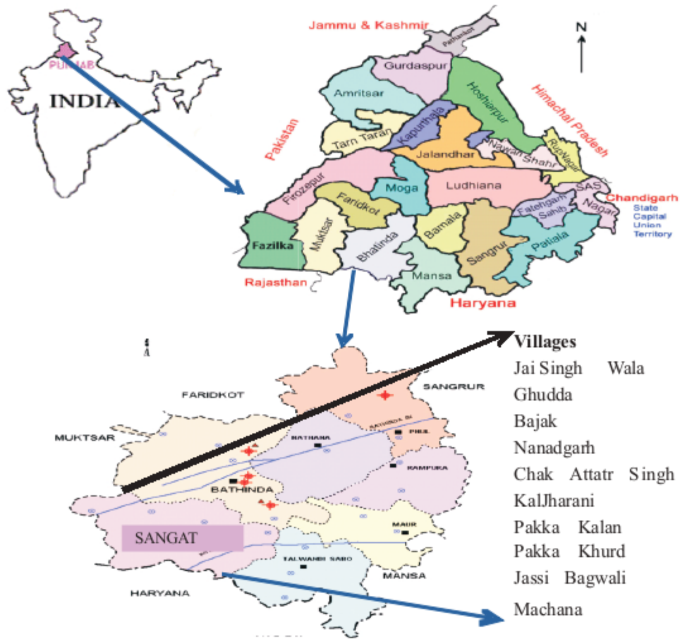
one of which is nutrient availability (Certini, 2005). The concentrations, forms, and depth distribution of soil nutrients can be dramatically altered after fire disturbance (Neff *et al.,* 2005). The productivity of burned soils can be impacted, in some cases, in an irreversible way resulting from fire-induced changes on soil properties (Robichaud, 2009). Post-fire nutrient losses can be accelerated through volatilization, leaching and erosion (Certini, 2005). Most studies on fire-associated alterations in soil nutrients have been focused on evaluating changes in available macro-nutrients (Carballas, 1997; Couto-Vazquez and Gonzalez-Prieto, 2006). Very few studies have evaluated post-fire effects on soil micronutrients in the region. Keeping the above facts, this paper presents information regarding the post-fire availability of micro nutrients of the unburned and burned soils of semi arid region of Punjab, India.

MATERIALS AND METHODS

Bathinda district is situated in the southern part of Punjab, lies between 29˚33' and 30˚6' North latitude and 74 ˚38' and 75˚46' East longitudes. The surveyed area (Fig. 1) falls in semi-arid region of Punjab having annual average rainfall of ~ 523 mm. During the study (*kharif* 2018) from each villages, five surface (0-15 cm) and sub surface (15-30 cm) soil samples were collected after harvesting of rice, and from unburned as well as open rice residues burned field. The samples were collected in labelled plastic bags and transferred to the laboratory. The samples were dried and prepared for the analysis of micronutrients. Available micronutrients (Fe, Zn, Cu and Mn) in soil were determined using the procedure of Lindsay and Norvell (1978). The extracting solution consisted of 0.005 M DTPA (diethylene triamine penta-acetic acid), 0.01 M $CaCl_2$ and 0.1 M TEA (Tri ethanol amine) buffer adjusted to pH 7.3. Ten grams of air-dried soil was shaken with 20 ml of extracting solution for 2 hours at 25ºC and filtered. Concentration of nutrients in the extract was determined by atomic absorption spectrophotometer. For statistical analysis of data, Microsoft Excel (2007) software was used.



Villages	GPS Location
Jai Singh Wala	30 - 43' 27.012" N 75 - 5' 19.104" E
Ghudda	30 - 8' 29.544" N 74 - 50' 47.616" E
Bajak	30 - 5' 7.8" N 74 - 50' 30.12" E
Nanadgarh	30 - 9' 49.536" N 74 - 43' 51.996" E
Chak Attatr Singh Wala	30 - 31' 56.748" N 75 - 9' 35.82" E
KalJharani	30 - 12' 46.512" N 74 - 55' 59.41" E
Pakka Kalan	30 - 12' 0 .396" N 75 - 16' 3.432" E
Pakka Khurd	30 - 9' 13.212" N 75 - 11' 42.756" E
Jassi Bagwali	30 - 9' 14.868" N 74 - 58' 3.468" E
Machana	30 - 12' 46.508" N 74 - 55' 59.40" E

