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Winter Wheat Emergence after 30 minutes Rainfall in the Central Great Plains

by

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SUMMARY:

Winter wheat emergence decreases greatly with increasing rainfall amounts occurring after planting. The use of wide flat press wheels in reduced tillage fields with increased levels of surface residue significantly increased wheat emergence.

KEYWORDS: wheat, emergence, rainfall, furrows, wheels

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Abstract

Rainfall within a few days of winter wheat planting can significantly reduce emergence and furrow height. A 30-minute, 5-year frequency storm of 30 mm reduced emergence more than 50 percent for wheat planted with V-shaped press wheels or in loose, clean-tilled soil conditions. Reduced tillage or increased surface residue along with the use of 75 mm wide, flat press wheels increased emergence significantly. Wheat planted in heavy residue and no-till soil conditions had full emergence with 0 to 40 mm water application in 30 minutes. Deeply planted (8 to 10 cm) wheat had slightly less emergence and showed no benefit to reduced tillage or increased surface residue.

Introduction

Winter wheat is a major crop in the Central Great Plains region of the United States. It is primarily grown using two-year, wheat-fallow, clean-till management that leaves little or no residue on the soil surface at planting time. Farmers will commonly till the soil 4 to 8 times using sweep plows, rod weeders, one-way disks, tandem disks and field cultivators to control weeds during the fallow season. As a result of these tillage operations, the surface soil becomes a dry mulch which helps reduce soil water evaporation. Reduced-tillage and chemical-fallow systems are being adopted which leave residue or standing stubble from the previous wheat crop on the soil surface at planting time.

Winter wheat is planted primarily with grain drills that have double disk or hoe-shoe openers at a desired depth of 2 to 4 cm. These openers will push or throw aside the dry surface soil mulch to form V-shaped furrows with the wheat planted below the furrow bottoms. The V-shaped furrows may also reduce soil water evaporation around the wheat seed and reduce wind erosion if the furrows are oriented perpendicular to prevailing winds. Typically, grain drills may have steel V-shaped press wheels, steel flat press wheels with or without a center rib, or rubber flat press wheels among others, all located behind the furrow openers.

Rain storms occurring after wheat planting can inhibit emergence because soil from the sides of the furrow will erode or slump into the bottom of the furrows. When this happens, the wheat plants must emerge through the normal planting soil depth of 4 to 6 cm, plus the additional soil eroded to the bottom of the furrow that may have also formed a surface seal or crust. If populations of the remaining emerged wheat plants are too low, grain yields may be reduced the following year.

Soil, residue, planting, and storm factors can affect the amount and pattern of soil deposited in the bottom of wheat furrows. Soil factors affecting wheat furrow slump and emergence may include soil type, land slope and plant residue levels. The planting characteristics of the grain drill can also affect wheat furrow slump. Row spacing and the type of furrow opener affect furrow slope, height and shape. The shape of the furrow can be affected by the type of press wheels. V-shaped steel press wheels generally leave a V-shaped furrow regardless of soil tillage or residue levels. Flatter press wheels with reduced tillage or increased surface residue conditions may leave a flatter-bottomed furrow.

The intensity, duration and pattern of the rain storm may also affect the amount of soil slump in wheat furrows. High intensity storms generally cause greater soil erosion because water ponds on the surface sooner, eliminating soil water matrix potential at the surface which reduces aggregate stability. Amount of soil eroded also increases generally with storm duration. The intensity of rain storms is generally high initially, then decreases over the duration of the storm, so the pattern of the storm may affect the amount of wheat furrow slump.

Objectives and Procedures

Objectives of this research were to quantify any changes in wheat plant emergence and furrow height due to 30 minutes of uniform artificial rainfall applied within four days after planting. Variables in this study were amount of applied water, residue level, tillage, planting depth and soil texture. The research was conducted in 1987 and 1988 during the normal winter wheat planting period of late September and early October at various locations within 10 km of the U.S. Central Great Plains Research Station near Akron, Colorado. The soils (Petersen, et al, 1986), tillage treatments, residue levels and planting depths are summarized in Table 1.

Table 1. Site numbers, soils, tillage treatments, residue levels, and planting depths of the winter wheat emergence and rainfall plots.

Year	Site	Soil texture	Tillage treat.	Residue level	Planting depth
1987	1.	sandy loam	no-till	5860 kg/ha	4 - 6 cm
			clean-tilled	0 kg/ha	4 - 6 cm
	2.	silt loam	disked	1790 kg/ha	4 - 6 cm
1988	3.	sandy loam	sweep-plowed	4880 kg/ha	4 - 6 cm
			disked	2060 kg/ha	4 - 6 cm
	4.	loam	no-till	6540 kg/ha	8 - 10 cm
			sweep-plowed	4060 kg/ha	8 - 10 cm
			clean-tilled	0 kg/ha	8 - 10 cm

Check plots that received no artificial rain between planting and emergence were also included in the study. All plots received no natural precipitation between planting and emergence except site 3 which received 6 mm of light rain over a 12 hour period. The plots at site 3 exhibited little or no soil movement due to this precipitation and were allowed to dry for 36 hours before the artificial rain treatments were applied.

