EFFECT OF LAND LEVELING ON SOME PHYSICO-CHEMICAL PROPERTIES OF SOIL IN DISTRICT DIR LOWER

Farmanullah Khan, S.U. Khan, M.S. Sarir and R.A. Khattak

ABSTRACT
The present research work was conducted in District Dir Lower, NWFP to determine the effect of land leveling on some soil properties during 2005. There was a considerable variation in most of the soil physical and chemical properties of leveled and unleveled soils. Bulk density and sand contents of the leveled soil were higher while saturation percentage, moisture percentage, organic matter, clay and silt contents of leveled soil were low as compared to unleveled soil. Organic matter was lost due to leveling and it was deficient (< 1 %) in leveled soil. Effect of land leveling was non significant on soil pH, AB-DTPA extractable P and K. Although leveling disturbed sand, silt and clay contents of the soil but it did not affect soil texture significantly. Leveled land had lower electrical conductivity in horizon-Ap and B/BC than those of unleveled land, while in horizon-C the effect of leveling on EC was non-significant. Results suggested that besides land leveling, it is necessary to improve productivity of the sloping lands of District Dir lower through management and conservation strategies. Proper fertilizer management is needed to correct deficiencies of nutrients and to increase water and fertilizer use efficiency. Good soil cover is also suggested to improve the conditions of the sloping lands of District Dir lower.

INTRODUCTION
Land leveling is the process of preparing or modifying (i.e. reshaping) the land surface to a planned grade for providing a suitable surface for crop cultivation. Land leveling usually requires cutting of high areas and raising of low or deeper spots, in order to remove the surface irregularities and unevenness to make a plane surface. Land leveling provides suitable surface to control the flow of water, to check soil erosion and provide better surface drainage. Factors governing land leveling are soil characteristics, topography, cropping pattern, methods of irrigation and rainfall characteristics (Singh et al. 1999).

Land leveling is essential to the development of surface irrigation systems. This practice has been adopted in humid regions as a method for improving surface drainage on flat land. Grading land for both irrigation and drainage is entirely practical (Schwab et al. 1981). Precise land leveling improve irrigation application efficiency, uniform soil moisture for germination, improve fertilization efficiency, increase yields, decrease salt accumulation, increase cultivable land and reduce delivery losses (Eckert et al. 1975). Land leveling sometimes lowers the productivity of soils. Moving heavy equipment across the field compact soils, especially if they are wet and often creates a condition that is not easily reclaimed (Criddle and Haise, 1957). Removal of topsoil and exposure of subsoil significantly affects soil fertility status. Land leveling is essential on sloping land to enable better irrigation and distribution of rainfall.

It is also reported that cut and fill policy has not produced positive results. It requires a lot of financial resources for operating bulldozers and at the same time it buries the top fertile soil and the infertile material comes on the top. In this way soil becomes more prone to erosion. In a survey carried out by Soil and Water Conservation Research Institute, Chakwal, it was found that macro and micronutrients were so low in leveled soil that it could hardly support any plant and the crop could not recover the investment in decades.
Most of the organic matter and nutrients are present in the upper layer of the soil. Removal of this top horizon reduces soil fertility and decrease structural stability and organic matter declines in the surface layer of 0-15 cm cuts. Harold (1986) observed small changes in N levels at the surface layer but N declines more at 15-30 cm and soils exposed by land leveling are deficient in available N and P.

In order to meet the challenges of the rapid growing population in Pakistan it is essential to bring all the potential resources of the country to its full use, so that there should be no food shortage. District Dir Lower is mostly mountainous and has a greater shortage of leveled land. As no research work regarding effect of land leveling on soil properties has been done in the past in District Dir Lower, so the present research work was conducted to study the effect of land leveling on some soil properties and to formulate recommendations for the improvement of soil properties of the leveled lands of District Dir Lower to enhance crop productivity of the area.

