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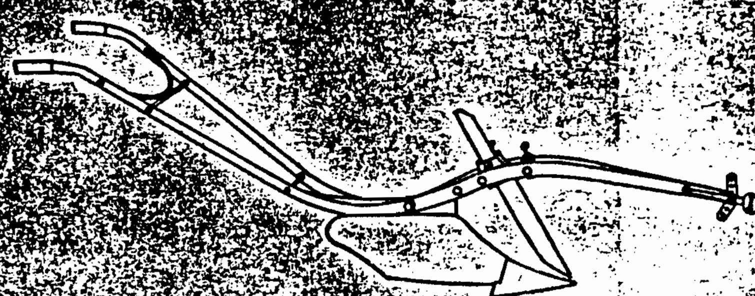

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Seed Zone Soil Water Conditions with Reduced Tillage in the Semiarid Central Great Plains 1/

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ABSTRACT

Soil water changes measured by 1-cm increments to the 15-cm depth in all-tillage, reduced-tillage, and no-tillage fallow treatments 1, 12, 19, and 34 days after a 1.35-cm rain are presented and discussed. Soil in the all-tillage treatment dried faster and to a deeper depth than the other two treatments. The no-tillage treatment dried the slowest and to the shallowest depth. Sufficient water to germinate and support initial growth was found at the 14-, 12-, and 7-cm depth for the all-, reduced-, and no-tillage treatments, respectively.

Winter wheat (*Triticum aestivum* L.) is a well-adapted and extensively planted crop on dryland in the semiarid Central Great Plains. Stable economical wheat production in this area depends on stored soil water, because precipitation amounts and frequencies vary widely. A winter wheat-fallow rotation is commonly practiced to ensure sufficient water storage (5, 6). During the 14-month fallow period, all vegetative growth is generally controlled by tillage.

The development of new and more reliable herbicides since the mid-1960's has generated considerable interest in replacing some or all of the fallow tillage operations necessary for weed control with herbicides (reduced- and no-tillage fallow, respectively). Reduced- and no-tillage fallow systems have significantly increased total fallow period soil water storage (4, 7, 8). Extended dry periods just before seeding the winter wheat crop are common in the semiarid Central Great Plains. Therefore, of major importance is the influence of fallow cultural system on soil water content at the planting depth to insure good germination and initial seedling establishment.

METHODS AND MATERIALS

This study was conducted on the U. S. Central Great Plains Research Station near Akron, Colorado, USA. The semiarid climate of the area has a mean annual temperature of 7°C and receives 80% of the average annual 38 cm of rainfall from April through October. The soil of the experimental area is Weld silt loam which is an Aridic Paleustoll. At field capacity the soil holds 0.33 cm of water per cm of soil.

1/ Contribution from Agricultural Research Service, USDA.

Weed control treatments were [illegible]cated 3 times in fallow plots 11 m wide by 30 m long and were (a) [illegible]surface mechanical tillage as needed throughout the 14-month fallow period (all-tillage treatment), (b) residual plus contact herbicides applied only at the start of fallow with subsequent mechanical tillage as needed (2 operations) when the residual herbicide no longer satisfactorily controlled weeds (beginning about the middle of the 12th month after initial herbicide application) (reduced-tillage treatment), and (c) residual plus contact herbicides applied at start of fallow with subsequent contact herbicide applications as needed (2 applications) when the residual herbicide no longer satisfactorily controlled weeds (no-tillage treatment). The residual herbicide used was 2, Chloro-4-ethylamino-6-isopropylamino-s-triazine (Atrazine) at 1.12 kg/ha active ingredient (a.i.). The contact herbicide used was 1,1'-Dimethyl-4,4'-bipyridylium ion as dichloride salt (Paraquat CL) at 0.28 kg/ha a.i.

