Soil Management | RASHTRIYA KRISHI | Volume 10 | Issue 1 | June, 2015 | 69-70
e ISSN–2321–7987 | ●●● Article ●●● |Visit us : *www.researchjournal.co.in*|

Impact of tillage and residue management on soil health and productivity of wheat under rice-wheat cropping system

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Protection of soil health under intensive cultivation and fast economic development is a major challenge for sustainable resource use in the developing world. The basic assessment of soil health is necessary to evaluate the changing trends following different land management interventions. The concept of soil health has consistently evolved with an increase in the understanding of soils. Soil health cannot be measured directly, but soil properties that are sensitive to changes in management can be used as indicators.

Cropping system refers to temporal and spatial arrangements of crops and management of soil, water and vegetation in order to optimize the biomass/ agronomic production per unit area, per unit time and per unit input. Three components of soil health (e.g. physical, chemical and biological) are determined by soil characteristics, which can be altered by management practices followed under various cropping systems. Soil degradation, caused by land misuse and soil mismanagement, should be quantified by measuring management-induced changes in soil properties or processes and their impacts on actual and potential productivity. Establishment of the cause-effect relationship between soil properties and processes on the one hand and crop productivity and environmental moderating functions on the other is crucial to enhancing soil productivity, restoring degraded lands and improving environmental quality.

Resource-conserving technologies are defined here as any practice that improves the efficiency of use of natural resources, including water, air, fossil fuels, soils, inputs, and people. Adoption of the resource conserving technologies offers newer opportunities of better livelihood for the resource poor small and marginal farmers. At the same time, these technologies are generating alternative sources of productivity growth through diversification and intensification of production systems.

Rice–wheat cropping is dominant in the alluvial tract of Indo-Gangetic plains in South Asian countries like India, Pakistan, Nepal and Bangladesh, due to high productivity and profitability. Because of deteriorated physical and hydraulic properties and low organic carbon content of the soil under increasing intensification, the present productivity potential of rice–wheat cropping system in this region is under threat. With decreasing per capita land area (currently <0.1 ha), the risk of degradation has greatly increased, posing a severe challenge to soil management for resource conservation, especially sustainable soil use.

Residue management systems improve soil quality by increasing SOC, fungal biomass, earthworm populations, and microbial enzyme activity. Crop residues absorb rainfall energy, reduce splash effect and prevent soil surface from crusting or sealing and increases organic matter.

Intensive cultivation of agricultural soils can lead to deterioration in soil properties and consequently reduction in crop productivity (Table 1). Thus, the need for tillage has been questioned in the last few decades because of the excessive erosion from farmland after tillage. Crop yield may vary significantly within a field due to natural variability (soil, topography), random variability (rainfall, wind) and soil management (soil tillage, seeding, fertilization).

The net effect of any tillage system depends on the integration of the system itself in relation to crop rotation and residue management. Indeed, surface residues accumulated due to any tillage were shown to promote higher soil organic C, microbial biomass N and C, potential N mineralization and total N. Incorporation of plant residues, coupled with appropriate tillage, increases soil organic carbon and if used as mulch, modifies soil temperature. Tillage and crop residue management can influence soil physical properties as a direct result of altering the soil physical matrix or indirectly by altering surface energy partitioning, microbial activity and soil chemical composition.

Thus, different tillage systems can change number, shape, continuity and size distribution of the pore network, which controls the ability of soil to store and transmit water and regulate aeration while its influence on soil bulk density are variable.

The physico-chemical parameters of the soils like pH and EC both decreased almost significantly over control under these treatments. Changes in some chemical parameters of the soil revealed a significant increase in organic carbon content along with available N, P_2O_5 and K_2O content over control under influence of the tillage and organic residues treatments and their interactions. Maximum increase in these parameters was observed under mould bold and combination of green manure and rice husk and their interactions. This might be attributed to the improvement in physico-chemical properties of the soils.

Table 1: Wheat yield (kg/ha) of IGP (Source: International Journal of Scientific and Research Publications, Volume 4, Issue 3, March 2014)

Year	Wheat yield (kg/ha)
2000	3258
2001	3197
2002	3157
2003	3091
2004	3047
2005	3119
2006	3282
2007	3416
2008	3456
2009	3414
2010	3580
Standard deviation	171.90
Mean	3274.27

Tillage operations and application of organic residues alongwith their interactions significantly decreased the soil strength/compaction and consequently the bulk density of the soils over control. It was further confirmed by the positive and highly significant correlation of soil strength with the bulk density (r = 0.802**) (Table 2).

Mould board plough (MB) and GM + rice husk and their interactions showed maximum decrease in clod size and maximum increase in water stable aggregates. This might be attributed to the increase in porosity and decrease in compaction of the soils which led to increase in hydraulic conductivity. This was further confirmed by positive and highly significant correlation of hydraulic conductivity with MWD (r = 0.788**) and negatively and highly significant correlation with compaction (r = -0.646**) and BD (r = -0.846**).

Soil moisture content showed variable increase with variable depth and number of days after sowing (DAS) under influence of these tillage (T) and organic residues (C) treatments and their interactions.

The significant increase in yield attributes and yields of wheat grain and straw was observed. It was further indicated that the maximum increase in yield attributes and yield of wheat grain and straw was under influence of the treatments mould bold and combination of green manure and rice husk and their interaction. This increase in yields and yield attributes might be ascribed chiefly to the effect of tillage and organic residues treatments on the improvement of soil properties along with availability of nutrients to the plants. These observations were confirmed by the positive and highly significant correlation of yield of wheat grain with available N (r = 0.744**), available P_2O_5 (r = 0.645**), available K_2O (r = 0.519**), MWD (r = 0.514*) and HC (r = 0.482*) and negative and highly significant correlation with soil strength (r = -0.649**).

A significant improvement in soil health along with yields of wheat grain under influence of MB and GM + rice husk and their interactions was observed. Positive and highly significant correlation of yield of wheat grain with available N (r = 0.744**), available P_2O_5 (r = 0.645**), and available K_2O (r = 0.519**) were observed. Moreover, the increase in yield attributes and yield of wheat crop was not only contributed by a single factor, but a combination of factors was responsible for such significant increase.

Table 2 : Correlation co-efficient between soil properties and yield of wheat (Source : S.K.Mandal, M.Sc. Thesis, RAU, Pusa)

	Av. N	Av. P_2O_5	Av. K_2O	pH	EC	Soil strength	MWD	HC	BD
wheat yield	0.744**	0.643**	0.519**	-0.316	-0.270	-0.649**	0.514*	0.422*	-0.507*

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Received : *03.11.2014* ***Revised :*** *25.04.2015* ***Accepted :*** *10.05.2015*