MATERIALS AND METHODS

Site Selection:
The study was conducted on three leveled and three unleveled lands in villages namely, Osakai, Ouch Shah and Tesu, Tehsil Adenzai, District Dir Lower, NWFP during 2005. Each site was separately sampled. The field in each site was divided into three transacts randomly for the purpose of replications. A pit of about 1 m$^2$ was dug in each transact up to the depth of C horizon for detail soil profile description. Descriptions were made according to the principles laid down in the key to soil taxonomy (USDA, 1998) for soil description. Soil horizons were designated and each of them was described in terms of colour, texture, structure, consistence, porosity, calcareousness, kanker and pH. Soil series and their phases were identified, on the basis of observations made during the profile study.

Soil Sampling
In each leveled and unleveled land three pits were dug and soil samples from different master horizons i.e. A, B, BC and C were collected. Sampling was done following proper procedure. The samples from different sites were taken into separate dry clean plastic bags and then labeled. Core sampling was also done from Ap, B, BC and C-horizons of every pit in all the selected sites by using a core sampler. These cores were also properly covered and labeled. Soil samples were then brought to the Laboratory of Soil and Environmental Sciences, NWFP Agricultural University, Peshawar. Soil samples were prepared and analyzed for soil characteristics according to the established standard procedures. Mechanical analysis (Gee and Bauder, 1986), Bulk density (Blake and Hartage, 1986), Electrical conductivity (Rhoades and Miyamoto, 1990), Organic matter (Nelson and Sommer, 1982), Soil pH (McClean, 1982), AB-DTPA extractable P and K (Soltanpour and Schwab, 1977), Saturation percentage (Gardner, 1986).

Statistical Analysis
Data collected on the effect of leveling on soil physical and chemical properties were statistically analyzed by using Randomized Complete Block (RCB) design. Means of the data for each property were calculated and variation in each property among different horizons was compared by using LSD test. Correlation studies were computed for different properties in Ap, B and C horizons (Steel and Torrie, 1980).

RESULTS AND DISCUSSION
The data pertaining to physical and chemical properties of the selected leveled and unleveled sites (horizons, Ap, B/BC and C) are presented in Table I.

Physical Properties of Soil
There was a considerable variation in the physical properties of leveled and unleveled soil profile (Horizons, Ap, B/BC and C). Physical characteristics of various sites are presented and discussed as follows.

Bulk Density
The effect of leveling on bulk density was statistically significant (P < 0.05) for all the soil Horizons. Bulk density of unleveled land was less than that of leveled land in all soil horizons. The data showed that the lowest bulk density of 1.40 g cm$^{-3}$ was observed in unleveled Ap horizon at Tesu, while the highest value of 1.72 g cm$^{-3}$ was observed at leveled Ap horizon at Osakai (Table 1). Similar trend was followed in B/BC and C- horizons where bulk density was high in leveled as compared to...
unleveled soils. The difference in bulk density of leveled and unleveled soils clearly shows the effect of leveling on bulk density which is low in unleveled profile due to high organic matter, better structure and low runoff and erosion losses. The results are supported by Shafiq et al. (1988) and Brady (1984), who reported that unleveled soil had low bulk density than leveled soil and leveled soils are extremely low in organic matter and clay content by removal of top soil to a depth of 30-45 cm. According to Nunes et al. (2002), leveling process increases soil bulk density and reduces total porosity in the sub-surface due to the intense machinery traffic.

### Table I  Effect of leveling on some physical properties of soils

#### (A-Horizon)

<table>
<thead>
<tr>
<th>Soil Properties</th>
<th>Osakai</th>
<th>Ouch Shah</th>
<th>Tesu</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. density (g cm$^{-3}$)</td>
<td>Lev. 1.72</td>
<td>Un. Lev. 1.53</td>
<td>Lev. 1.66</td>
<td>1.53</td>
</tr>
<tr>
<td>Saturation (% age)</td>
<td>34.60</td>
<td>44.63</td>
<td>37.94</td>
<td>44.56</td>
</tr>
<tr>
<td>Moisture (% age)</td>
<td>1.11</td>
<td>2.11</td>
<td>1.49</td>
<td>1.61</td>
</tr>
<tr>
<td>Sand (%)</td>
<td>52.19</td>
<td>71.09</td>
<td>59.95</td>
<td>78.43</td>
</tr>
<tr>
<td>Silt (%)</td>
<td>43.33</td>
<td>24.00</td>
<td>36.00</td>
<td>24.00</td>
</tr>
<tr>
<td>Clay (%)</td>
<td>4.54</td>
<td>4.91</td>
<td>4.05</td>
<td>4.24</td>
</tr>
</tbody>
</table>

