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EFFECT OF TILLAGE AND HERBICIDE (PRETILACHLOR) APPLICATION ON PHYSICO-CHEMICAL PROPERTIES OF SOIL IN WINTER RICE

Dipankar Sonowal[1]*, Kaberi Mahanta[1], Anjuma Gayan[1], Dhrubajoti Nath[1], Khagen Kurmi[2], Britan Rahman[3], Lolesh Pegu[4] and Sanchita Brahma[5]

[1]Department of Soil Science, Assam Agricultural University, Jorhat - 13, Assam, India.
[2]Department of Agronomy, Assam Agricultural University, Jorhat - 13, Assam, India.
[3]Department of Soil Science, SCS College of Agriculture, AAU, Dhubri, Assam, India.
[4]Department of Crop Physiology, SCS College of Agriculture, AAU, Dhubri, Assam, India.
[5]Department of Horticulture, SCS College of Agriculture, AAU, Dhubri, Assam, India.
*Corresponding author E-mail : dipankarsonowal799@gmail.com
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ABSTRACT

This study was conducted in the year 2020-21 which forms a part of the long-term trial under AICRP on Weed Management that was established during 2016 at ICR farm of Assam Agricultural University, Jorhat-13, Assam, India. The experiment was laid out in randomized block design (RBD) replicating three times with five treatments *viz*., T_1 (Conventional Tillage + Transplanted), T_2 (Conventional tillage + Transplanted + Herbicide), T_3 (Conventional Tillage + Direct-Seeded + Herbicide), T_4 (Minimum Tillage + Direct-Seeded + Herbicide), T_5 (Minimum Tillage + Direct-Seeded + Herbicide + Residue retained on the surface). Ranjit and Basundhara was used as the rice variety in transplanted and direct seeded rice, respectively. The soil physico-chemical properties *viz.,* bulk density (BD), cation exchange capacity (CEC), porosity, water holding capacity (WHC), pH, available nitrogen (N), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg) and organic carbon (OC) were determined from surface soil (0-15 cm) samples collected after the harvest of rice. Minimum tillage (MT) was found to improve almost all the physico-chemical properties of soil including BD, porosity, WHC, CEC and pH as compared to conventional tillage (CT) system. MT with application of herbicide significantly increased soil OC and available N, K, Ca and Mg while its effect was found to be non-significant on available P.

Key words : Tillage, Herbicide, Organic carbon, CEC, Porosity, Bulk density, pH, Winter rice.

Introduction

Tillage is the mechanical manipulations of soil to keep it loose for plant growth and free from weed during the growth of plant while the main purpose of tillage is to prepare suitable seed bed for plant growth, destroying competitive weed and improving the physical condition of soil. In conventional agriculture, tillage has generally the greatest impact on biological properties since physical disturbance changes soil water content, temperature, aeration and the degree of mixing of crop residues within the soil matrix (Dick, 1992; Buckley and Schmidt, 2001; Kladivko, 2001). Tillage also reduces soil macro-aggregate content which provides an important micro-habitat for microbial density, diversity, and activity (Ranjard and Richaume, 2001; Six *et al*., 2002). On the other hand conservation tillage results in retention of more than 30 *per cent* of crop residue that helps in improving the overall soil quality, carbon sequestration and crop productivity (Tessier *et al*., 1990). Conservation tillage is one of the most important components of sustainable agriculture which involves reducing intensity of tillage operations and retaining plant residues on the soil surface aims to promote certain economic and environmental benefits. The practices involve in conservation tillage like zero tillage (ZT), minimum tillage (MT) and permanent raised beds (PRB). Conversion from conventional to conservation tillage with the principle of conservation agriculture, may improve soil structure, increase soil organic carbon (SOC), minimize soil erosion risks, conserve soil water, decrease fluctuations in soil temperature and enhance soil quality and its environmental regulatory capacity.

