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Anusuiya Panda
ICAR- Indian Institute of Soil Science, Nabibagh, Berasia Road, Bhopal, Madhya Pradesh, India

Pramod Jha
ICAR- Indian Institute of Soil Science, Nabibagh, Berasia Road, Bhopal, Madhya Pradesh, India

Awanish Kumar
ICAR- Indian Institute of Soil Science, Nabibagh, Berasia Road, Bhopal, Madhya Pradesh, India

RK Bajpai
Indira Gandhi Krishi Vishwavidyalaya, Krishak Nagar, Jora, Raipur, Chhattisgarh, India

Correspondence
Anusuiya Panda
ICAR- Indian Institute of Soil Science, Nabibagh, Berasia Road, Bhopal, Madhya Pradesh, India

Impact of organic residues application as a soil amendment on response in soil acidity

Anusuiya Panda, Pramod Jha, Awanish Kumar and RK Bajpai

Abstract
An experiment was conducted on *Alfisols* of northwest India, to assess the impact of organic residue applications as a Soil amendment on response in soil acidity. In the present investigation four crop residues maize, wheat, rice and soybean were tested in completely randomized design. The incorporation of *Zea mays, Oryza sativa, Triticum aestivum* and *Glycine max* crop residues increased soil pH compared with the initial value and no significant difference was observed between the EC of initial and amended soils. The addition of soybean and maize residue in acid soils during the incubation period led to significantly decline in Al^{3+} concentration compared with other treatments.

Keywords: Acid soil, soil pH, incubation, organic residues, Al^{3+} toxicity, *Alfisols*

1. Introduction
Soil acidity is one of the most yield-limiting factors for crop production. Land area affected by acidity is estimated at 4 billion ha, representing 30% of the total ice-free land area of the world (Sumner and Noble, 2003) [1]. Soil acidity affects nearly 50 percent of the world's potentially arable land, particularly in humid tropics (Von Uexkull and Mutert 1995) [2]. Soil acidity is quantified on the basis of hydrogen (H^+) and aluminum ($Al^{3+)}$ concentrations of soils. Many factors contribute to phyto toxicity of these soils; however, in acid soils with a high mineral content, aluminum (Al^{3+}) is the major cause of toxicity. Soils become acidic for several reasons. The forms of aluminum are mostly exchangeable Al^{3+} under very acidic conditions (pH< 4.5) to aluminum-hydroxyl ions at higher pH (4.5–6.5) (Carson and Dixon, 1979) [3]. Al^{3+}toxicity are the single most important factor, being a major constraint for crop production on 67% of the total acid soil area (Eswaran *et al.*, 1997) [4]. The main factor of soil acidity are the nature of the parent material, weathering processes (Owolabi *et al.*, 2003) [5], nitrification process, organic matter decomposition, acid rain (Sparks, 2003) [6] and ammonium-based N fertilizer sources to nitrate causes a net H^+ release, which lowers the soil pH in the plant rooting zone (Garvin and Carver, 2003; Prasad and Power, 1997) [7, 8]. The cost of conventional lime is away from the reach of the farmer. Lime may not be available locally and in many developing countries, lime application and transportation is very costly. Another alternative is the use of organic materials because Organic matter also helps in soil revegetation and erosion control (Alexander 1999) [9], for example farmyard manure maize stover alone or in combination with inorganic fertilizers, different crop residue (Haynes, 1986; Tang *et al*., 1999) [10, 11] like wheat, rice, chickpea, corn (*Zea mays* L.) and soybeans (*Glycine max* [L.] Merr.) (Aulakh *et al*. 1991) [12], sugar beets (Falih and Wainwright 1996) [13], and cottage cheese whey (Kelling and Peterson 1981) [14] and industrial by-products such as paper mill and cardboard sludge (Xiao *et al*., 1999, Rosen *et al*., 1999) [15, 16]. Leaf litters also neutralized soil acidity (Noble *et al*., 1996; Tang and Yu, 1999) [17, 18].
Recent research has shown that additions of composts, green, or animal manures reduce Al toxicity and increase crop yields (Hue and Amien, 1989; Wong and Swift, 2003; Vieira *et al*., 2009) [19- 21].

2. Materials and methods
2.1 Experimental site and soil sampling
The experiment was conducted at ICAR-Indian Institute of Soil Science, Bhopal (MP). An acidic *Alfisols* (U.S. Soil Taxonomy) used in this study was collected from the long-term fertilizer experiment plot of Palampur, Himachal Pradesh.

The plot is under continuous application of NPK fertilizers since 1972. The sample was taken from the topsoil (0-15 cm), air dried and ground to pass through a 2- mm sieve.