Soil water was determined gravimetrically in 1-cm increments to a 15-cm depth to encompass the normal 7- to 13-cm seeding depth. Four sites were randomly selected in each treatment in each replication at each sampling. Samples were taken the first day after a rainfall of 1.25 cm or greater, then at 3- or 4-day intervals until the next rainfall. The data reported here were collected during a 34-day period following a rainfall of 1.35-cm. No rain fell during these 34 days, and data collection was stopped by wheat seeding. The soil in the all- and reduced-tillage treatments had been tilled to the 10-cm depth 8 days before the rain and remained weed free during the 34 days without additional tillage. Soil water distribution in the 15-cm soil depth 19 days after the rain was comparable to the water distribution one day before the rain.

RESULTS AND DISCUSSION

Days 1, 12, 19, and 34 after the rain were selected to show the initial and major soil water changes between samplings. Omitted samplings fit uniformly between those shown. Between 1 and 12 days after the rain, soil water decreased drastically in the top 3 cm of soil (Fig. 1A, B, C). The decrease was greatest for the all-tillage treatment. Some of the water lost from the top 3 cm of soil undoubtedly was redistributed because soil below the 9-cm depth showed an increase for all treatments. However the largest loss was due to surface evaporation during first-stage drying. Environmental evaporation potential was high during this time and water in this depth was available for flow to the soil surface. Soil water loss between 3 and 9 cm was greater than the increase between 9 and 15 cm for each of treatment. Evidently some water moved into the soil below the 15-cm sampling depth.

Between the 12th and 19th days, the soil dried to a depth of 4 cm in the all-tillage treatment, but to only 3 cm in the reduced- and no-tillage treatments (Fig. 1A, B, C). The all- and reduced-tillage treatments lost some water throughout the 15-cm sampling depth, whereas the no-tillage treatment had no change in water content below the 6-cm depth. Water loss below the 4-cm depth in the all- and reduced-tillage treatments loss decreased because more of the water had to move to the soil surface as vapor.

By the 34th day after the rain, the top 2 cm of soil of all treatments had the same soil water content (Fig. 1A, B, C). Below this depth, however, the treatments differed strikingly. The all-tillage treatment was dry to a depth of 11 cm, which was the depth of the deepest tillage operation performed during the fallow period. The reduced-tillage treatment was dry to 7 cm and the no-tillage treatment was dry to only 4 cm.

The length of time after the rain that the soil water content was 0.14 cm/cm or greater (the water content needed for seed germination and initial growth) in the 15-cm soil depth is presented in Fig. 2. On the 9th day after the rain the water content of the top centimeter of soil in the all- and reduced-tillage treatments dried to a water content of 0.14 cm/cm. With the no-tillage treatment 12 days were required to dry the top centimeter of soil to a water content of 0.14 cm/cm. The rate of drying in the all-tillage treatment was almost linear from the surface to a depth of 13 cm between the 9th and 26th days. With reduced- and no-tillage treatments the increase in depth of drying was slow until the 26th and 30th days, respectively, when a trend toward rapid drying to deeper depths was noted.

The data in Figure 2 clearly show that with the all-tillage treatment, wheat would have had to be seeded at the 7-cm depth during the first 22 days after the rain. However with the no-tillage treatment, it could have been seeded at the 7-cm depth during 34 days after the rain. At the time of seeding on the 34th day after the rain, the 14-, 12-, and 7-cm soil depths contained sufficient water to germinate wheat and support initial growth for the all-, reduced-, and no-tillage treatments, respectively. All treatments were in third-stage drying at this time and all water moved to the soil surface as vapor. The depth of vapor movement would have been 11, 7, and 4 cm for the all-, reduced-, and no-tillage treatments, respectively. Obviously, tilling the soil created conditions that favored drying deeper than where no-tillage was performed.

During the 34 days following the rain, measured water loss from the 15-cm sampling depth was 2.79, 2.34, and 1.85 cm for the all-, reduced-, and no-tillage treatments, respectively. Water loss during the 34 days was 34% less from the no-tillage treatment than from the all-tillage treatment. Water evaporation from a U. S. Weather Bureau Class "A" pan during this 34 day period was 34.99-cm.