#### (B-Horizon)

<table>
<thead>
<tr>
<th>Soil Properties</th>
<th>Osakai</th>
<th>Ouch Shah</th>
<th>Tesu</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. density (g cm$^{-3}$)</td>
<td>Lev. 1.78</td>
<td>Un. Lev. 1.62</td>
<td>Lev. 1.71</td>
<td>1.60</td>
</tr>
<tr>
<td>Saturation (% age)</td>
<td>30.54</td>
<td>40.86</td>
<td>30.64</td>
<td>41.39</td>
</tr>
<tr>
<td>Moisture (% age)</td>
<td>1.52</td>
<td>1.73</td>
<td>1.46</td>
<td>1.57</td>
</tr>
<tr>
<td>Sand (%)</td>
<td>50.85</td>
<td>69.76</td>
<td>61.09</td>
<td>70.85</td>
</tr>
<tr>
<td>Silt (%)</td>
<td>46.67</td>
<td>26.00</td>
<td>39.33</td>
<td>24.67</td>
</tr>
<tr>
<td>Clay (%)</td>
<td>2.48</td>
<td>4.24</td>
<td>2.91</td>
<td>4.45</td>
</tr>
</tbody>
</table>

#### (C-Horizon)

<table>
<thead>
<tr>
<th>Soil Properties</th>
<th>Osakai</th>
<th>Ouch Shah</th>
<th>Tesu</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. density (g cm$^{-3}$)</td>
<td>Lev. 1.81</td>
<td>Un. Lev. 1.68</td>
<td>Lev. 1.74</td>
<td>1.62</td>
</tr>
<tr>
<td>Saturation (% age)</td>
<td>34.60</td>
<td>44.63</td>
<td>37.94</td>
<td>44.56</td>
</tr>
<tr>
<td>Moisture (% age)</td>
<td>1.20</td>
<td>1.64</td>
<td>1.55</td>
<td>1.49</td>
</tr>
<tr>
<td>Sand (%)</td>
<td>56.85</td>
<td>61.76</td>
<td>64.85</td>
<td>67.95</td>
</tr>
<tr>
<td>Silt (%)</td>
<td>40.00</td>
<td>33.33</td>
<td>31.33</td>
<td>26.00</td>
</tr>
<tr>
<td>Clay (%)</td>
<td>3.15</td>
<td>4.91</td>
<td>3.81</td>
<td>6.05</td>
</tr>
</tbody>
</table>

Means followed by different letters are significant at 0.05 level of significance.

That is why the saturation percentage of Ap horizon is greater than B/BC and C horizons.

**Saturation Percentage**

In Ap horizon the lowest value of saturation percentage of 34.0% was observed in leveled Ap horizon at Tesu, while the highest value of 44.6% was reported in unleveled soil at Osakai (Table 1). Similarly saturation percentage was high in B/BC and C-horizons of unleveled soil as compared to leveled soil. As leveling affects the organic matter content, structure, texture and aggregation of the soil, therefore saturation percentage of leveled soil is low than unleveled soil. Runoff and erosion also affect the saturation percentage in leveled soil. Soils having more organic matter (unleveled) form granular aggregates whereas leveled soils having more clay form blocky aggregates, which are less receptive to water as compared to granular aggregates (Frye,1987).
Moisture Percentage
In case of Ap horizon the highest value of 2.1% and the lowest value of 1.1 % was observed in unleveled and leveled soils at Osakai respectively. In B/Bc horizon both the lowest and the highest values of 1.5% and 2.0% were found in leveled soil at Ouch Shah and Tesu respectively (Table 1). Similarly in case of C horizon minimum value of 1.20% in leveled and maximum value of 1.64% in unleveled soil was observed at Osakai. The difference between mean values of moisture percentage in Ap and C horizons were significant (P<0.05) except B/BC horizon. This can be attributed to the difference in organic matter level, structure, texture, increase in bulk density and reduction in clay content due to which the moisture percentage decreased with soil depth and considerably with the effect of leveling. Due to low evaporation losses moisture content in C horizon may be high despite low organic matter. According to Rashid (1996), subsoils generally contains less organic matter and less total pore spaces but generally have higher moisture content than top soils.