Fig. 1: Location map of the soil sampling sites

RESULTS AND DISCUSSION

The data regarding DTPA extractable- Fe and Zn availability was presented in table 1, showed that minimum and maximum Fe was reported in Chak Attar Singh wala and Jai Singh Wala, varied from 1.6 -4.2 mg kg^{-1} and 1.2- 3.9 mg kg^{-1} with mean value of 2.9 mg $kg^{-1}$and 2.5 mg kg^{-1} in upper soil (0-15 cm) and lower soil (15-30 cm), respectively under unburned condition. Whereas, it varied from 1.8 -4.8 mg $kg^{-1}$and 1.3- 4.1 mg kg^{-1} with mean value of 3.2 mg $kg^{-1}$and 2.7 mg kg^{-1} in upper soil (0-15 cm) and lower soil (15-30 cm), respectively under burned condition. Similarly, the minimum (1.1 mg kg^{-1}) and maximum (2.8 mg kg^{-1}) Zn was reported in Pakka Kalan and Ghudda, respectively with mean value of 1.6 mg kg^{-1} in upper soil layer (0-15 cm) and 1.1 mg kg^{-1} (Pakka Kalan) to 2.5 mg kg^{-1} (Ghudda) with mean value of 1.38 mg kg^{-1} in lower layer (15-30 cm) under unburned situation. However, the Zn availability varied from 1.3 mg kg^{-1} (Machana) to 3.1 mg kg^{-1} (Gudda) with mean value of 1.9 mg kg^{-1} in upper soil (0-15 cm) and 1.4 mg kg^{-1} (Pakka Khurd) to 2.8 mg kg^{-1} (Gudda) with mean value of 1.7 mg kg^{-1} in lower layer (15-30 cm) under stubble burnt soils. The table 1 also revealed that stubble burning increased the Fe and Zn availability in soil and ranged from 2.7 -15.8% (Fe) and 8.3-27.3% (Zn) in upper layer, 4.5-9.1% (Fe) and 12.0-45.5% (Zn) in lower layer. The DTPA-extractable Cu and Mn availability in soil under unburned and stubble burnt condition were presented in table 2. The minimum (1.30 mg kg^{-1}) and maximum (3.10 mg kg^{-1}) Cu availability with average value (2.57 mg kg^{-1}), and minimum (1.80 mg kg^{-1}) and maximum (3.10 mg kg^{-1}) Mn availability with average value (2.64 mg kg^{-1}), was reported under unburned conditions in upper soil layer. However, the Cu varied from 1.10- 2.90 mg kg^{-1} with mean value (2.14 mg kg^{-1}) and Mn varied from 2.10-3.50 mg kg^{-1} with mean value (2.95 mg kg^{-1}) under burned conditions in upper soil layer. Similarly, minimum (1.10 mg kg^{-1}) and maximum (2.80 mg kg^{-1}) Cu with average value (2.25 mg kg^{-1}), and minimum (1.10 mg kg^{-1}) and maximum (2.40 mg kg^{-1}) Mn with average value (2.10 mg kg^{-1}), was reported under unburned conditions in lower soil. However, the Cu ranged from 1.0- 2.2 mg kg^{-1} with mean value (1.86 mg kg^{-1}) and Mn ranged from 1.70- 2.90 mg kg^{-1} with mean value (2.51 mg kg^{-1}) in lower soil under burned conditions. It was also revealed that similar to other micronutrients studied the Mn availability increased by 10.0-16.7 % and 13.0- 22.7% in upper and lower soil, respectively, while, decrease in Cu was reported and ranged from 6.0 -27.8% in upper soil and 9.0-25.0 % in lower soil due to stubble burning.

The surface soils showed higher content of Fe, Zn, Cu and Mn than sub-surface soils, which exhibited a decreasing trend with increase in soil depth. Higher Fe in surface soil may be due to sufficient organic matter and low pH of surface soils. The higher Zn might be due to higher organic carbon at surface soils, as organic carbon is a major contributor of available Zn in soils. The decline in DTPA-extractable Zn may be ascribed to decline in soil organic C content down the soil profile as organic carbon content significantly correlated with DTPA-extractable Zn in surface soil (Behera *et al.,* 2011). The surface soils have higher Cu, might be due to higher organic matter and regular addition of manures. The lower depth had less mean DTPA extractable-Cu, which corroborates the observations made by Kher (1993) in an Alfisol and Behera *et al.* (2009) in an Inceptisol. The Mn content of surface soils was higher than sub-surface soils and showed a decreased trend with increased in depth might be due to low pH and high organic matter in surface soil layers. The adequacy of available Mn might be attributed to the positive effect of organic matter and suitable soil pH for Mn availability. The results are in accordance with the observation reported by Sharma *et al.* (2009) that the surface horizons showed relatively higher content of available micronutrient (DTPA-Fe, Cu, Zn and Mn) than the subsurface horizon in salt affected soils of the Punjab. Further, Yadav *et al.* (2016) studied the soil fertility status of PAU seed farm, Chak Ruldu Singh Wala, Sangat, Bathinda, Punjab and reported decreased trends in DTPA-extractable Fe, Cu, Zn and Mn with the increase in soil depth and ranged from 5.25 to 6.25, 0.25 to 0.95, 1.11 to 1.88 and 3.56 to 4.66 mg kg^{-1} with mean value of 5.8, 0.44, 1.51 and 4.09 mg kg^{-1} in lower layers. Sadanshiv *et al.* (2017) reported the decreased trends of micronutrients in all the soils of Nagalvadi micro-watershed of Wardha district of Maharashtra with the increase in depth of soil profiles. Moreover, Yadav *et al.* (2018b) studied the status of DTPA-extractable micronutrients in soils of Bathinda district of Punjab, India and calculated the nutrient index representing fertility status of soil, showed that the soils were sufficient for supply of Fe, Cu, Zn and Mn to crops. The soil heating, due to residue burning increased the DTPA extractable Fe, Zn and Mn content of soil, might be due to heating may be result of dissolution of minerals due to increased acidity during drying process and also due to decomposition of metallo-organic complexes at higher .While, the higher temperature reduced the DTPA extractable Cu, may be due to fixation of soluble Cu by Fe and Al oxides which would be activated by soil heating, as Cu is the most strongly adsorbed of all the divalent metal on Fe and Al oxides (Tisdale *et al.,* 1997).