A rainfall simulator was used to apply different depths of artificial rain in 30 minutes. The rainfall simulator was built on a design developed by Shelton et al (1985). It consists of nine spray nozzles arranged in a three by three array with variable spacing of approximately 2 m. Different continuous application rates are obtained by varying the nozzle spacing or by injecting air with the water. Each nozzle assembly includes an inlet for injecting air into the water just before it exits the nozzle which displaces water flow to reduce application rates. The simulator was built as a portable unit mounted on a four wheel trailer which was towed by a tractor.

The simulator was operated at conditions that produce water drops with velocities and sizes similar to rainfall (Shelton et al, 1985). The nozzles used were Spraying Systems[1] Fulljet HH30WSQ which at low nozzle pressures of 10-14 kPa produce a range of drop sizes up to 6 mm. The nozzles were positioned 2.9 m above the plots to guarantee that water drop impact velocities were within a few percent of terminal velocities. Application uniformity was measured and had Christiansen's (1942) Uniformity Coefficient between 70 to 90 percent. Water application amounts in the field plots were measured using four catch cans. Application amounts between 25 to 50 mm in 30 minutes were used, which correspond to 5 to 50 year frequency storms, respectively (Hershfield, 1961) in the U.S. Central Great Plains region.

Winter wheat was planted at all sites with grain drills that had identical hoe-shoe furrow openers and either V-shaped steel or 7.5 cm flat rubber press wheels. Row spacing was 28 cm (11 in). The wheat was planted in moist soil. The seeding rate was 51 kg/ha using "Carson" variety in 1987 and "Tam 107" in 1988. Simulated rainfall was applied to all plots within 4 days after planting and emergence started five to ten days after planting. Land slope at all sites was less than one-half of one percent. Almost all non-infiltrated water ponded in the furrows and soil did not moved laterally along the furrows.

Each time the rainfall simulator was set up, water was applied to two plots. One plot was seven furrows formed with the V-shaped press wheels adjacent to another plot which was seven furrows formed with the flat press wheels. The rainfall simulator was then moved a few meters to adjacent plots for the different combinations of application amount, tillage and residue. There were four replications of each plot. Applied water depth was calculated as the average of water depths collected with the four catch cans for each pair of plots.

When the wheat plants were 8 to 10 cm tall, the plants in a 1 meter length of the 3 middle rows of each plot were counted. By this stage of development, sufficient time had elapsed to ensure complete emergence. A diagram of the simulator nozzle array, plot layout and catch can location are shown in figure 1.

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1. Note: The mention of trade names or commercial products does not constitute their endorsement or recommendation for use by the USDA-ARS.

Results

Winter wheat plant emergence and furrow height were reduced by the application of 30 minutes of simulated rainfall after planting. Increased application amounts caused greater reduction of winter wheat emergence and furrow height. The use of flat press wheels with reduced tillage or surface residue increased the emergence of winter wheat plants.

The 5860 kg/ha of crop residue on the soil surface after planting in 1987 and/or the firmer no-till soil conditions, and the flat press wheels improved wheat emergence significantly at site 1, as shown in figure 2. The error bars in all figures indicate 95% confidence intervals of average plant populations from the 4 replications for each application amount. The 1790 kg/ha of residue in the disked plots at site 2 also caused a lesser but still significant increase in emergence, as shown in figure 3.

Wheat planted with the flat press wheels in the clean-tilled plots with no residue at site 1 had plant populations similar to the plots planted with the V-shaped wheels. The shape and geometry of the furrows made by the flat press wheels in the clean-tilled plots at site 1 were V-shaped and similar to furrows made with the V-shaped press wheels. Soil in the clean-tilled plots was so loose that soil moved by the hoe-shoe furrow openers would fall back into the furrows behind the flat press wheels. Therefore, the 7.5 cm wide flat press wheels appear to have no effect in changing the furrow geometry in clean-tilled soil with no surface residue after planting.

Planting with flat press wheels in no-till, firm soil conditions produced furrows in which the furrow bottoms were almost as wide and flat as the press wheels. The no-till soil conditions with sufficient surface residue and flatter-bottomed furrows reduced the amount of soil from the top and sides of the furrows that eroded into the furrow bottoms. The eroded soil was deposited over a wider area and consequently, left a shallower depth of eroded soil.

Furrow height reduction for the plots at sites 1 and 2 are shown in figure 4 and 5. Furrow height decreases with greater amounts of water applied in 30 minutes. Furrows formed by the flat press wheels in the no-till plots at site 1 had significantly less furrow height reduction than any of the other plots.

Plant populations in the check plots that received no artificial or natural rain were similar and averaged 147 plants per square meter. Plant populations on the no-till, flat press wheel plots with the 2 lowest water applications were greater at 166 and 155 plants/m^2. The applied water may have increased the number of wheat seeds that germinated more than the reduction in emergence caused by soil sedimentation into the furrow bottoms.

Wheat emergence in plots that were planted with the V-shaped press wheels and in those planted with the flat press wheels in clean-tilled plots at site 1 are not significantly different and plant population appears to decrease linearly with increasing application amounts. The linear regression of plant population to application amount is shown in figure 6 for these plots, along with the data from the plots with surface residue, and is,

$$y = 151 - 2.68x, \quad r^2 = 0.88 \quad \ldots\ldots\ldots\ldots \quad [1].$$

where, y = wheat plant emergence, plants/m^2
x = water applied in 30 minutes, mm
r = correlation coefficient, -.