2.2. Treatments details

An incubation study was conducted in laboratory at Indian Institute of Soil Science, Bhopal. A 100 gram of soil sample was weighed and transferred in 100 ml beakers and subsequently 40 ml distilled water was added in each beakers to maintain 60% of water holding capacity of soil. Crop residue 3.5 g was taken to maintain approximate equivalent amount of C in each soil. Soil moisture level was maintained throughout the study. Soil sample were analyzed at 7, 15, 30, 45 and 90 days after incubation. Treatment in incubation studies were as follows in Table 1.

Table 1: Details of treatments used in incubation study

Treatments	Treatments detail
T_1	Soil only
T_2	Soil + Soybean Residue
T_3	Soil + Maize Residue
T_4	Soil + Rice Residue
T_5	Soil +Wheat Residue

2.3. Methods of soil analysis

Soil pH and EC were determined in 1:2.5 soil to water suspension. Exchangeable Al was extracted by shaking 5g soil with 50 ml of 1*M*KCl for 30 minutes, followed by centrifugation and filtration and Al concentration in filtered extracts were then determined by inductively coupled plasma atomic emission spectrometer (ICP-AES, Perkin Elmer, USA). Exchangeable Al^{3+} was extracted by shaking 5g soil with 50 ml of 1*M* KCl for 30 minutes, followed by centrifugation and filtration and Al concentration in filtered extracts were then determined by titrimetric method. Soil basic physical and chemical properties are given in table 2.

Table 2: General Characteristics of the soil used in incubation study

Particulars	Value
Sand %	30
Silt %	46
Clay %	24
Soil pH (H_2O)	4.52
EC(dS m^{-1})	0.11
Al^{3+} (meq/100g)	2.99

2.5. Statistical analysis

SPSS window version was used for statistical analysis. One way analysis of variance (ANOVA) was performed for each time interval of the incubation for comparisons of means. Significant effects of various treatments were measured using the t-test.

3. Results and Discussion

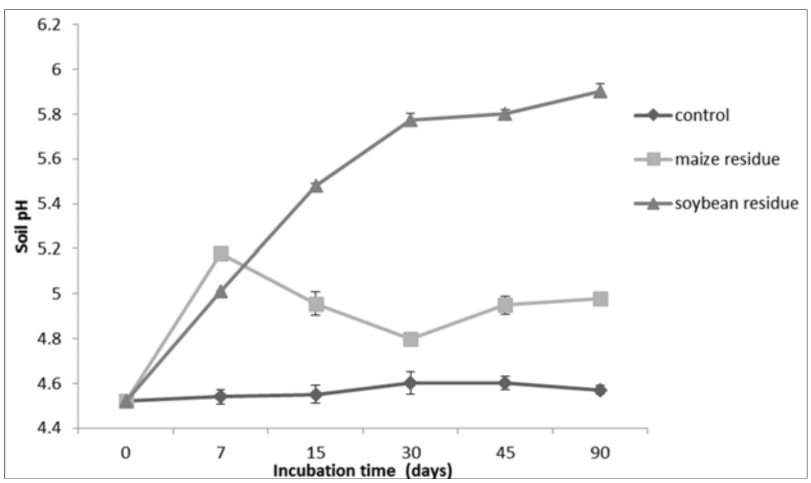

Fig 1: Changes in soil pH of acid soil as affected by incorporation of maize and soybean residue

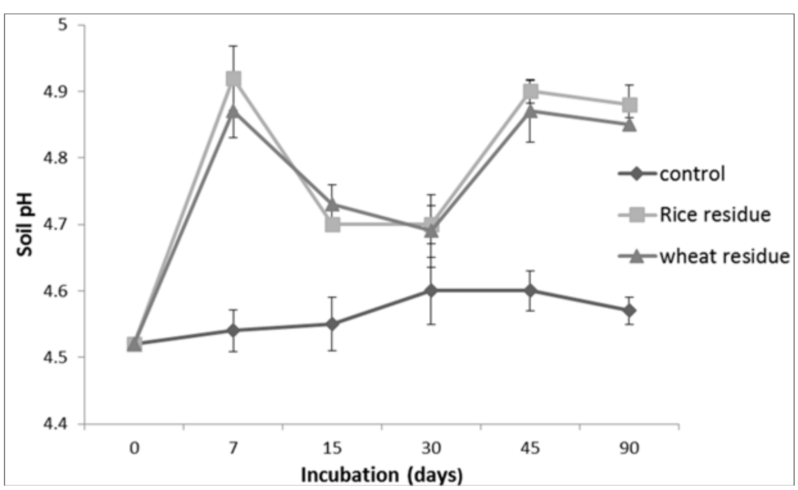

Fig 2: Changes in soil pH of acid soil as affected by incorporation of rice and wheat residue