Weeds are a significant constraint and cost involving to agricultural production worldwide. For Asia as a whole, weeds cause an estimated 10-15 per cent reduction in rice yield equivalent to about 50 MMT of rice annually (Pingali and Roger, 1995). Besides reduction in yield, weeds can remove a large amount of plant nutrients from the soil. The mechanical and cultural methods are not always possible on account of scarcity of labour in the peak period of transplanting. In these situations, herbicides play a major role in increasing rice production by decreasing weed intensity. With widespread application of herbicides in rice, questions have often posed about the movement and length of time these herbicides remain toxic in soil.

Since information about the effect of tillage and herbicide application on soil physico-chemical properties in acid soil is limited, and therefore it is felt essential to understand the changes in such indicators of soil quality as influenced by tillage and use of herbicide in rice-rice cropping system. The present study is carried out as a part study under AICRP on Weed Management, Jorhat centre at Instructional-cum-Research Farm (ICR) of Assam Agricultural University with continuous use of herbicides and minimum tillage in rice-rice cropping system provided the necessary platform to study the effect of tillage and herbicide (pretilachlor) application on soil physico-chemical properties.

Materials and Methods

The present investigation was carried out in the ICR Farm and Department of Soil Science of Assam Agricultural University, Jorhat-13 (Assam) situated at $26^0 47'$ N latitude, $94^0 12'$ E longitude and at an altitude of 86.6m AMSL during the *kharif* season of 2020. The experiment was laid out in randomized block design (RBD) replicating three times with five treatments *viz*., T_1 (Conventional Tillage + Transplanted), T_2 (Conventional tillage + Transplanted + Herbicide), T_3 (Conventional Tillage + Direct-Seeded + Herbicide), T_4 (Minimum Tillage + Direct-Seeded + Herbicide), T_5 (Minimum Tillage + Direct-Seeded + Herbicide + Residue retained on the soil surface). Ranjit and Basundhara was used as the rice variety in transplanted and direct seeded rice, respectively. The monthly mean minimum and maximum temperatures during the crop season ranged from 10.3 to 26.2^0C and 23.9 to 32.6^0C respectively, total rainfall received was 51.1 mm during the entire crop season. Relative humidity and sunshine hours were found to varied from 90.3 to 99.1 per cent and 2.3 to 6.4 hours, respectively. Prior to the experimentation the soil samples were collected from 0-15cm depth and various physico-chemicals parameters were analyzed. The soil was found sandy clay loam with pH value of 5.01, bulk density (1.34 gcm^{-3}), Porosity (44.56%), Water Holding Capacity (42.05%), CEC (6.77 cmol (p+) 100 g-1), available N (302.54 Kg ha^{-1}), P (19.35 Kg ha^{-1}), K (150.23 Kg ha^{-1}), exchangeable Ca (0.68 meq $100g^{-1}$), exchangeable Mg (0.33meq $100g^{-1}$) and organic carbon (0.72%). The pH was analyzed by using a glass electrode pH meter (Jackson, 1973), BD was determined by gravimetric method using undisturbed soil cores (Blake and Hartge, 1986), WHC and total porosity was estimated by using Keen Rackzowski box following the method described by Baruah and Borthakur (1997), CEC was determined by centrifuge method as described by Baruah and Barthakur (1997). OC content was determined by Walkley and Black (1934) wet digestion method. Available N was determined by alkaline potassium permanganate method (Subbiah and Asija, 1956). Available P was determined by Bray and Kurtz (1945) No 1 method. Available K was determined by Ammonium Acetate Extraction method (Jackson, 1973). Available Ca and Mg in the soil was determined by Complexometric Titration Method (Schwarzenbach, 1947). Soil samples from all the treatments were collected after harvest of the winter rice and analyzed for the above-mentioned parameters. The technique of analysis of variance as described by Panse and Sukhatme (1967) was used in RBD for statistical analysis of data obtained from various treatments. The physicochemical properties were statistically analyzed by using ANOVA table.