Emergence and furrow height reduction in 1988 (site 3) were similar to those observed in 1987, as shown in figures 7 and 8, respectively. Again, more surface residue and the use of the flat press wheels increased wheat emergence and generally decreased furrow height reduction. Average plant population in the dryland check plots was again 147 plants/m^2. Plant populations for the V-shaped wheels in the sweep-plowed plots and the lowest water application in the disked plots are greater than expected from comparisons to the V-shaped press wheel emergence results in figures 2 and 3. However, these data points are not significantly different as judged by the magnitude of the 95% confidence intervals.

Results from sites 1,2 and 3 which had a planting depth of 4 to 6 cm for the 4 tillage and residue conditions were combined and are shown in figure 9. A single regression line is shown for all plots planted with the V-shaped press wheels or in clean-tilled, no residue plots, and is

$$y = 151 - 2.62x, \quad r^2 = 0.83 \quad \ldots\ldots\ldots\ldots \quad [2].$$

Wheat emergence increases if planted with flat wide press wheels in reduced tilled fields with increased surface residue. The regression equation will be useful for predicting relative differences in winter wheat emergence after 30 minutes rainfall in fields planted with V-shaped press wheels or clean-tilled fields. If predicted plant populations are low enough to greatly reduce yields, then the decision to replant could be made sooner than waiting for full emergence to occur.

Soil texture appeared to have little effect on wheat emergence. Plant populations among the plots planted with V-shaped press wheels or in clean-tilled soil, and likewise among the disked plots with 1790-2060 kg/ha of residue show no significant difference between silt loam and sandy loam soils. Reduced tillage and/or increased surface residue appear to be the major factors that affect emergence and furrow height change.

Emergence of winter wheat planted at site 4 at a depth of 8 to 10 cm was slightly less overall, as shown in figure 10, than that planted at a depth of 4 to 6 cm. The average dryland check plot population was 121 plants/m^2. However, there was no significant difference due to tillage or residue. The 4 cm average additional depth of soil that the wheat plants had to emerge through evidently negated any benefit of reduced tillage or surface residue. A linear regression for the 8 to 10 cm planting depth emergence is shown in figure 10, along with eq. 2, and is,

$$y = 120 - 2.04x, \quad r^2 = 0.79 \quad \ldots\ldots\ldots\ldots \quad [3].$$

Furrow height reduction was similar, as shown in figure 11, to that of the 4 to 6 cm planting depth plots.

Summary and Conclusions

Heavy rainfalls occurring within a few days after winter wheat planting can significantly reduce wheat emergence. A 30 mm rainfall in 30 minutes can potentially reduce wheat emergence by 50 percent. Wheat planted with more traditional V-shaped press wheels and wheat planted in clean-tilled, loose soil conditions exhibited significantly greater population reductions. A linear equation can be used to predict the decreased plant populations.

Use of wide flat press wheels in reduced-tillage conditions with surface residue will significantly increase emergence. No-till plots with 5860 kg/ha of surface residue exhibited population reduction only with water applications greater than 40 mm in 30 minutes. Plots that were only sweep-plowed had slightly less emergence than in no-till plots followed by less emergence on plots that were sweep-plowed during the fallow season, then disked just before planting.

Furrow height decreased with increasing water application and was reduced most for the furrows planted with the V-shaped press wheels. Wheat planted at 8 to 10 cm soil depth exhibited less emergence than the other plots planted at 4 to 6 cm soil depth. At a depth of 8 to 10 cm, reduced tillage and surface residue did not increase emergence. The additional 4 cm of soil appears to have negated any benefits of reduced tillage or surface residue. Reduced wheat emergence is a significant problem if heavy rains occur within a few days after planting. Wheat planted at normal soil depths in fields with reduced tillage, increased surface residue and with wide flat press wheels will significantly increase wheat emergence.

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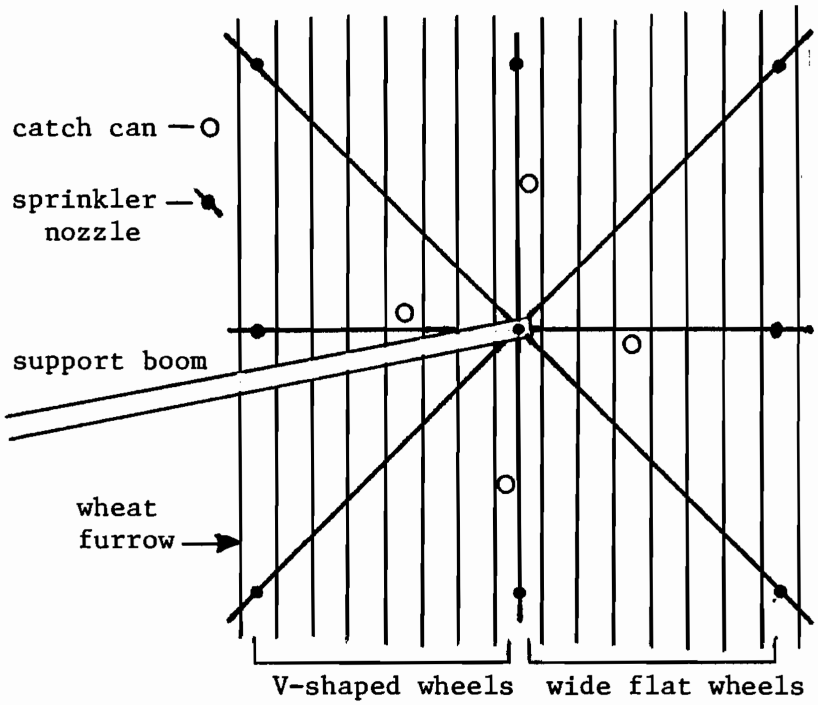

Figure 1. Rainfall simulator sprinkler array, plot layout and catch can location.