Table 1. DTPA extractable Iron and Zinc (Mean*± SD) of soil under unburned and burned condition

Villages	Fe ($mg\ kg^{-1}$)				Zn ($mg\ kg^{-1}$)			
	0-15 cm		15-30 cm		0-15 cm		15-30 cm	
	Un- burned	Burned	Un- burned	Burned	Un- burned	Burned	Un- burned	Burned
Jai Singh wala	4.2±0.35	4.8±0.32	3.9±0.29	4.1±0.31	1.5±0.11	1.9±0.16	1.4±0.11	1.6±0.12
Ghudda	1.9±0.16	2.2±0.19	1.6±0.15	1.7±0.11	2.8±0.13	3.1±0.21	2.5±0.15	2.8±0.15
Bajak	2.4±0.19	2.6±0.18	2.2±0.16	2.4±0.21	1.8±0.12	2.1±0.14	1.2±0.11	1.5±0.12
Nanadgarh	2.8±0.21	3.1±0.21	2.6±0.22	2.8±0.22	2.4±0.22	2.7±0.19	1.9±0.12	2.2±0.18
Chak Attatrsingh Wala	1.6±0.15	1.8±0.14	1.2±0.15	1.3±0.11	1.6±0.12	1.9±0.12	1.2±0.11	1.5±0.12
KalJharani	3.3±0.28	3.6±0.23	2.9±0.26	3.1±0.23	1.2±0.11	1.5±0.11	1.2±0.11	1.5±0.11
Pakka kalan	3.1±0.27	3.3±0.26	2.8±0.21	2.9±0.21	1.1±0.11	1.4±0.13	1.1±0.09	1.6±0.13
Pakka khurd	3.7±0.29	3.8±0.29	3.1±0.26	3.3±0.25	1.2±0.11	1.5±0.12	1.2±0.09	1.4±0.11
Jassi bagwali	2.9±0.19	3.3±0.16	2.6±0.19	2.8±0.24	1.4±0.12	1.7±0.14	1.2±0.11	1.5±0.12
Machana	2.8±0.22	3.1±0.23	2.4±0.15	2.6±0.22	1.2±0.11	1.3±0.11	1.2±0.11	1.7±0.14

* Mean of 5 samples

Table 2. DTPA extractable Copper and Manganese (Mean*± SD) of soil under unburned and burned condition

Villages	Cu ($mg\ kg^{-1}$)				Mn ($mg\ kg^{-1}$)			
	0-15 cm		15-30 cm		0-15 cm		15-30 cm	
	Un- burned	Burned	Un- burned	Burned	Un- burned	Burned	Un- burned	Burned
Jai Singh wala	3.1±0.23	2.8±0.15	2.4±0.15	2.0±0.12	3.1±0.24	3.5±0.25	2.3±0.18	2.6±0.19
Ghudda	2.8±0.21	2.3±0.19	2.4±0.16	2.1±0.14	1.8±0.15	2.1±0.14	2.1±0.16	2.5±0.21
Bajak	2.7±0.22	2.3±0.11	2.5±0.21	2.1±0.15	2.3±0.16	2.5±0.19	1.1±0.08	1.3±0.12
Nanadgarh	2.8±0.21	2.2±0.11	2.6±0.21	2.2±0.17	2.6±0.18	2.9±0.16	2.3±0.15	2.7±0.24
Chak Attatrsingh Wala	1.8±0.14	1.3±0.11	1.4±0.14	1.2±0.11	2.8±0.16	3.1±0.24	2.4±0.16	2.8±0.23
KalJharani	1.3±0.11	1.1±0.09	1.1±0.09	1.0±0.09	2.6±0.21	2.9±0.26	2.1±0.14	2.4±0.22
Pakka kalan	2.7±0.18	2.2±0.14	2.4±0.13	1.8±0.12	2.9±0.21	3.2±0.25	2.2±0.16	2.7±0.25
Pakka khurd	2.9±0.16	2.2±0.12	2.6±0.14	2.1±0.15	2.6±0.19	2.9±0.28	1.9±0.11	2.2±0.12
Jassi bagwali	3.1±0.23	2.9±0.15	2.8±0.16	2.2±0.18	2.8±0.21	3.1±0.29	2.2±0.18	2.6±0.19
Machana	2.5±0.19	2.1±0.11	2.3±0.17	1.9±0.13	2.9±0.23	3.3±0.21	2.4±0.21	2.9±0.17

* Mean of 5 samples

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