EFFECT OF TILLAGE AND INTEGRATED PLANT NUTRIENT MANAGEMENT ON NITROGEN UPTAKE AND CROP YIELD OF WHEAT UNDER IRRIGATED CONDITION

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ABSTRACT

The effects of tillage and integrated use of organic and inorganic fertilizers on N uptake and crop yield of wheat were studied in a field experiment at Agricultural Research Station, Serai Naurang, Bannu, Pakistan during 2010-11. Effects of two tillage methods (in main plots) and four fertilizer treatments (as sub-plots) were evaluated in RCBD split plot configuration. Tillage treatments consist of conventional till (CT) and deep till (DT). The various combination of organic and inorganic fertilizer were 60-45 kg ha⁻¹ NP (T1), 120-90-60 kg ha⁻¹ NPK (T2), 50 % N + PK + 10 t ha⁻¹ FYM (T3), and 25 % N + PK + 20 t ha⁻¹ FYM (T4). The results showed that tillage treatments had significant effect on wheat yield. Considering average yield over all fertilizer treatments, the mean wheat yield (biological, straw and grain) were 11.88, 8.28 and 3.60 t ha⁻¹ respectively for DT as compared to 10.99, 7.66 and 3.33 t ha⁻¹ for CT. Deep tillage significantly increased the wheat yield. Considering the fertilizer treatments, the maximum yield of 13.58, 9.51 and 4.07 t ha⁻¹ for biological, straw and grain yield respectively of wheat were obtained from treatment receiving 50 % N + PK + 10 t ha⁻¹ FYM (T3). The treatment (T4), receiving 25 % N + PK + 20 t ha⁻¹ FYM produced significantly lower yields. Similarly tillage and fertilizer treatments had a positive effect on N uptake of wheat crop. The soil of DT treatment had consistently the highest N uptake in grain (84.18 kg ha⁻¹) and straw (27.38 kg ha⁻¹) compared to the 68.75 and 25.19 kg ha⁻¹ in grain and straw respectively under CT. The fertilizer treatment (T3) recorded significantly high N uptake in grain (96.73 kg ha⁻¹) and straw (34.05 kg ha⁻¹) as compared to other fertilizer treatments.

Key words: Fertilizer, Nitrogen Uptake, Tillage, Wheat, Yield.

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INTRODUCTION

Nutrient recycling by application of organic fertilizers is needed to replace nutrients removed by plants from fields in order to restore crop production potential of a soil. But application of organic fertilizer alone insufficiently increases crop yield per area because nutrient content of organic fertilizer is unbalanced. Therefore, integrated plant nutrient management (IPNM) involving the judicious use of organic and inorganic fertilizers is a feasible approach to overcome soil fertility constraints (Mugwe et al., 2009; Abedi et al., 2010; Kazemeini et al., 2010). Combined organic/inorganic fertilization both enhanced C storage in soils, and reduced emissions from N fertilizer use while contributing to high crop productivity in agriculture (Pan et al., 2009). Tiwari et al. (2002) have also reported that the inclusion of manure in the fertilization schedule improved the organic carbon status and available nitrogen (N), phosphorus (P), potassium (K) and sulfur (S) in soil, sustaining soil health.

Lamp (2000) concluded that organic manures and residue can improve physical and chemical properties of soil and fertilizer use efficiency when applied in conjunction with mineral fertilizers. Organic materials can serve as basal fertilizer, whereas only mineral fertilizer ensures synchrony with crop demand (Palm et al., 1997). Pang and Letcy (2000) supported the combined use of both nitrogen sources, as the supply of nitrogen from organic sources is difficult to synchronize with crop demand. Fan et al. (2005) concluded from long term experiment that addition of organic material and inorganic fertilizer has significantly enhanced grain yield, water use and soil chemical proprieties as compared with control or only inorganic N and P. Addition of organic manure with inorganic fertilizers is necessary for sustainable production (Singh and Sarivastore, 1971). Hussain et. al. (1988) and Sharma and Dua (1995) have recommended the combined use of both sources for sustainable crop production. The synergistic use of organic and mineral fertilizers not only increases each other’s efficiency but also helps in the substitution of costly chemical fertilizers (Hussain et. al., 1992).