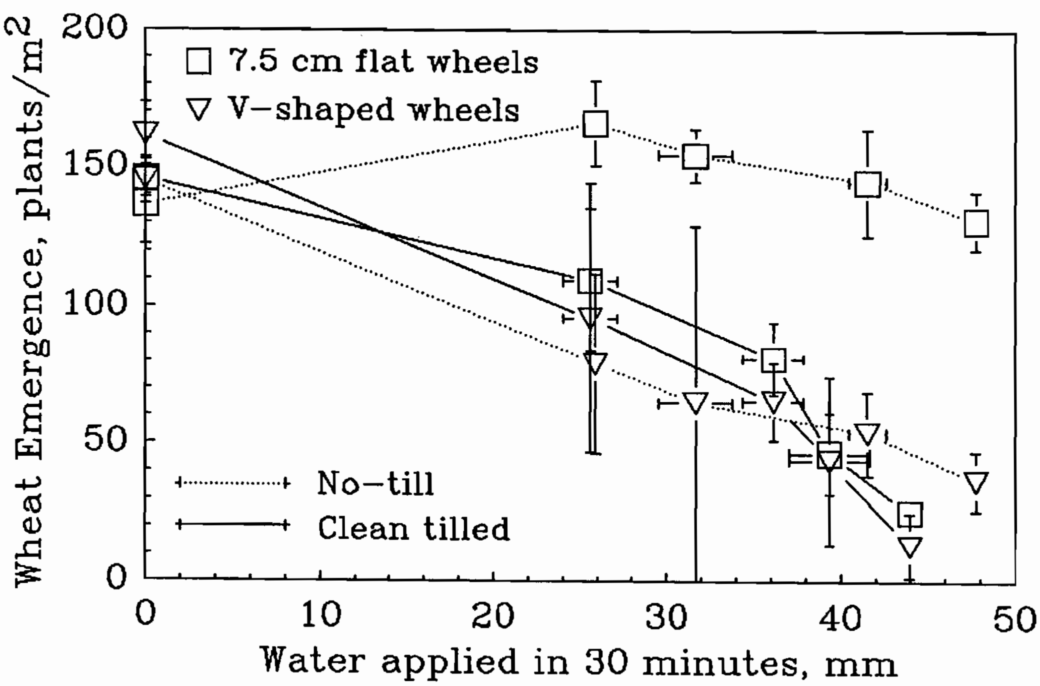

Figure 2. Winter wheat emergence at the sandy loam site in 1987.

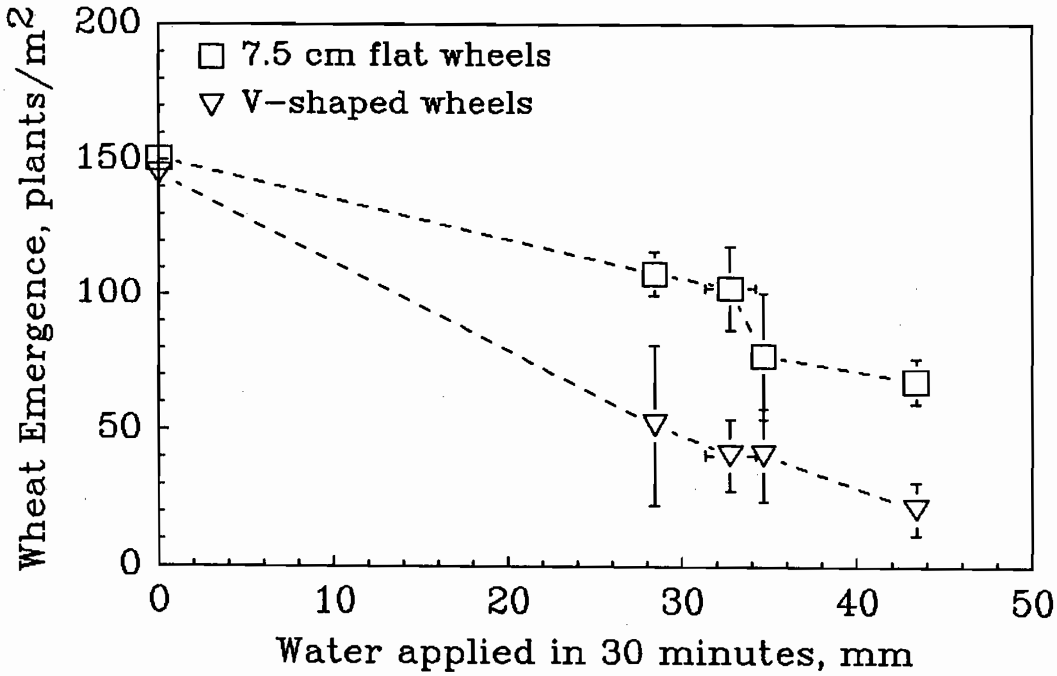

Figure 3. Winter wheat emergence at the silt loam site in 1987.