Results and Discussion

Physico-chemical properties of soil after harvesting of winter rice

Data regarding Physico-chemical properties of soil after harvesting the winter rice have been presented in Table 1. Better improvement in soil health was observed in treatment T_5 where minimum tillage + direct-seeded + herbicide (Pretilachlor) + residue retained on the surface of the experimental field which was followed by treatment T_4 where Minimum Tillage + Direct Seeded + herbicide (Pretilachlor) was applied. The bulk density was found significantly lower in treatment T_5 with the value 1.29 mg m^{-3} while significantly higher bulk density was observed in treatment T_1 (1.42 mg m^{-3}) receiving CT treatment. Sharma *et al*. (2011) and Singh *et al*. (2018)

Table 1 : Effect of tillage and herbicide application on soil physico-chemical properties after harvest of winter rice.

Treatment	OC (%)	Bulk density (mg m^{-3})	Porosity (%)	WHC (%)	pH	CEC [cmol (p+) 100 g^{-1}]
T_1: Conventional tillage (CT)+ Transplanting	0.70	1.42	43.49	42.36	5.16	6.77
T_2: Conventional tillage (CT)+ Transplanting+Pretilachlor	0.77	1.36	40.46	45.47	4.67	6.54
T_3: Conventional tillage (CT)+ Direct Seeded+Pretilachlor	0.73	1.34	44.42	41.52	5.03	6.98
T_4: Minimum Tillage (MT)+ Direct Seeded+Pretilachlor	0.81	1.32	47.41	44.53	4.86	7.03
T_5: Minimum Tillage (MT)+ Direct Seeded+Residues+Pretilachlor	0.84	1.29	50.54	46.70	4.95	7.30
SEd±	0.017	0.018	1.83	1.752	0.018	0.016
$CD_{P=0.05}$	0.04	0.042	4.286	NS	0.042	0.038

reported similar result for bulk density. Parihar *et al.* (2018) found that after 6 years of study, minimum tillage practices with residue incorporation has significantly decreased ($P<0.05$) the bulk density at 0–5 cm, 5–15 cm and 15–30cm soil depths. Significantly higher porosity (50.54%), water holding capacity (46.7%), CEC (7.30 cmol (p^+) kg^{-1}soil) and soil OC (0.84%) was recorded in treatment T_5 as compared to the rest of the treatments. A similar trend of result was reported by Bhattacharya *et al.* (2008) and Glab and Kulig, (2008) on porosity where the effect of minimum tillage with residue incorporation showed reduced volume fraction of macro pores and increased volume fraction of micro pores relative to the conventional tillage. The results on WHC are similar with the findings of McVay *et al.* (2006). Where they reported significantly higher WHC has been found in the top soil (0–15 cm) under no or minimum tillage with residue incorporation compared to other tillage practices. Su *et al.* (2007) found that the WHC under Zero Tillage was 25 *per cent* higher than traditional tillage during their six-year study. Though CEC is a permanent property of soil. WoŸniak *et al.* (2020) reported that disturbances made to soil might decrease CEC of soil. In turn, Palm *et al.* (2014) claim that zero tillage or minimum tillage shows no effect on the parameters of CEC of soil compared to conventional tillage. Regarding the effect of herbicide on porosity and WHC, Bera and Ghosh (2013), reported that herbicide had no significant effect on soil porosity. Parihar *et al.* (2018) showed a increase in SOC by 37.2 *per cent* in zero or minimum tillage compared to CA. Kevat *et al.* (2019) reported that tillage systems had significant effect on SOC at end of two-year experiment. Minimum tillage found significantly higher SOC compared to conventional tillage at 0-15 cm soil depth. Zhou *et al.* (2007), Correia and Moreira (2010), Trimurtulu *et al.* (2015) reported that the herbicides, pendimethalin, oxyfluorfen and pretilachlor increased the organic carbon content in soil. The soil pH was recorded acidic varying from 4.67 to 5.16 (Table 1) after harvest of winter rice and the treatment T_5 showed significantly less pH (4.95). Most of the experiments have shown that tillage system has no effect on soil pH (Comia *et al.*, 1994; Nielsen and Hansen, 1982; Rasmussen, 1981; Rasmussen and Andersen, 1991; Rydberg, 1987; Riley, 1988). But in long-term experiments (6±18 years) a decrease in the pH by 0.2± 0.3 pH-units in the topsoil (0±5 cm) was found after minimum tillage (Ekeberg and Riley, 1997; Bùrresen and Njùs, 1993; Rasmussen, 1988). Soil pH has been reported to be lower in no-till or minimum till systems compared to Conventional tillage (Rahman *et al.*, 2008).

