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Winter Wheat Emergence Reduction Following Simulated Rainfall

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ABSTRACT

Rain occurring within a few days of winter wheat (*Triticum aestivum* L.) planting with a furrow drill can significantly reduce plant emergence. A 30-minute, 5-year frequency storm of 30 mm reduced emergence more than 50% 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. An equation was developed to predict plant emergence levels after a heavy rain.

INTRODUCTION

Winter wheat (*Triticum aestivum* L.) 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 very little or no crop residue on the soil surface at planting time. Farmers will commonly till the soil four to eight times using sweep plows, rod weeders, one-way disks, tandem disks or 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.

Winter wheat is planted primarily with grain drills that have disk or hoe-shoe openers at a desired depth of 35 to 50 mm. Typically, the drills will have steel V-shaped press wheels, steel flat press wheels, or rubber flat press wheels among others, all located behind the furrow openers. These drills will push or throw aside the dry surface-soil mulch to form V-shaped furrows with seed placement below the furrow bottoms.

Rain storms occurring after wheat planting can inhibit emergence because soil from the ridge and 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 depth plus the additional eroded soil deposition in the bottom of the furrow that may have also formed a surface seal or crust. Reduced populations of the remaining emerged wheat plants may reduce grain yields the following year.

Increasing intensity and duration of a rain storm increases the amount of soil slump into wheat furrows. High intensity storms generally pond water on the surface sooner, causing saturated soil surface conditions which reduce aggregate stability. Amount of soil eroded also increases generally with storm duration with rain intensity normally declining with time for the longer duration storms. Objectives of this research were to quantify any changes in wheat plant populations caused by 30 minutes of uniform sprinkler-applied simulated rain applied within four days after planting.

METHODS AND MATERIALS

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. Variables in this study were amount of applied water, residue level, tillage, planting depth, and soil texture. Soil texture and planting depth may also affect emergence. The soils, tillage treatments, residue levels, and planting depths are summarized in Table 1. The soils were described by Petersen et al. (1986). Planting depth was measured from the bottom of the furrows to seed placement. Disk treatment plots were actually sweep-plowed during the fallow period and then disked just before planting, which is a common practice. Check plots that received no simulated rain between planting and emergence were also included in the study. No natural precipitation occurred between planting and emergence.

A rainfall simulator similar to a design by Shelton et al. (1985), was used to apply different depths in 30 minutes, an arbitrarily selected time interval. Water application was monitored with a flowmeter to attempt to maintain approximate water application levels, but wind and humidity varied water application amounts somewhat between treatments. The simulator had nine spray nozzles arranged in a three by three array with variable spacing of approximately 2 m. Ground water was used to sprinkle the plots and the water had 350 ppm of total dissolved solids.

The simulator was operated at conditions that produce water drops with velocities and drop sizes similar to rainfall in the Central Great Plains (Shelton et al. 1985). The nozzles used were Spraying Systems Full-jet HH30WSQ which at low nozzle pressures of 14-20 kPa produce a range of drop sizes up to 6 mm. Application uniformity was measured and had Christiansen's (1942) Uniformity Coefficient between 70 to 90%. Water application amounts in the field plots were measured using four catch cans of 15 cm (6 in) diameter. Application amounts between 25 to 50 mm in 30 minutes were used, which correspond to 5 to 50 year annual-frequency storms, respectively (Hershfield 1961) in the U.S. Central Great Plains region.

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 (kg ha^{-1})	Planting Depth (mm)
1987	1	Ascalon	no-till	5860	40—60
		sandy loam	clean-tilled	0	40—60
	2	Weld silt loam	disked	1790	40—60
1988	3	Ascalon	sweep-plowed	4880	40—60
		sandy loam	disked	2060	40—60

Winter wheat was planted at all sites with grain drills that had identical hoe-shoe furrow openers and either V-shaped steel or 75 mm flat rubber press wheels. Row spacing was 280 mm (11 in). The seeding rate was 51 kg ha^{-1} using "Carson" variety in 1987 and "TAM 107" in 1988. Both varieties have a medium-length coleoptile. Simulated rainfall was applied to all plots within 4 days after planting and emergence started seven to ten days after planting. Land slope at all sites was less than 0.5%. Almost all non-infiltrated water ponded in the furrows and eroded soil did not move 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 and tillage. Four replicated tests were made on each plot. Applied water depth was the average of depths collected in the four catch cans for each application. A diagram of the simulator nozzle array, plot layout and catch can location are shown in Figure 1. Plant populations were determined by counting the plants in a 1 meter length of the three middle rows of each plot.