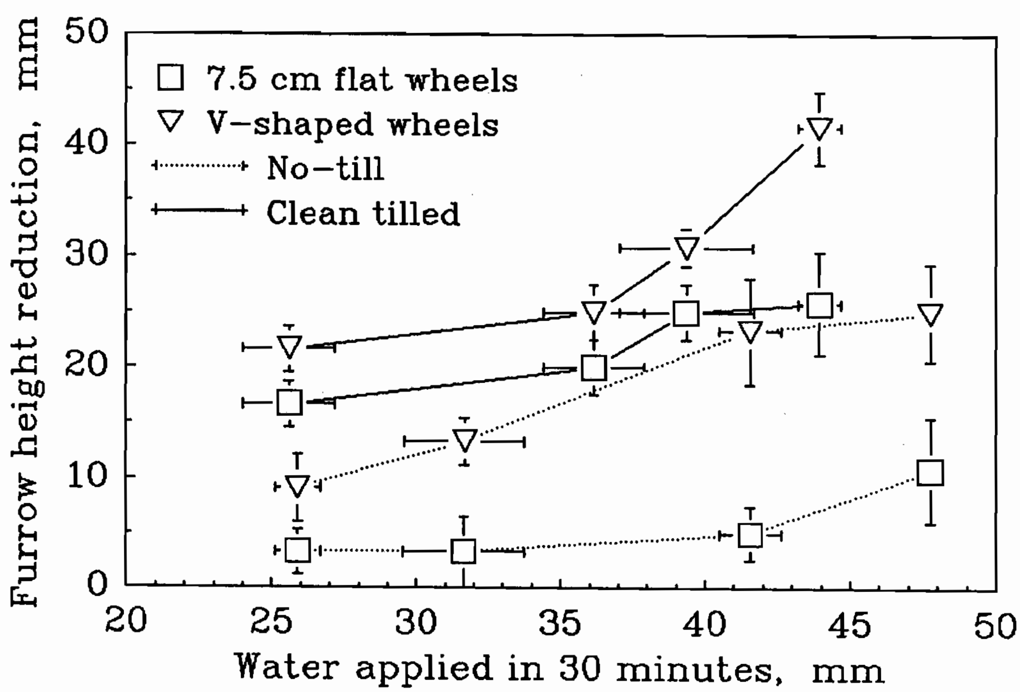

Figure 4. Furrow height reduction at the sandy loam site in 1987.

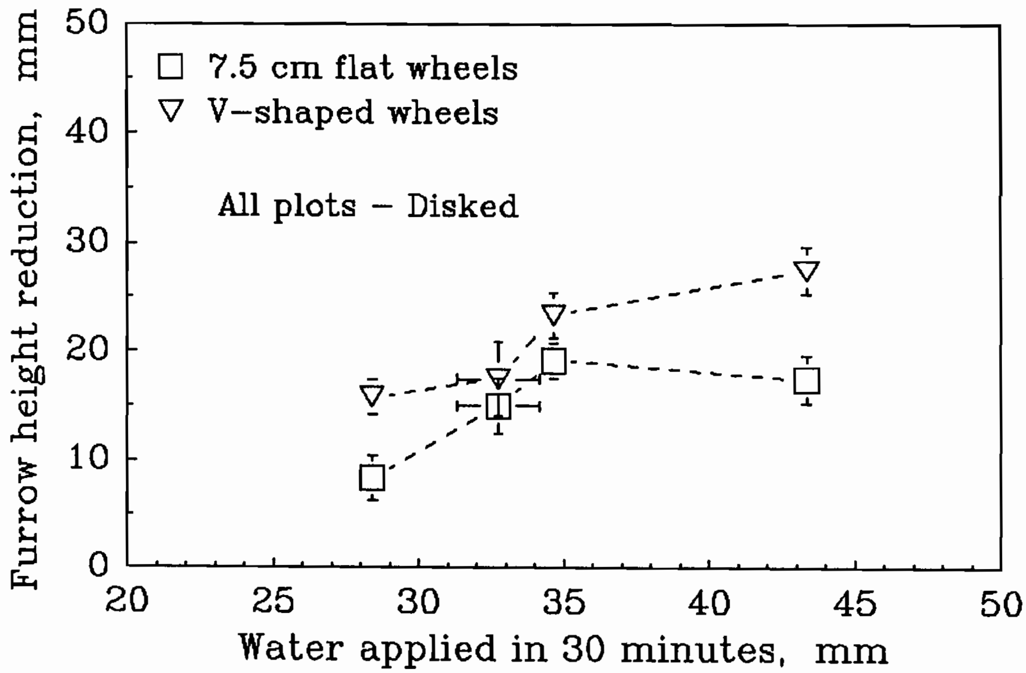

Figure 5. Furrow height reduction at the silt loam site in 1987.

