Efficient Water and Resource-saving Technique of Soils Pre-sowing Treatment Under Winter Wheat Cultivation Conditions

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Whole history of agriculture represents man's endeavors to rehabilitate and increase soil fertility and control its water regime.

Cotton was a dominant single-crop in the Central Asian countries up to a recent time. In connection with social and economical reforms in these countries, and giving land to leasers and private land users, vast areas for grain crop cultivation are envisaged. Program, providing the increase of total grain yield up to 3mln tons by the year of 2010, was developed in Turkmenistan.

In the production conditions main pre-sowing ploughing of soil is done with the turn up of the layer to the depth of 30-32 cm. As is well known, deep ploughing up of the whole area under winter wheat sowing leads to rather long procedure of pre-sowing treatment of soil, which in its turn results in late sowing of winter wheat. Besides, deep ploughing up of whole area planned for winter wheat sowing also causes premature wear of the machinery and burst of its numerical need (2 – 3 times), waste of irrigation water and fuels and lubricants as well.

Studies on the development of more advanced and simplified technique of soil treatment for the grain crops sowing were carried out in 1999 – 2003 on the territory of Akhal scientific and production centre under Research Agricultural Institute of Ministry of Agriculture of Turkmenistan. Soils on the experimental plot are light grey desert soils (sierozems). Their mechanical composition represents paddy-field soils, non-saline. Humus content is 0.7-0.8 % of dry soil mass. Ground water level is below 5 m.

The work aimed at the development of efficient water and resource-saving technology of soils presowing treatment allowing prudent use of irrigation water ensuring winter wheat optimal yield with minimal water consumption coefficient (water supply per unit of wheat yield).

Field experiments had following trials:

1. Main soil treatment was carried out with the layer turn up to the depth of 30-32 cm, control provided.
2. Similar to the depth of 20-23 cm.
3. Main soil treatment with the layer turn up to the depth of 30 -32 cm was replaced by pre-sowing sub-soiling to the depth of 15-16 cm.
4. Instead of deep soil treatment pre-sowing lengthwise and crosswise disking to the depth of 10-12 cm was done.

Each experiment version was repeated four times. Total area of the experimental plot was 2.1 ha.

At present in Turkmenistan basic soil preparation for winter wheat sowing consists of 30-32cm ploughing including layer turn up.

However annual ploughing of fields hampers the accumulation of humus in soil and renovation of resistant fine lumpy texture. Disadvantage of this system of soil cultivation was mentioned in the works of T.S. Maltsev who claimed that decline of soil fertility lays in annual ploughing of soil with layer turning. He said that if to exclude annual real tillage, oxygen less (anaerobic) process of plant residues decay will prevail in soil. In such conditions plant roots are not ruined up to simple mineral salts by the germs. Anaerobic germs reprocess plant residues to humus. Soil enriched with humus forms lumpy texture.

In the process of research work different simplified methods of pre-sowing soil cultivation for winter wheat planting to different depths were studied.

Optimal method of pre-sowing soil cultivation ensuring rational use of water resources was found out while comparing elements of water balance of various pre-sowing soil cultivation scenarios.

According to the 1999-2003 studies rated irrigation norm for the main deep ploughing to the depth of 30-32 cm scenario made up 4400 m^3/ha when total precipitation was 200 mm (2000 m^3/ha). With the reduction of ploughing depth up to 20-23 cm irrigation water need decreased up to 4100 m^3/ha. Sub-soiling scenario to the depth of 15-16 cm allowed decreasing of irrigation norm up to 3700 m^3/ha, and disking scenario to the depth of 10-12 cm allowed decreasing up to 3500 m^3/ha. Different experiments showed that plants used 1000-1200 m^3/ha of field moisture storage. Taking into consideration such correlation between elements of water balance, total evaporation from the winter wheat field for the real tillage scenario made up 7300-7600 m^3/ha. Sub-soiling and disking scenarios allowed decreasing of total water consumption up to 6600-6722 m^3/ha.

Minimal evapo-transpiration, 6600 m^3/ha, for the disking scenario can be explained by the following: when soil was ploughed with the disk harrows to the depth of 10-12 cm loosening of the upper soil horizons took place, that made for capillary breaking and decrease of speed of moisture capillary rise. That made for preservation of soil moisture in the root zones as well.