Small amounts of residue on the soil surface will effectively decrease evaporation during the first-stage drying (1, 2, 3) but large quantities of residue are required to save significant amounts of soil water for any extended time. At the time this 34-day drying cycle occurred surface residue had been reduced to approximately 1200 kg/ha on the all-tillage treatment, 2200 kg/ha on the reduced-tillage treatment while 3700 kg/ha was present on the no-tillage treatment. Where tillage had been performed the residue was all flat on the soil surface; on the no-tillage treatment, 50% was still standing. Thus, with no-tillage, sufficient residue may have been present, both flat and standing on the soil surface to effectively decrease turbulent transfer of water vapor to the atmosphere, thereby effectively decreasing depth of soil drying for a longer time.

CONCLUSIONS

Following extended periods without rainfall during fallow, the elimination or reduction of tillage will result in a higher soil water content nearer the soil surface than where only tillage is used. With the higher soil water content nearer the soil surface, the depth at which seeding must be performed to insure good germination and initial growth can be reduced.

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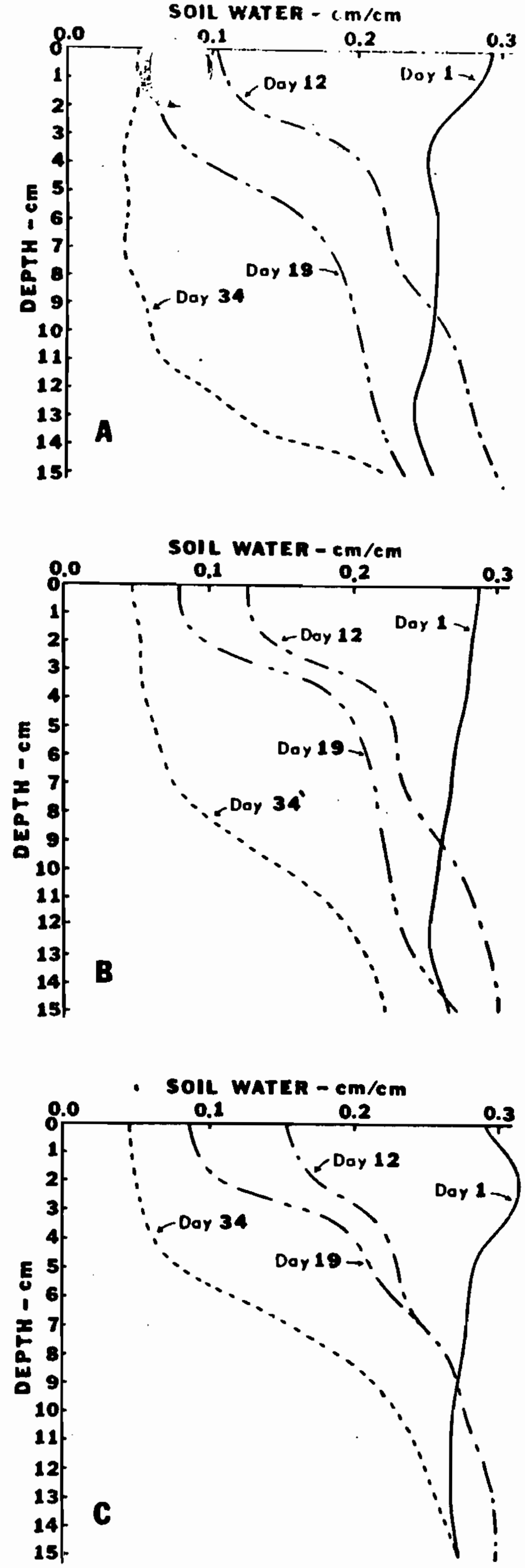

FIGURE 1. **Soil water content in top 15 cm of soil on days 1, 12, 19, and 34 after a 1.35-cm rain for all-tillage (A), reduced-tillage (B), and no-tillage (C) fallow treatments.**

