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Rice straw mulching and nitrogen response of no-till wheat following rice in Bangladesh

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Abstract

Wheat (*Triticum aestivum* L.) cultivation in no-till soil of a postrice harvest field utilizes residual soil moisture and reduces the time period from rice harvest to wheat seeding in intensive rice-wheat cropping systems. Some of the major constraints in no-till wheat production are high weed infestation, poor stand establishment due to rapid drying of topsoil and low nitrogen use efficiency (NUE). A field experiment was conducted at the research farm of the Wheat Research Centre, Dinajpur, Bangladesh, for two consecutive years to overcome those constraints, to evaluate rice straw as mulch, and to determine the optimum application rate of nitrogen (N) for no-till wheat. The treatments included 12 factorial combinations of three levels of mulching: no mulch (M_0), surface application of rice straw mulch at 4.0 Mg ha^{-1} that was withdrawn at 20 days after sowing (M_1), the same level of mulch as M_1 but allowed to be retained on the soil surface (M_2), and four nitrogen levels (control 80, 120 and 160 kg ha^{-1}). Rice straw mulching had a significant effect on conserving initial soil moisture and reducing weed growth. Root length density and root weight density of wheat were positively influenced both by straw mulching and N levels. N uptake and apparent nitrogen recovery of applied N fertilizer were higher in mulch treatments M_1 and M_2 as compared to M_0. Also mulch treatment of M_1 and M_2 were equally effective at conserving soil moisture, suppressing growth of weed flora, promoting root development and thereby improved grain yield of no-till wheat. N application of 120 kg ha^{-1} with straw mulch was found to be suitable for no-till wheat in experimental field condition.

Keywords: Rice straw mulch; No-till; Soil moisture; N recovery; Wheat yield

1. Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops in terms of area usage and production in Bangladesh. Wheat is followed by transplanted aman rice under the rice-wheat cropping

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system. Transplanted aman rice is cultivated under rain fed conditions and its transplantation depends on the onset of the main monsoonal rains. Late onset of monsoonal precipitation may cause delayed transplantation of rice and, as a result, also delayed wheat sowing. A timely sowing of wheat until 30th November is recommended to expose the crop to the short winter and to get higher yields in Bangladesh conditions. But wheat sowing is often delayed to as late as the second week of January, resulting in low grain yields. Also in some years, due to heavy rain or flooding, post-harvest paddy fields remain too wet for the land to be ready for timely wheat sowing. Farmers usually turn the moist soil by animal-drawn country plough to facilitate drying. Then the soil is ploughed four to six times of and leveled by a ladder attached to the plough. Therefore, it caused substantial loss of soil moisture and takes long time from rice harvest to wheat sowing. Late sowing of wheat due to late harvesting of rice and the longer time period for land preparation is one of the main causes of low wheat yields under intensive rice–wheat cropping in South Asian countries (Fujisaka et al., 1994). Under such conditions, no-till wheat cultivation is an alternative option for exploring the benefits of residual soil moisture and reducing the time period from rice harvests to wheat seeding (Hobbs et al., 1998).

No-tillage is a resource conserving technology that reduces soil erosion, and evaporation loss of soil moisture and land preparation costs (Lal, 1989; Blevins and Frye, 1993). One of the negative effects of no-tillage is greater invasion of weeds in wheat fields (Gill and Arshad, 1995; Fisher et al., 2002; Rahman et al., 2002). Crop residue mulch has the potential to control weed growth (Erenstien, 2002) and retaine soil moisture (Dalrymple et al., 1992; Enrique et al., 1999; Manakul, 1994). Root development and proliferation depend on soil moisture (Gajri and Prihar, 1985) and grain yield of wheat under mulches is higher due to longer rooting and higher moisture content in the upper soil layers (Bonfil et al., 1999). Under no-till conditions, fertilizers are applied on the soil surface rather than mixed into the sub-surface soil. As a result, most of the applied fertilizer is directly exposed to air and sunlight, which may result in an increased loss of N fertilizer. Fertilizer N is more effective in no-tillage when the straw is retained rather than removed (Malhi and Nyborg, 1990), and mulching may protect the loss of fertilizers, especially the volatilization loss of N fertilizer (Bhagat and Verma, 1991) and thereby increase nitrogen use efficiency. Nitrogen use efficiency depends on the methods of N fertilization, management practices, and generally decreases with N fertilizer level (Sieling et al., 1998; Bellido and Bellido, 2001).

The beneficial effect of crop residue mulch is well established and with the introduction of combine harvesters in developed countries cereals straw remains in the field, either as mulch or is incorporated into the soil. The use of crop residue in soil conservation has been limited in Bangladesh. Farmers use the rice straw as feed for livestock, fuel and also in thatching their huts. The dual use of rice straw, as mulch for a short period and later withdrawing it for fuel may be possible to resolve such competing needs for crop residue. Information relating to mulch management and N requirement in wheat under no-till conditions of paddy soil is scarce. Therefore, the objectives of this study were to determine the N requirement and to investigate whether rice straw mulch has the potential of increasing yield of no-till wheat by controlling weed growth, conserving soil moisture and increasing nitrogen use efficiency.

2. Materials and methods

2.1. Soil and climate

The experiment was conducted during the two consecutive years of 2000–2001 and 2001–2002 on a postrice harvested paddy field in the Wheat Research Centre, Dinajpur, Bangladesh. The soil of the experimental field is characterized by non-calcareous acidic alluvial soil in the Old Himalayan Piedmont Plains of Bangladesh. The pH of the soil was 5.3 with exchangeable calcium 2.0 and magnesium 0.5 $cmol_c\ kg^{-1}$ soil, respectively. Organic C, total N and available P (extracted in 0.5 M $NaHCO_3$ as described by Olsen et al., 1954) content of the soil were 4.7, 0.7 $mg\ g^{-1}$ and 5.3 $\mu g\ g^{-1}$, respectively. The texture of the soil was loam at the surface layer (0–15 cm) but there was a thick layer of sand in the sub-surface that enhanced percolation and rapid drainage of the soil. Daily rainfall and pan-evapora-