RESULTS AND DISCUSSION

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

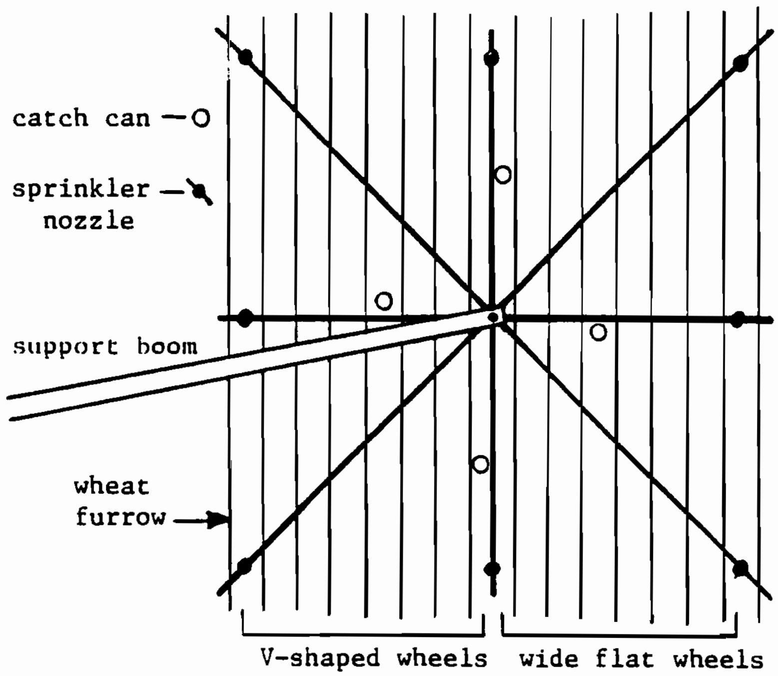

Figure 1. Rainfall simulator sprinkler array, plot layout and catch can location.

The 5860 kg ha^{-1} of crop residue on the soil surface after planting in 1987 or the firmer no-till soil conditions, and the flat press wheels improved plant populations significantly at site 1, as shown in Figure 2. The 1790 kg ha^{-1} of residue in the disked plots at site 2 also caused a lesser but still significant increase in populations over the clean-tilled or V- shaped press wheel plot. Wheat planted with the flat press wheels in the clean-tilled plots (no residue) on the Ascalon sandy loam had similar reductions in plant population 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 were V-shaped and similar to furrows made with the V-shaped press wheels. The surface soil in the clean-tilled plots was so loose that soil moved by the hoe-shoe furrow openers fell back into the furrows behind the flat press wheels. Therefore, flat press wheels appear to have had 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 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 shallower soil deposition over the seed. This shallower soil deposition tended to be most shallow at the center of the furrow, where the drying soil crust would more easily crack and provide easier emergence. The V-shaped furrows did not exhibit this type of soil drying and cracking.

Statistical analysis was made of plant population after emergence among the different tillage and wheel treatments for the different water application levels. Duncan's Multiple Range Test (MRT) of plant population means at the 5% alpha level are shown in Table 2. The no-till, flat wheel treatment is significantly different for all

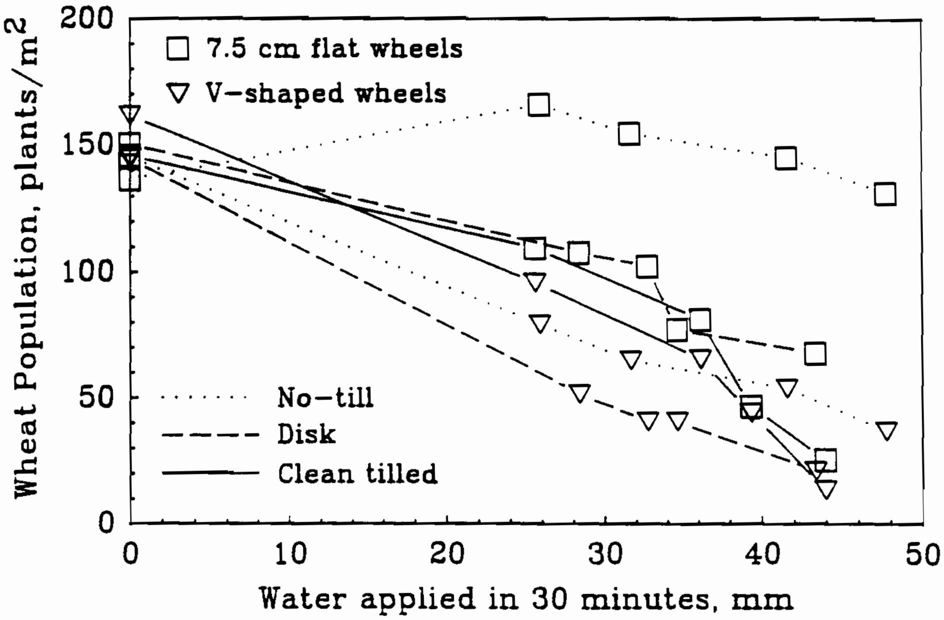

Figure 2. Winter wheat population versus water applied in 30 minutes for sites 1 and 2 from 1987.

treatments, and the flat wheel, disk treatment is significantly different from the V-wheel, disk treatment, for all water levels, so these two treatments will be treated separately. The other four treatments have population means not clearly different among the four water levels.