Tillage is among the important factors affecting soil physical properties and crop yield. Tillage methods affect the sustainable use of soil resources through their influence on soil properties. A proper tillage can alleviate soil related constraints while improper tillage may lead to a range of degradation processes e.g. deterioration of soil structure, accelerated erosion, depletion of soil organic matter and fertility and disruption in cycles of water, organic carbon and plant nutrients (Lal, 1993). Tillage systems are site- specific and depend on crop, soil type and climate (Rasmussen, 1999). Oussible and Crookston (1987) reported that sub- soiling up to 70 cm depth of compacted clay loam soil increased the wheat grain yield from 1.0 Mg ha⁻¹ in control to 1.7 Mg ha⁻¹ in sub-soiled plot. Ahmad et al. (1996) reported that under Pakistan climate, tillage and fertilizer contributed toward crop
productivity from 5-20% and 20-50%, respectively. Similarly, Ishaq et al. (2001) found that tillage and fertilizer treatment had a positive effect on nutrient uptake by wheat crop.

At this time, a wide range of tillage methods are used under local condition without evaluating their effects on soil physical properties and crop yield. Air and water movement in soil and plant roots growth is often hindered by hard pan created through repeated use of tractor-driven cultivator (Hassan and Gregory, 1999). Yet, little information is available about the effect of different tillage methods on crop yield and nutrient uptakes under integrated use of organic and inorganic fertilizer. Therefore, the present investigation was planned to evaluate the tillage and integrated nutrients management effects on crop yield of wheat and N uptake by wheat.

MATERIALS AND METHODS

A field experiment was conducted at Agricultural Research Station Serai Naurang, Bannu, Pakistan during 2010-11 to assess the influence of tillage and integrated use of organic and inorganic sources of nutrients on crop and N yield of wheat.

The experiment was laid out in a RCB split plot design with three replicates. The field layout consisted of 24 plots divided into two main plots each with 12 subplots for conventional tillage (CT) and deep tillage (DT) treatments. The subplot size was 5×3 m. Within each tillage treatment, four levels of organic or inorganic fertilizer applied alone or in combination as control (T1 farmer practice) 60-45 kg ha⁻¹ NP, recommended dose 120-90-60 kg ha⁻¹ NPK (T2), 60 kg ha⁻¹ N + 90-60 kg ha⁻¹ PK + 10 t ha⁻¹ FYM (T3), and 30 kg ha⁻¹ N + 90-60 kg ha⁻¹PK + 20 t ha⁻¹ FYM (T4). Cultivator was used for conventional tillage while deep tillage was carried out one month before sowing with moldboard plough (0-30cm) and well rotten farm yard manure (FYM) was properly mixed with soil. Sources of N, P and K were urea, triple super phosphate (TSP), and murate of potash respectively. All the P and K fertilizers dose was applied to each treatment plot uniformly at the time of sowing, while treatment (T4) requiring N from urea below 60 N ha⁻¹ received all the N at sowing time while those (T2 and T3) requiring N 60 kg N ha⁻¹ or above, received half N at sowing time and the remaining N as a second dose with 2nd irrigation. Composite soil sample at 0-15 cm was collected from the experimental field and analyzed for soil characteristics (Table 1).

After thorough seed-bed preparation and fertilizer application, wheat (variety: Pirsabak-2005) was planted in rows 30 cm apart on November 15, 2010. The crop was irrigated from canal or tube well water according to the crop requirement and weeds were removed. At maturity, on 2.5.2011, central 2 lines from each treatment plot to get a representative sample, were harvested. After sun drying, the bundles were threshed mechanically. Grain and straw weight were recorded and samples were analyzed for N to determine N uptake by wheat crop.