3.1. Soil pH

The initial pH of the unamended soil was (control) 4.52 in Table 2. The maximum increase in soil pH (5.90) was recorded in case of soybean residue incorporation, which was significantly higher than the rest of the treatments. The increase in soil pH was higher in the beginning of the study thereafter it decreased gradually till completion of incubation study (fig. 1 & 2). When the *Alfisols* was incubated with organic residues the soil pH for all treatments increased with incubation time (fig. 2).The maximum rise in soil pH was observed after one week of incubation thereafter a slight decrease in soil pH was recorded till the termination of incubation study. Generally, legume materials have higher ash alkalinity due to the unbalanced uptake of cations and anions, and thus have greater amelioration effects on soil acidity than non-legume materials (Wang *et al*., 2009) [22].

3.2. Electrical conductivity

Changes in soil electrical conductivity (EC) with the application of maize, rice, wheat and soybean crop residues were measured periodically during the incubation experiment (fig. 3 and 4). No significant difference between the EC of initial and amended soils (P<0.05) were recorded at the end incubation study. This is in conformity with the finding of (Novak *et al.* 2009) [23].

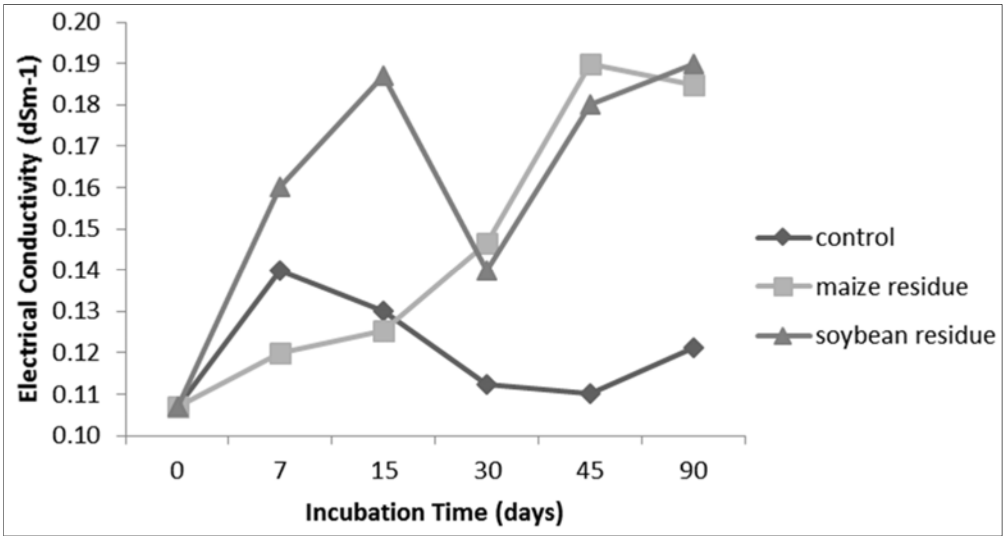

Fig 3: Soil EC during the incubation study amended with the residue of maize and soybean

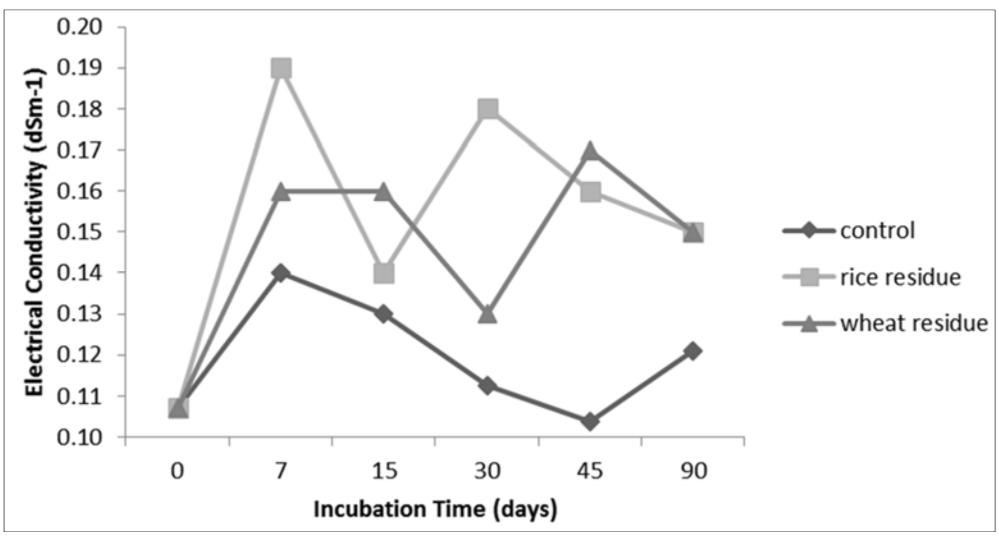

Fig 4: Soil EC during the incubation study amended with the residue of rice and wheat