Plant populations after emergence in the check plots that received no simulated or natural rain were similar and averaged 147 plants m^{-2}. Plant populations on the no-till, flat press wheel plots with the 2 lowest water applications averaged 166 and 155 plants m^{-2}. The applied water may have increased seed germination more than reduced emergence caused by soil sedimentation into the furrow bottoms.

Plant populations (Fig. 3) on a Ascalon sandy loam soil in 1988 (site 3) were similar to those observed in 1987. Again, more surface residue and the use of the flat press wheels increased wheat populations. Average plant population in the dryland check plots was 147 plants m^{-2}. Plant populations for the V-shaped wheel plots and the lowest water application were not statistically different from flat wheel plots with the same tillage as shown in Table 3. However, the flat wheel plots had significantly greater plant population than the V-wheel plots for the same tillage, at the greater water application levels.

Two-year combined results from sites 1, 2, and 3 which had a planting depth of 40 to 60 mm are shown in Figure 4 for the 4 tillage and residue conditions. A single linear-regression line is shown and represents all plots planted with the V-shaped press wheels or in clean-tilled, no residue plots, and is

$$y = 151 - 2.62x, \; r^2 = 0.83 \qquad (1)$$

where, y = winter wheat plant population (plants m^{-2}); x = water applied in 30 minutes (mm); and r^2 = regression coefficient.

Table 2. Duncan's Multiple Range Test of plant population means to the various wheel type and tillage treatments at sites 1 and 2.

		Winter Wheat Plant Population after Emergence (plants m^{-2})							
		Average water (mm) applied in 30 minutes							
Tillage Trt.	Site	26.6		33.5		38.5		45.0	
		Flat wheels							
No-till	1	166	a[1]	154	a	145	a	131	a
Disk	2	108	a	102	b	68	b	77	b
Clean-till	1	109	b	81	bc	46	bc	25	c
		V—wheels							
No-till	1	79	bc	65	bc	54	b	37	c
Disk	2	51	c	40	c	21	cd	40	cd
Clean-till	1	96	bc	65	bc	44	bc	13	d

[1] *Means within a column that are followed by the same letter are not significantly different at the 5% level.*

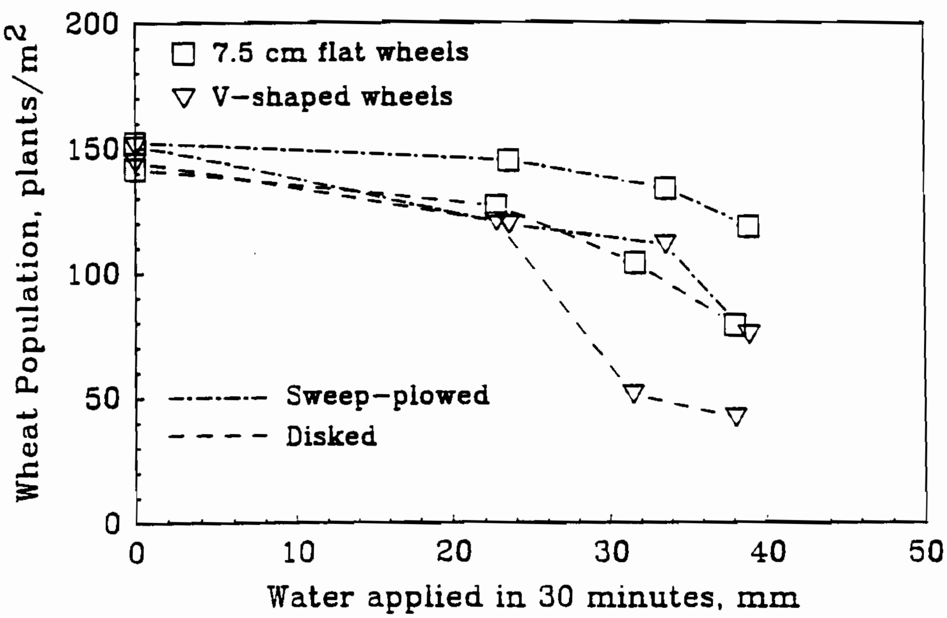

Figure 3. Winter wheat population versus water applied in 30 minutes for site 3 from 1988.