Table 1. Soil characteristics of the experimental site.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>%</td>
<td>9.6</td>
</tr>
<tr>
<td>Silt</td>
<td>%</td>
<td>60.0</td>
</tr>
<tr>
<td>Clay</td>
<td>%</td>
<td>30.4</td>
</tr>
<tr>
<td>Texture class</td>
<td></td>
<td>Silty clay loam</td>
</tr>
<tr>
<td>pH (1:5)</td>
<td></td>
<td>8.45</td>
</tr>
<tr>
<td>EC (1:5)</td>
<td>dSm⁻¹</td>
<td>0.28</td>
</tr>
<tr>
<td>Organic matter</td>
<td>%</td>
<td>0.92</td>
</tr>
<tr>
<td>Total N</td>
<td>%</td>
<td>0.11</td>
</tr>
<tr>
<td>Mineral N</td>
<td>Mg Kg⁻¹</td>
<td>19.6</td>
</tr>
</tbody>
</table>

Soil and Plant Analysis

The composite sample collected before the experimental set up was air dried, ground with the help of wooden mortar and then were pass through 2 mm sieve. Textural analysis was performed using the hydrometer method (Gee and Bauder, 1986). Total N in soil, grain and straw samples was determined by the Kjeldhal method of Bremner and Mulvaney (1982). Similarly Total N uptake was measured by adding grain N and straw N uptake. The mineral N (NH₄-N, and NO₃-N) in soil was determined by the steam distillation method of Keeney and Nelson (1982).

Soil pH and EC were determined in soil-water suspension (1:5) with the help of pH meter (McLean, 1982) and Electrical Conductivity Meter (Rhoades, 1882), respectively. Organic matter content was determined by method of Nelson and Sommer (1982).

The data were subjected to statistical analysis following ANOVA technique and treatment differences were differentiated using LSD test (Steel & Torrie 1984).
RESULTS AND DISCUSSION

The results obtained on the effect of tillage and integrated use of organic and inorganic fertilizers on yield, yield component and nitrogen uptake of wheat are summarized and discussed below:

**Biological Yield**

The results regarding biological yield (Table 2) showed that deep tillage (DT) had significantly (P < 0.05) increased the biological yield of wheat compared to the conventional tillage (CT). The maximum biological yield of 11.88 t ha\(^{-1}\) was obtained in deep tillage as compared to 10.99 t ha\(^{-1}\) in conventional tillage. The results also indicated that fertilizer treatments increased significantly the biological yield of wheat compared with the control treatment. The higher biological yield (13.58 t ha\(^{-1}\) ) was obtained in treatment (T3) receiving 50 % N + PK + 10 t ha\(^{-1}\) FYM followed by treatment T2 (12.24 t ha\(^{-1}\)) receiving the recommended dose of only NPK. The minimum biological yield (11.61 t ha\(^{-1}\)) was obtained in treatment T4 receiving 25 % N + PK + 20 t ha\(^{-1}\) FYM. The lower biological yield was obtained (8.33 t ha\(^{-1}\)) in the farmer practice treatment T1 receiving 50 % NP only.

**Straw Yield**

The straw yield of wheat was also significantly affected by tillage system and higher straw yield (8.28 t ha\(^{-1}\)) was recorded in deep tillage plot as compare to conventional tillage (Table 2). The higher straw yield in DT treatment may be due to good crop stand and low weed infestation (Khan et al., 1986). Fertilizers also have significantly affected straw yield of wheat and higher yield was found in T3 receiving 50 % N + PK + 10 t ha\(^{-1}\) FYM followed by treatment receiving the recommended dose of NPK (T2). Moreover, the results of treatment T2 were statistically at par with treatment (T4) receiving 25 % N + PK + 20 t ha\(^{-1}\) FYM. These results showed that combined application of organic and inorganic fertilizer significantly improved straw yield of wheat only when the N contribution from inorganic fertilizer was 50 % along with 10 t ha\(^{-1}\) FYM. Reducing the level of N from inorganic source to 25 % with the increasing level of FYM (20 t ha\(^{-1}\)) did not produced higher straw yield than treatment (T2) receiving N 100 % from inorganic source. The results are similar with Negi and Mahajan (2000) and Mishra (2000) who reported significant increases in wheat grain and straw yields with addition of FYM to inorganic fertilizers as compared to no FYM.