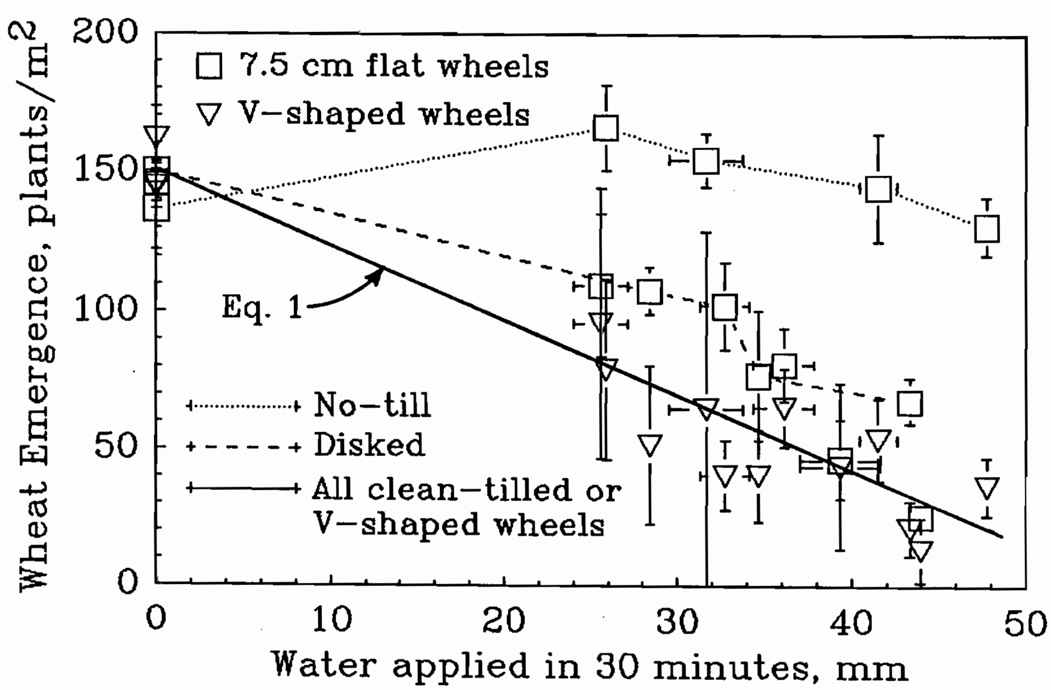

Figure 6. Combined winter wheat emergence results for 1987.

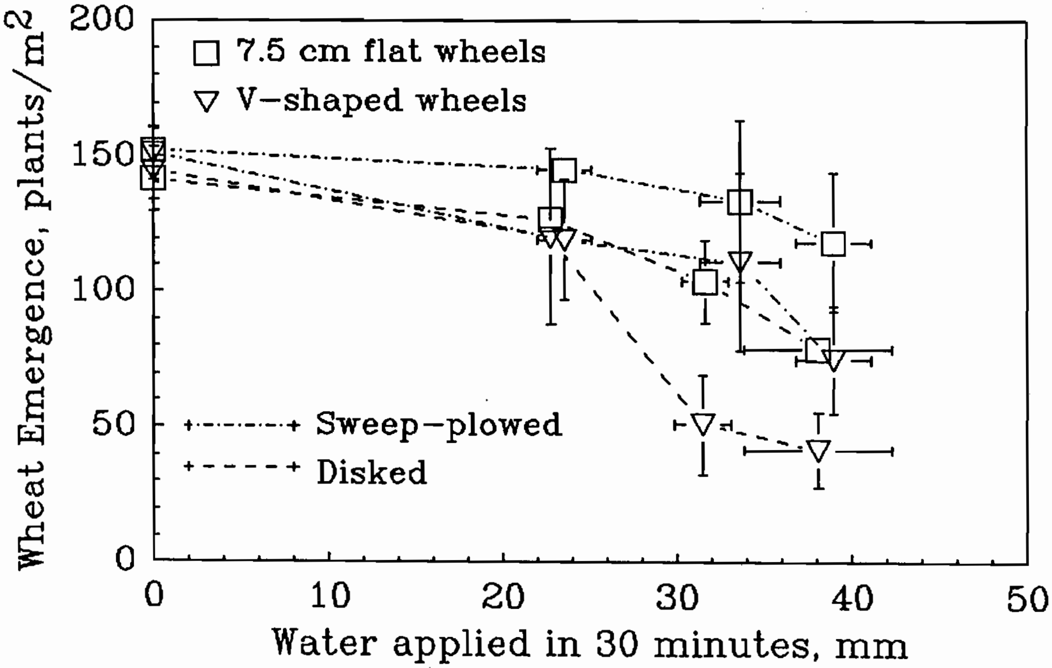

Figure 7. Winter wheat emergence at the sandy loam site in 1988.