3.3. Exchangeable Al^{3+} content

The cause of soil acidity is mainly due to exchangeable Al, while exchangeable H^+ contributes less to exchange acidity. When the soil pH drops below 5, Al^{3+} is solubilized into the soil solution and this is the most important rhizotoxic Al species. The impact of the addition of rice, wheat, soybean and maize crop residues in soils exchangeable Al concentration during the incubation period is shown in Fig. 5. Exchangeable Al is the major contributor of exchangeable acidity of *Alfisols* (Yu, 1997; Yuan and Xu, 2011) [24, 25]. Application of wheat, soybean, rice, maize crop residues significantly (P<0.06) reduced the concentration of exchangeable Al during the incubation period (fig 5 and 6). The addition of soybean residue in acid soils decreased Al concentration compared with other treatments. It indicates that Al toxicity decreased due to its complexation to high-molecular-weight organic compounds present in the residues (Alleoni *et al.* 2010) [26].

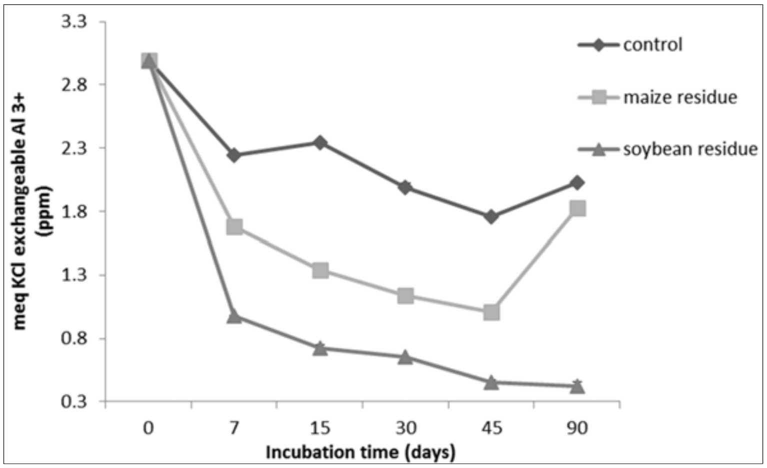

Fig 5: Changes in soil exchangeable Al^{3+}concentration in acid soil as affected by incorporation of residue of maize and soybean

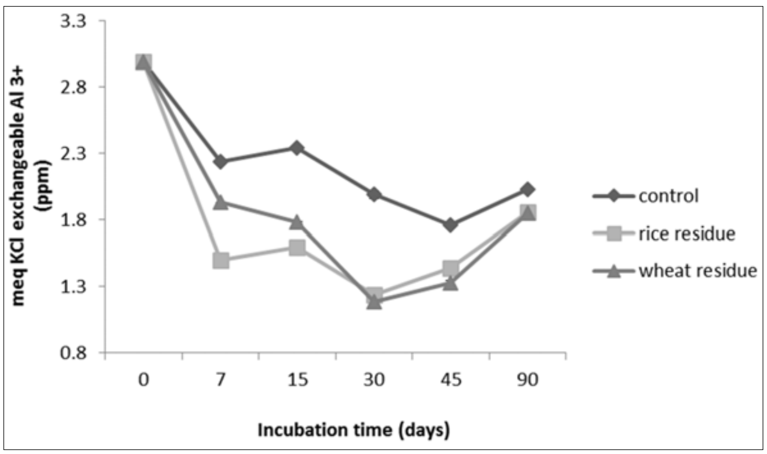

Fig 6: Changes in soil exchangeable Al^{3+}concentration in acid soil as affected by incorporation of residue of rice and wheat

4. Conclusion

It was observed from the incubation study that legume crop residue (particularly soybean) is one of the most potential amendments for reclamation of acid soil and also transformation of nutrients under acidic soil conditions. The results emanating from acid soil indicated that legume residue could be as effective for remediation of low soil pH. The incorporation of maize, rice, wheat and soybean residues effectively decreased soil exchangeable Al^{3+} toxicity. In conclusion, if the goal is to increase soil reaction and reduced Al^{3+} toxicity in acid soil quickly, then the use of crop residue as an organic amendment could be considered as a viable option and the choice of a legume crop residue should be recommended.

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