Available nutrients N, P, K, Ca and Mg of soil after harvest of winter rice

The result indicated (Table 2) that the tillage and weed management practices cause significant effect on available N, P, K, Ca and Mg content. Significantly higher available N (309.51 kg ha^{-1}), P (20.80 kg ha^{-1}), K (167.62 Kg ha^{-1}), Ca (0.62 meq 100g^{-1} soil) and Mg (0.40 meq 100g^{-1} soil) were observed under treatment T_5 receiving MT+ Herbicide+ Residue retained on the soil surface which was followed by treatment T_4 receiving MT + Direct Seeded + Pretilachlor (av. N= 303.67 Kg ha^{-1}, P=20.27 Kg ha^{-1}, K= 158.10 Kg ha^{-1}, Ca=0.61 meq 100g^{-1} soil and Mg = 0.37 meq 100g^{-1} soil).

The results are similar with the findings of Lavado *et al.* (1999), who reported that tillage practices affect the concentration and nutrient availability. Tillage influences the depth distribution of macro and micronutrients (Wright

Table 2 : Effect of tillage and herbicide application on available N, P, K, Ca and Mg in soil after harvest of winter rice.

Treatment	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Ca (meq. 100g^{-1})	Mg (meq. 100g^{-1})
T_1: Conventional tillage (CT)+Transplanting	289.35	17.26	146.49	0.53	0.27
T_2: Conventional tillage (CT)+Transplanting+Pretilachlor	272.31	18.98	141.57	0.54	0.28
T_3: Conventional tillage (CT)+Direct Seeded+Pretilachlor	293.65	18.26	152.34	0.58	0.34
T_4: Minimum Tillage (MT)+Direct Seeded+Pretilachlor	303.67	20.27	158.10	0.61	0.37
T_5: Minimum Tillage (MT)+Direct Seeded+Residues+ Pretilachlor	309.51	20.80	167.62	0.62	0.40
SEd±	1.688	0.069	1.833	0.015	0.018
$CD_{P=0.05}$	3.952	0.161	4.293	0.036	0.042

et al., 2007). Bertol *et al*. (2007) and Lo´pez-Fando and Pardo (2009) reported that minimum-till treatments have higher N P, K concentrations in the superficial 0–15 cm soil layer. Ismail *et al*. (1994) and Rahman *et al*. (2008) reported that exchangeable Ca, Mg and K were significantly higher in the surface soil under MT than ploughed soil. Ali *et al*. (2006) revealed that lowest values of available N, P, K, Ca and Mg in CT plots and it could be due to the inversion of top soil during ploughing which shifts less fertile subsoil to the surface in addition to possible leaching. Balesdent *et al*. (2000) reported that mineralizable N in the surface soil (0-15 cm) was more in case of no-tillage as compared with CT.

Conclusion

In the present investigation, an attempt was made to evaluate the effect of tillage and herbicide (pretilachlor) application in winter rice on physicochemical properties, available nutrients and organic carbon content in soil. Under winter rice, MT was found to improve the physico-chemical properties, available nutrients and soil organic carbon content as compared to conventional tillage (CT). Regarding the effect of herbicide application on organic carbon content in soil and available nutrients it showed a stimulatory effect on these parameters. All physicochemical properties, available nutrients and organic matter was found highest in the treatment T_5 receiving MT, herbicide along with residues retained on the surface. Hence, it may be concluded that conservational tillage (MT) treatment helps in improving the physical and chemical properties of soil.

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