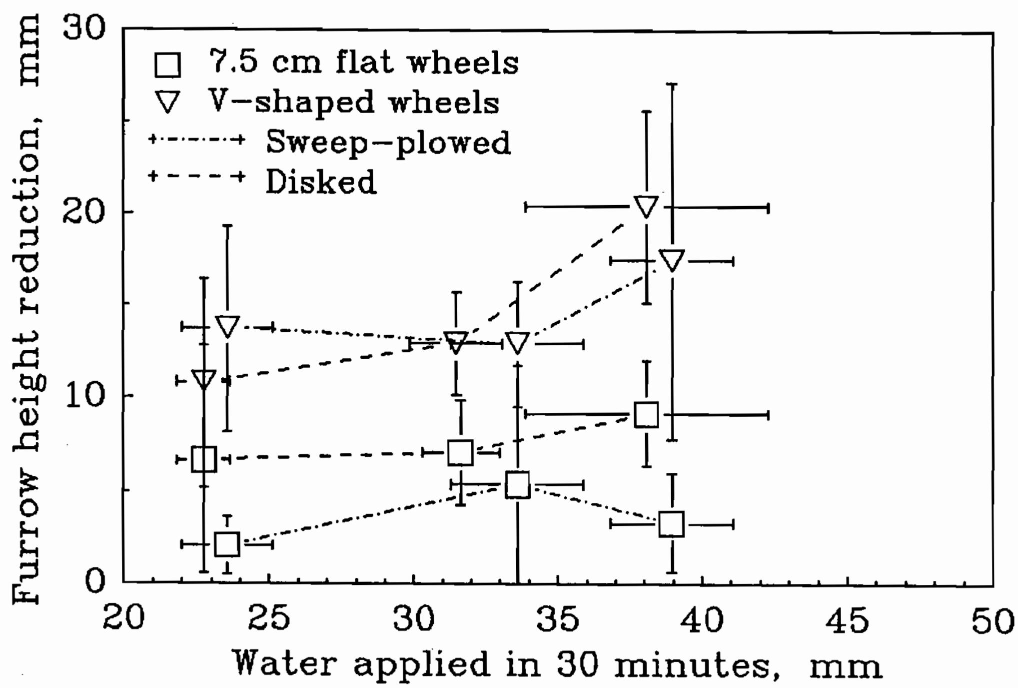

Figure 8. Furrow height reduction at the sandy loam site in 1988.

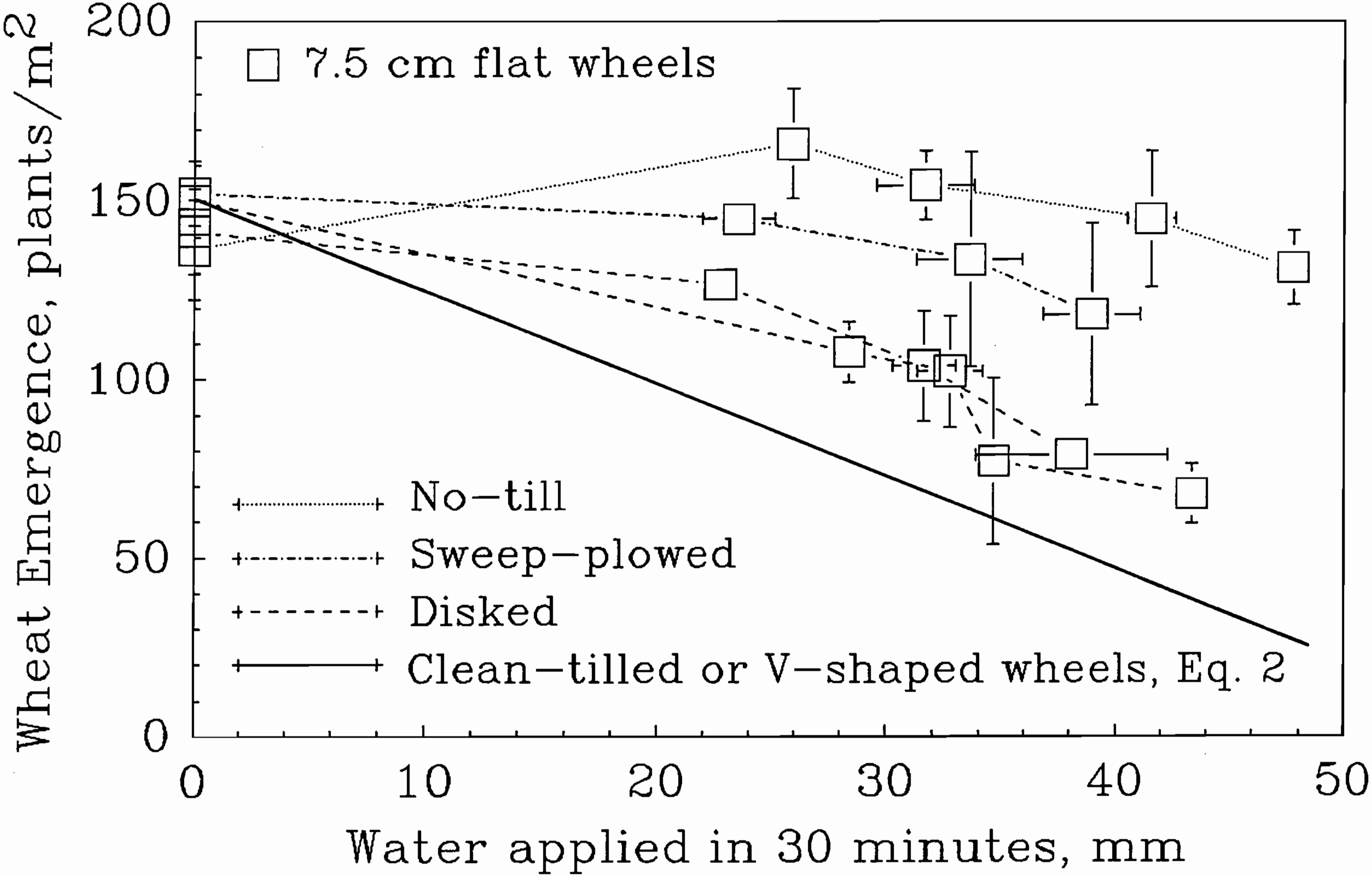

Figure 9. Combined winter wheat emergence results for 1987 and 1988.