Sand Content
The highest amount of sand content (78.4%) in Ap horizon was found in Ouch Shah in unleveled soil, while the lowest value of sand content (52.2%) was observed in Ap horizon of leveled soil at Osakai. Statistical analysis of the data showed significant variation (P<0.05) in sand content of different horizons between leveled and unleveled soils. In B/BC horizon minimum sand content of (50.9 %) and maximum sand content of (70.9 %) was observed in leveled and unleveled soils at Osakai and Ouch Shah respectively. In case of C horizon both minimum and maximum sand content of (56.4%) and (67.9%) was observed in unleveled soil at Tesu and Ouch Shah respectively. Sand content decreased in unleveled soil from Ap to C horizon while in case of leveled soil it decreased from Ap to B/BC horizon and then increased in C horizon which may be due to mixing of soils of different horizons during leveling. Naseem (1998) also reported that sand content decreased with increasing soil depth.

Silt Content
Minimum silt content of 24 % each in Ap-Horizon of unleveled soil was observed at Osakai and Ouch Shah while maximum silt content of 43 % in Ap horizon of leveled soil was observed at Osakai. In case of B/BC horizon lowest value of silt content (24.7 %) in unleveled soil at Ouch Shah was reported while highest value of (46.7 %) in leveled soil was observed at Osakai. Similarly in C horizon both minimum and maximum silt content (26.0% and 41.3 %) were observed in unleveled soil at Ouch Shah and Tesu respectively. Silt content in case of unleveled soil increased from Ap to C horizon while in leveled soil silt content increased from Ap to B/BC horizon and decreased in C horizon. The variation in silt content in case of leveled soil may be due to leveling and mixing of horizons, as well as effect of erosion and runoff. Statistical analysis of the data indicated that the difference in silt content between leveled and unleveled Ap and B/BC horizons was significant (P<0.05) except C horizon. The result is supported by Miller et al. (1988) who reported a change in silt content due to leveling of soil. Unger et al. (1990) reported significant effect of land leveling on sand, silt and clay content.

Clay Content
Minimum values of clay (4.1 %) and maximum (7.2 %) were observed in Ap horizons of leveled soils at Ouch Shah and Tesu, respectively, while both minimum and maximum values of (4.3 % and 5.6 %) were also observed in unleveled soils at Ouch Shah and Tesu respectively. In B/BC horizon the lowest clay value in leveled soil 2.5 % at Osakai while the highest value 6.2 % at Tesu were observed in unleveled soils (Table 1). Similarly in case of C horizon minimum clay value (2.24%) and maximum value (7.2 %) were observed at Tesu in unleveled and leveled soils respectively. Statistical analysis of the data showed that the difference in clay content between Ap, B/BC and C horizons of leveled and unleveled soils were non-significant. In case of unleveled soil clay content has shown an increasing trend from Ap to B/BC horizon while decreasing trend from B/BC to C horizon. This variation in case of unleveled soil may be due to erosion and runoff effect. Nizami et al. (1997) also reported greater clay content in subsoil than in top soil.

Chemical Properties
Soil Reaction (pH)
Minimum soil pH value of 7.89 was observed in Ap horizon of unleveled soil at Ouch Shah, while maximum pH value of 8.05 was observed in leveled
soil at Tesu (Table 2). Similar trend of low pH was observed in B/BC horizons of unleveled soil. In unleveled soil pH decreased from Ap to C-horizon, which may be due to high organic matter content in Ap than B/BC horizons. In case of leveled soil pH was almost similar from Ap to C-horizon which may be due to intermixing of horizons and effect of leveling. The pH in leveled and unleveled soil was basic which shows low organic matter content and calcareous nature of the soil. Miller et al. (1984) reported that the pH values of the surface horizon increased with leveling. Variation in pH values in different horizons can also be attributed to leaching of salts due to irrigation or rainfall as well as organic matter content.