**Grain Yield**

The results of grain yield followed similar trend as was noted for biological yield. Tillage effect was significant on the grain yield of wheat (Table 2). The maximum mean wheat grain yield (3.60 t ha\(^{-1}\)) was recorded in DT plots and was significantly (P ≤ 0.05) higher than CT. The grain yield (4.07 t ha\(^{-1}\)) of wheat was significantly (P ≤ 0.05) increased by T3 receiving 50 % N from mineral fertilizer along with 10 t ha\(^{-1}\) FYM (Table 2) whereas the lowest yield (2.65 t ha\(^{-1}\)) was recorded in control plots. Treatments (T4) receiving N 25 % from inorganic source along with organic fertilizer as FYM @ 20 t ha\(^{-1}\) produced significantly lower yield (3.40 t ha\(^{-1}\)) than treatments (T2 and T3) Dudhat et al. (1996), Kumar and Singh (1997), Vyas et al. (1997) and Shah and Ahmad (2006) reported similar finding of getting higher yield of wheat grain with combined application of FYM and inorganic fertilizers.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Biological Yield (t ha(^{-1}))</th>
<th>Straw Yield (t ha(^{-1}))</th>
<th>Grain Yield (t ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>10.98 b</td>
<td>7.66 b</td>
<td>3.33 b</td>
</tr>
<tr>
<td>Deep</td>
<td>11.88 a</td>
<td>8.28 a</td>
<td>3.60 a</td>
</tr>
</tbody>
</table>

Table 2. Biological, grain and straw yield (t ha\(^{-1}\)) of wheat as affected by tillage and integrated use of plant nutrients.

Within columns, means followed by similar letters are not significantly different at 0.05 % level.

These results showed that maximum biological yield (13.58 t ha\(^{-1}\)) was obtained with combined application of organic and inorganic source of fertilizer in ratio 50 % N + PK + 10 t ha\(^{-1}\) FYM. Reducing the level of N from inorganic fertilizer source to 25 % with increased FYM to 20 t ha\(^{-1}\) did not supporting higher biological yield. These results are agreement with finding of Rehman et al. (2008) and Zhao et al. (2009) who reported that FYM combined with chemical fertilizer resulted in significant increase in wheat yield components, biomass and maize yield.
**Nitrogen Concentration in Grain**

Effect of tillage was significant (P ≤ 0.05) on the N concentration of wheat grain (Table 3). Higher N concentration of 2.34 % in wheat grain was found in DT than CT. The fertilizer effect on N concentration in wheat grain showed variable response (Table 3). Maximum N concentration of 2.46 % was found in T2 receiving N 100 % from mineral fertilizer as a recommended NPK. The next highest N concentration of 2.38 % was found in T3 receiving 50 % N + PK + 10 t ha⁻¹ FYM. The significantly higher N content in wheat grains may be due to readily available N from inorganic source as compared to T4 where the readily available N from organic source was much lower. The higher uptake of N in grain was reflected in term of higher yield in T3 compared to other treatments. Similar results of higher N uptake in wheat grain under organic, inorganic or combined application were reported by Shah and Ahmad (2006), Vyas et al. (1997) and Fan et al. (2005).

**Table 3.** Straw and grain N concentration (%) of wheat as affected by tillage and integrated use of plant nutrients.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Straw N</th>
<th>Grain N</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tillage Methods (TM)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional</td>
<td>0.329 b</td>
<td>2.062 b</td>
</tr>
<tr>
<td>Deep</td>
<td>0.355 a</td>
<td>2.336 a</td>
</tr>
<tr>
<td><strong>Integrated Nutrient Management (INM)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>0.321 c</td>
<td>1.775 c</td>
</tr>
<tr>
<td>T2</td>
<td>0.348 b</td>
<td>2.457 a</td>
</tr>
<tr>
<td>T3</td>
<td>0.358 a</td>
<td>2.378 a</td>
</tr>
<tr>
<td>T4</td>
<td>0.346 b</td>
<td>2.185 b</td>
</tr>
</tbody>
</table>

Within columns, means followed by similar letters are not significantly different at 5 % level.