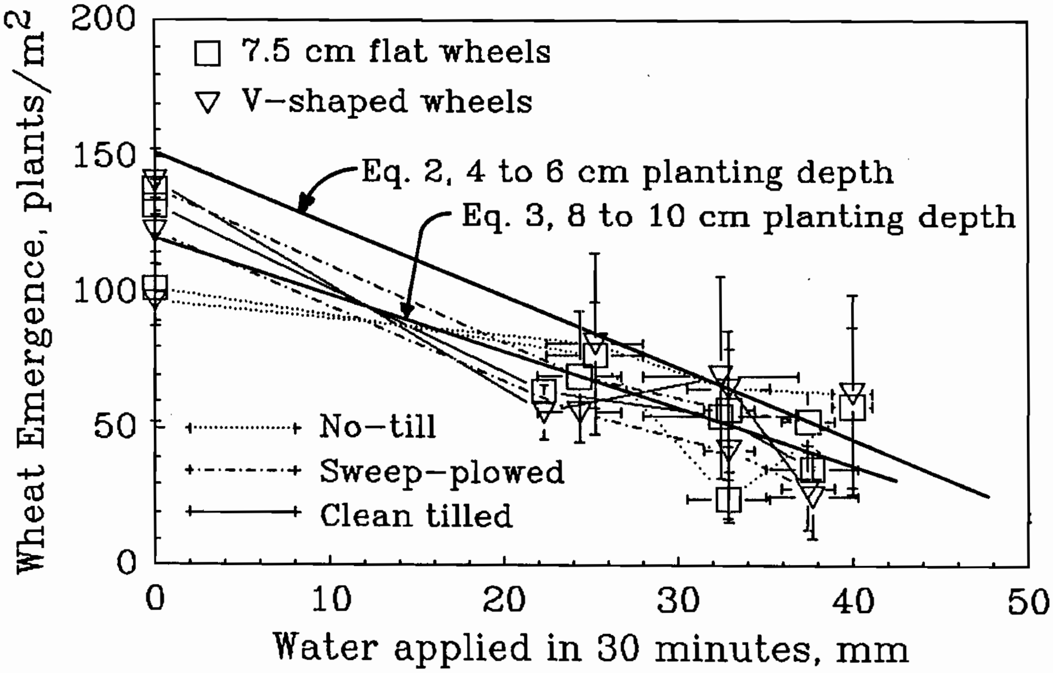

Figure 10. Deeply planted (8 to 10 cm) winter wheat emergence at the loam site in 1988.

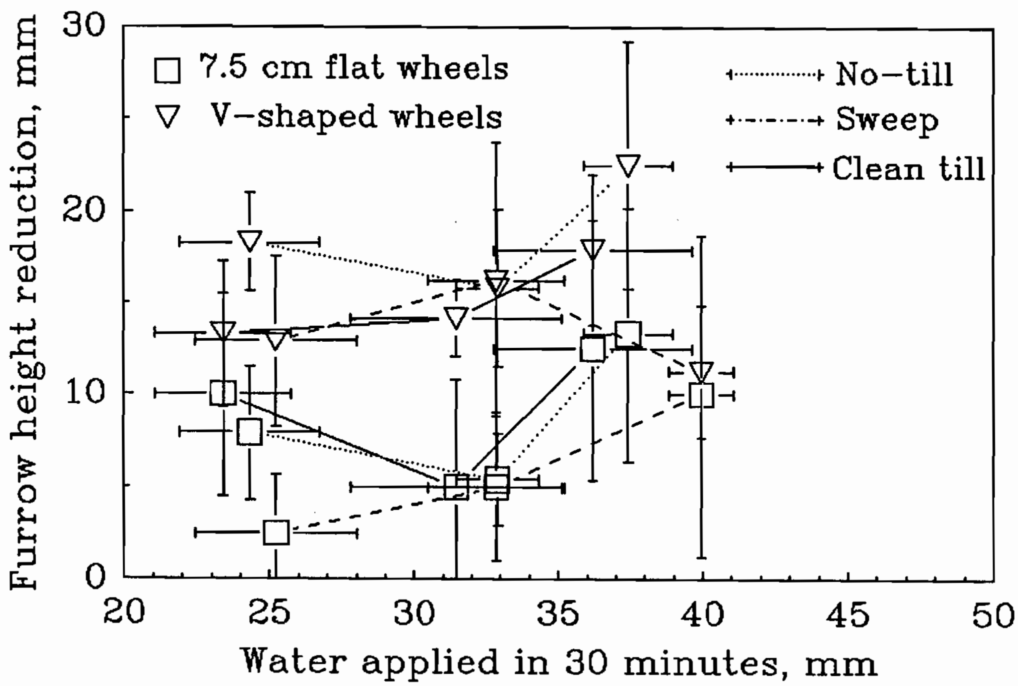

Figure 11. Furrow height reduction of the deeply planted wheat in 1988.