Electrical Conductivity
The lowest EC value of 0.45 dSm
-1
 in Ap horizons of leveled soil at Ouch Shah, while the highest EC value of 0.56 dSm
-1
 in unleveled soil at Tesu was recorded (Table 2). Similarly in B/BC and C-horizons the lower EC was observed in unleveled soil, while the higher EC was observed in leveled soil. In case of unleveled soil EC value decreased from Ap to C horizon which can be attributed to high level of salts at the surface, low rainfall and low leaching effect. In leveled soil variation in EC value of Ap and C horizon is low, which may be mainly due to the leveling effect and intermixing of horizons. Putman and Alt (1987) also reported that soil removal by leveling changes the concentration of salts in root zone.

Table II  
Effect of leveling on some chemical properties of soils

<table>
<thead>
<tr>
<th>(A-Horizon) Sites</th>
<th>Osakai</th>
<th>Ouch Shah</th>
<th>Tesu</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic matter (%)</td>
<td>0.48</td>
<td>0.85</td>
<td>0.47</td>
<td>0.59</td>
</tr>
<tr>
<td>Soil pH (1:5)</td>
<td>7.98</td>
<td>8.04</td>
<td>7.89</td>
<td>8.05</td>
</tr>
</tbody>
</table>
| EC (dS m
-1)                | 0.49   | 0.55      | 0.45 | 0.51    |
| AB-DTPA Ext. P (mg kg
-1) | 4.10   | 7.17      | 1.96 | 4.15    |
| AB-DTPA Ext. K (mg kg
-1) | 86.34  | 122.35    | 66.54| 107.67  |

<table>
<thead>
<tr>
<th>(B-Horizon) Sites</th>
<th>Osakai</th>
<th>Ouch Shah</th>
<th>Tesu</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic matter (%)</td>
<td>0.35</td>
<td>0.51</td>
<td>0.47</td>
<td>0.44</td>
</tr>
<tr>
<td>Soil pH (1:5)</td>
<td>7.96</td>
<td>8.00</td>
<td>7.98</td>
<td>7.99</td>
</tr>
</tbody>
</table>
| EC (dS m
-1)                | 0.46   | 0.54      | 0.47 | 0.44    |
| AB-DTPA Ext. P (mg kg
-1) | 2.96   | 4.58      | 0.72 | 1.57    |
| AB-DTPA Ext. K (mg kg
-1) | 109.80 | 69.80     | 68.55| 92.35   |

<table>
<thead>
<tr>
<th>(C-Horizon) Sites</th>
<th>Osakai</th>
<th>Ouch Shah</th>
<th>Tesu</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic matter (%)</td>
<td>0.43</td>
<td>0.46</td>
<td>0.38</td>
<td>0.45</td>
</tr>
<tr>
<td>Soil pH (1:5)</td>
<td>8.00</td>
<td>7.98</td>
<td>7.99</td>
<td>8.01</td>
</tr>
</tbody>
</table>
| EC (dS m
-1)                | 0.47   | 0.46      | 0.48 | 0.47    |
| AB-DTPA Ext. P (mg kg
-1) | 4.14   | 0.83      | 1.51 | 0.89    |
| AB-DTPA Ext. K (mg kg
-1) | 80.38  | 86.04     | 61.75| 121.96  |

Means followed by different letters are significant at 0.05 level of significance.
Organic Matter
The lowest soil organic matter content of 0.47% was found in Ap horizon of leveled soil at Ouch Shah, while the highest soil organic matter content of 0.85% was found in unleveled soil at Osakai (Table 2). Similarly in B/BC and C- horizons minimum organic matter was found in leveled soil and maximum organic matter was found in unleveled soils. The results showed that in unleveled soil SOM content decreased from Ap to C horizon which may be due to more addition of organic matter to Ap horizon in the form of manures, crop residues and roots. Similar variation in SOM content in leveled soil was also observed but this may be due to mixing of horizons during leveling and also more addition of organic matter to Ap horizon after leveling as compared to B/BC and C horizons. The difference in average soil organic matter content between unleveled and leveled soil both in Ap and C horizon was significant (P<0.05), while non-significant in B/BC horizon. Our results are supported by the findings of Helburg et al. (1978), who reported that soil organic matter content has decreased from surface to subsoil due to leveling. Similarly Olsen (1977) reported that subsoil exposed by removing the top 30 and 45 cm of soil, was extremely low in soil organic matter.