**Nitrogen Concentration in Straw**

The tillage effect on N concentration in wheat straw was significant (P ≤ 0.05). The highest N concentration (0.355 %) in wheat straw was found in DT. (Table 3). The fertilizer treatment responded variably to the N concentration of wheat straw (Table 3). The significantly high N concentration of 0.358 % was observed in T3 followed by T2 and T4 with N concentration of 0.348 and 0.346 % respectively.

**Total Nitrogen Uptake by Wheat**

The total crop uptake of N by wheat followed almost similar pattern of response to different tillage and fertilizer treatments as was noted for grain and straw N contents (Table 4). The tillage methods effect on N uptake by wheat grain and straw showed significant response (P ≤ 0.05). The total N uptake was 113.6 kg ha⁻¹ in DT treatment, which was significantly high than CT method (93.9 kg ha⁻¹). The data revealed that N uptake by wheat was consistently less under CT than DT treatment, because of low yields under CT. Carefoot and Janzen (1997) reported that N uptake by wheat was less with no tillage. The higher N uptake by wheat under DT over CT may be attributed to deep root proliferation (Campbell et al., 1988) and less competition by weeds (Unger, 1984).

**Table 4.** Total N uptake (kg ha⁻¹) in grain and straw of wheat as affected by tillage and integrated use of plant nutrients.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Straw N</th>
<th>Grain N</th>
<th>Total uptake</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tillage Methods (TM)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional</td>
<td>25.2 b</td>
<td>68.8 b</td>
<td>93.9 b</td>
</tr>
<tr>
<td>Deep</td>
<td>29.4 a</td>
<td>84.2 a</td>
<td>113.6 a</td>
</tr>
<tr>
<td><strong>Integrated Nutrient Management (INM)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>18.2 c</td>
<td>47.1 c</td>
<td>65.3 d</td>
</tr>
<tr>
<td>T2</td>
<td>29.5 b</td>
<td>92.2 a</td>
<td>121.7 b</td>
</tr>
<tr>
<td>T3</td>
<td>34.1 a</td>
<td>96.7 a</td>
<td>130.9 a</td>
</tr>
<tr>
<td>T4</td>
<td>28.4 b</td>
<td>74.3 b</td>
<td>102.7 c</td>
</tr>
</tbody>
</table>

Within columns, means followed by similar letters are not significantly different at 0.05 % level.

Fertilizer effect on total N uptake by wheat crop showed variable response to various treatments combination (Table 4). The results revealed that significant high N uptake by wheat was found in N fertilized than in the control treatment. The higher N uptake (130.9 kg ha⁻¹) was found in T3 receiving 50 % N + PK + 10 t ha⁻¹ FYM followed by T2 and T4 with total N uptake of 121.7 and 102.7 kg ha⁻¹, respectively. An increase in total N uptake by wheat crop under combine application of organic and inorganic fertilizer resulted in higher values of apparent net N release than those obtained when applied each separately (Metwally and Khamis, 1998) and (Shah and Ahmad, 2006).

These results suggested that integrated use of organic and inorganic fertilizer under deep tillage performed better than conventional tillage. The results also confirmed that combine application of 50 % N from inorganic
fertilizer with 10 t ha\(^{-1}\) FYM produced better result in improving crop yield and N uptake of wheat under deep tillage. Decreasing N below 50 % from inorganic source does not increase crop yield and N uptake by wheat crop, even with increased amount of FYM (20 t ha\(^{-1}\)). The finding also suggested that combined use of organic and inorganic source produced best result than the use of organic or inorganic fertilizer alone.

**CONCLUSION AND RECOMMENDATIONS**

The results showed that wheat yield was increased with deep tillage and combine use of organic and inorganic fertilizers. Therefore, deep tillage with moldboard plough along with integrated use of organic and inorganic fertilizer in the ratio of 50 % N from inorganic source and FYM @ 10 t ha\(^{-1}\) was found to be more appropriate and profitable combination for crop yield of wheat under irrigated condition of Bannu, Division, Khyber Pakhtunkhwa Pakistan.

**REFERENCES**