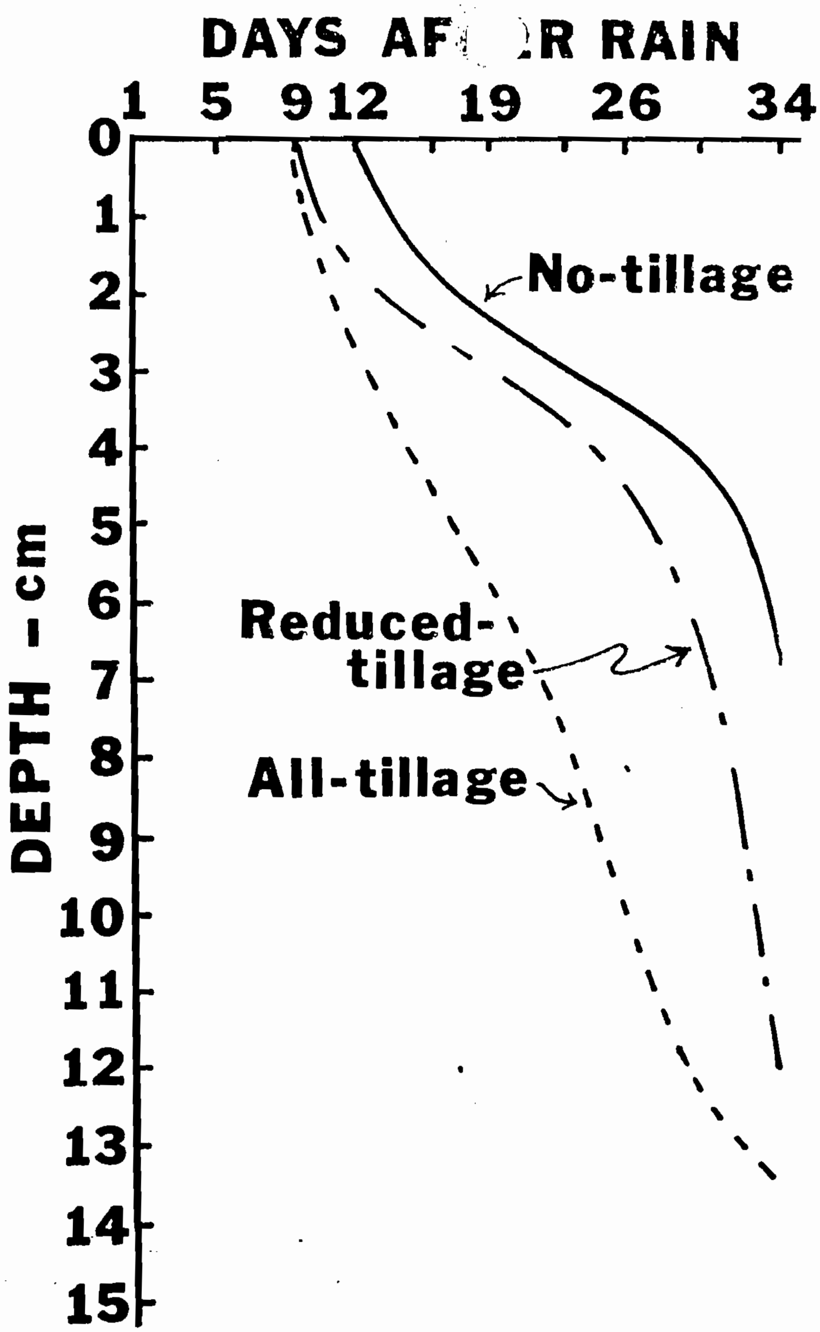

FIGURE 2. Days after rain when soil water content of 0.14 cm/cm available for seed germination and initial growth in the 15-cm soil depth for all-, reduced-, and no-tillage fallow treatment.