AB-DTPA Extractable P
The lowest value of 1.13 mg kg$^{-1}$ P in leveled soil of Ap horizon was found at Ouch Shah while the highest value of 7.17 mg kg$^{-1}$ P was observed in unleveled soil at Osakai (Table 2). In B/BC horizon minimum value of 0.72 mg kg$^{-1}$ P and maximum value of 4.58 mg kg$^{-1}$ P was found in leveled and unleveled soil at Ouch Shah and Osakai respectively. The lowest value of 0.80 mg kg$^{-1}$ P in unleveled C horizon at Tesu, while the highest value of 4.14 mg kg$^{-1}$ P in leveled C horizon was found at Osakai. Variation in average P values of C horizons of leveled and unleveled soils was significant (P<0.05) while non-significant in Ap and B/BC horizon. In unleveled soil the P content decreased from Ap to C horizon which may be due to high organic matter content and addition of chemical fertilizers to Ap horizon as compared to B/BC and C horizon. In leveled soil the P content was variable in Ap, B/BC and C horizons which may be due to the effect of leveling and variation in organic matter content as well as effect of runoff and erosion. The data also showed that the level of P in the different leveled and unleveled horizon is lower than the crop requirements and can be classified as phosphorus deficient soils (Rashid, 1996). According to Holt (1979), Herald (1986) and Olsen (1977) that subsoils are always deficient in N, P and zinc, while removal of 10-15 cm layer from calcareous soils affects its availability of P for plant growth. Nune (2002) reported significant changes in P content due to leveling of soil.

AB-DTPA Extractable K
The lowest value of 66.5 mg kg$^{-1}$ K and the highest value of 122.4 mg kg$^{-1}$ K was found in Ap horizons of unleveled soil at Ouch Shah and Osakai respectively, while in case of leveled Ap horizon minimum and maximum value of 82.75 mg kg$^{-1}$ K and 107.67 mg kg$^{-1}$ K was found in Ouch Shah and Tesu respectively (Table 2). In case of B/BC horizon the lowest and highest values of 66.16 mg kg$^{-1}$ and 109.80 mg kg$^{-1}$ K in unleveled and leveled soil were found at Ouch Shah and Osakai respectively. Similarly minimum and maximum values of 60.34 mg kg$^{-1}$ K and 121.96 mg kg$^{-1}$ K in unleveled and leveled C horizon were found at Ouch Shah and Tesu respectively. In unleveled soil the K value decreased from Ap to C horizon which may be due to high organic matter content and fertilizers addition at the surface, while in leveled soil from Ap to C horizon the K contents were variable which may be due to leveling and intermixing of soil of different horizons. According to Miles and Hammer (1989) the high content of available K on surface soil may be attributed to the application of K fertilizers and manures addition. Similarly the available K decreases due to leveling of soil as reported by Fullen and Brandsma (1995) and Miller et al. (1984). Campbell and Rouss (1961) also reported that K decreases with an increase in depth of soil.

CONCLUSION
There was a considerable variation in most of the soil physical and chemical properties of leveled and unleveled soils. On-site benefits may be less but off-site advantages are more valuable in terms of sediment control, flood hazards, increase in arable land and management of environment. Though leveling has adverse effects on soil...
properties for the first 2 to 3 years, yet it is recommended as a management practice for crop production and better yield. Besides land leveling it is necessary to improve productivity of the sloping lands of District Dir lower through management and conservation strategies. Proper fertilizer management is needed to build up P level and to correct deficiencies of nutrients and to increase water and fertilizer use efficiency. Good soil cover is recommended to improve the conditions of the sloping lands.

REFERENCES