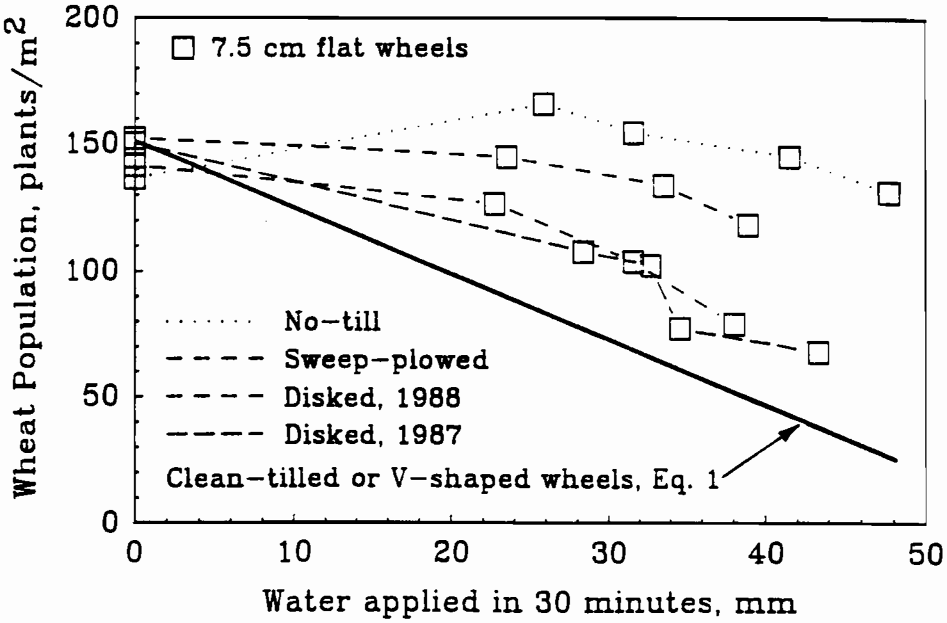

Figure 4. Combined winter wheat population versus water applied in 30 minutes for sites 1, 2 and 3 from 1987 and 1988.

Table 3. Duncan's multiple rage test of plant population means to the various wheel type and tillage treatments at site 3.

Tillage Trt.	Winter Wheat Plant Population after Emergence (plants m^{-2}) Average water (mm) applied in 30 minutes 23.1		32.6		38.5	
	Flat wheels					
Sweep-plow	145	a[1]	154	a	145	a
Disk	127	a	104	a	79	b
	V—wheels					
Sweep-plow	119	a	111	ac	75	b
Disk	120	a	51	b	42	c

[1] *Means within a column that are followed by the same letter are not significantly different at the 5% level.*

The regression equation will be useful for predicting relative differences in winter wheat plant populations 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. Knowing the relationship between plant population and final yield, a breakeven cost analysis can be made to determine what level of population loss in the fall is necessary to justify the cost of replanting.

Soil texture ranging from sandy loam to silt loam appeared to have little effect on wheat populations. 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^{-1} of residue show no significant difference between silt loam and sandy loam soils. Reduced tillage or increased surface residue appear to be the major factors that affect plant population for the same application depth.

SUMMARY AND CONCLUSIONS

Heavy rainfalls occurring within a few days after winter wheat planting significantly reduced wheat plant populations. A 30-mm rainfall in 30 minutes can reduce wheat populations by 50%. Wheat planted with more traditional V-shaped press wheels and wheat planted in clean-tilled. loose soil conditions exhibited significantly greater population reductions with increased water application after planting than plots with residue or planted with flat press wheels. A linear equation of plant population versus water application may be used to predict the decreased plant populations.

Use of wide flat press wheels in reduced-tillage conditions with surface residue significantly increased plant populations. How much of the population differences are due to tillage or due to residue is not known and should be a topic of future research. No-till plots with 5860 kg ha^{-1} of surface residue exhibited a population reduction only when water applications were greater than 40 mm in 30 minutes. Plots that were only sweep-plowed had slightly less plant populations than in no-till plots followed by plots that were sweep-plowed during the fallow season, then disked just before planting.

Reduced wheat emergence is a significant problem if heavy rains occur within a few days after planting. Wheat planted in fields with reduced tillage, increased surface residue and with wide flat press wheels will significantly increase wheat plant populations. If sprinkler irrigation is applied to germinating wheat to guarantee emergence, then flat press wheels should be used in combination with reduced tillage and surface residue.

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