In addition breaking of upper surface layer capillaries decreases ascending current of moisture and prevent processes of salt accumulation in rated soil horizons. While carrying out pre-sowing cultivation with toothed disk harrows total content of salts in the upper 1-m layer of soils decreased by 4,04 t/ha by the end of the winter wheat vegetation period (at the beginning of the vegetation period (October) content of dry residue for the rated horizon was 0,168%, by the end of vegetation period (June) its value decreased up to 0,145%). For the check scenario under deep ploughing to the depth of 30-32 cm the content of dry residue in 0-100 cm horizon increased by 2,5 t/ha for the vegetation period.

Main characteristic of agricultural efficiency is the crop yield. Average crop yield of winter wheat for the period of 1999 – 2003 according to the studied scenarios varied from 43,8 to 45,6 c/ha. In relation to that that crop yields do not diverge much, effectiveness of the studied techniques was estimated on the basis of water discharge per crop unit, i.e. coefficient of water consumption. Discharge of irrigation water per crop unit for real tillage scenario made up 93,4…86,9 m^3/c. While sub-soiling coefficient of water consumption was 82,1 m^3/c and while disking – 78,3 m^3/c.

Cultivation of surface layer with the disk harrows to the depth of 10-12 cm showed the improvement of soil fertility and soil texture and improvement of water resistance of soil aggregates as well, that made for more effective preservation of soil moisture.

Annually in early winter a mass of dead organic substance accumulated in soil. It enabled oxygenless (anaerobic) decay of plant residues in un-ploughed soil. Soil was enriched with humus and consequently with food stock for plants, its lumpy texture was improved. Cereals formed fibrous, branched, thin, shallow roots that evenly cut the soil. Cereals better than other crops formed fine fibrous texture of soil and made soil lumps waterproof. Roots got calcium out of lower horizons of soil and transferred it to the arable layer making soil lumps waterproof. Root and crop residues got into conditions very close to anaerobic conditions of winter death of organic matter.

Content of nutritious elements in the upper layer, i.e. 0-30 and 0-60 cm remained unchanged or slightly rose within three years period. Content of humus and total nitrogen actually didn't change for the years and made up 0.5-0,8 and 0,05-0,07% accordingly. Content of nitrogen nitrate, mobile phosphorus and exchange potassium was 4,6-5,5; 12,7-19.5 and 277-311 mg/kg of soil accordingly at the beginning of the experiments. After three years nitrogen and phosphorus characteristics increased up to 6,1-8,4 and 14,0-21,3 and potassium characteristics made up 222-320 mg/kg.

In addition to irrigation water saving when cultivating soil with disk harrows, lubricant and fuel saving by 10,0 l/ha can be observed as well. When increasing rate of production up to 3,08 ha/hour labour inputs decrease up to 0,32 man/hour.

The experiments allowed to found out that the most optimal method of pre-sowing ploughing providing preservation of soil texture, increase of its fertility, increase of winter wheat yield, saving of water and power resources is the ploughing with toothed disk harrows to the depth of 10-12 cm. Under this method of soil treatment indices and characteristics of technological efficiency are expressed as follow:

- Saving of irrigation water to the extent of 920 m^3/ha;
- Effective preservation of soil moisture resources in the root zone horizon of soil when the rate of capillary rise decreases;
- Increase of crop yield characterized by the coefficient of water consumption, i.e. 78,3 m^3/c (for real tillage and sub-soiling – 82,1 – 93,4 m^3/c);
- Preventing salinization of the rated horizons of soil (de-salinization of 0-100 cm horizon by 4,04 t/ha);
- Preservation of soil texture and prevailing of anaerobic processes of plant residue decay, which is the basis for rehabilitation of water resistance, lumpy composition and increase of soil fertility;
- Saving of fuel and lubricants by 10,0 l/ha, decrease of labour input up to 0,32 man/hour.

Introduction of the most efficient water and power saving method of soil cultivation under winter wheat sowing, i.e. disking to the depth of 10-12 cm was carried out since 2000 in the farms of Southern regions of Turkmenistan. Total area of introduction made up 100 000 ha.

Taking into consideration saved irrigation water of 920 m^3/ha actual volume of saved water was 0.092 km^3/year. This volume of water that made up 0,276 km^3 for the 3 years will allow developing of additional 61330 ha of new lands for winter wheat sowing (when total irrigation norm is 4500 m^3/ha).

As the result of the analysis and discussion of the material it was found out that the authors developed an efficient technique of pre-sowing treatment of soil for winter wheat sowing providing optimal water and salt regime of soils. Technical and economical characteristics show saving of

irrigation water, increase of winter wheat yield, prevention of salinization processes, increase of soil fertility and saving of fuels and lubricants.

Introduction of the developed technique was carried out in the farms of Southern regions of Turkmenistan on an area of 100, 000 ha.