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Water Injection at Seeding of Winter Wheat[1]

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ABSTRACT

Often wheat (*Triticum aestivum* L. em Thell) is grown in areas of limited rainfall, and stand establishment can be a serious production problem when seeding is done in dry soil. These experiments were designed to measure the effect of injecting small amounts of water into the soil seed zone at seeding on the germination, stand establishment, and yield of winter wheat. The experiments were done in the 1979–1980, 1980–1981, and the 1981–1982 growing seasons on a mixed mesic Typic Haploxeroll soil. The soil water potential at seeding was −1.1 MPa in 1979–1980, −0.9 MPa in 1980–1981 and −0.6 MPa in 1981–1982. Water injection rates were either 0, 20,. 40, 50, or 60 mL water/m row. Compared with the 0 rate, injection of any amount of water resulted in faster germination, most treatments gave denser stands, and all but one treatment in one year resulted in greater grain yields. Injection of 50 mL water/m row in 1979–1980 resulted in a 16% yield increase. In 1980–1981 injection of 20 mL water/m row gave a 4% greater yield than the check and injection of 40 mL water/m row gave a 33% yield increase. The soils were wetter in the 1981–1982 growing season and there was no difference between 20, 40, and 60 mL water/m row injection rates; all gave yield increases of 21 to 29%.

***Additional index words:* *Triticum aestivum* L., Stand establishment, Germination, Yield.**

GERMINATION and emergence of winter wheat (*Triticum aestivum* L. em Thell) are critical to crop stand establishment in semiarid areas. Low soil water potentials, often found in seed beds in semiarid areas, result in slow seed imbibition and germination (Collis-George and Sands, 1959). Slow emergence influences seedling vigor and can affect yield (Lindstrom, 1973). Guls and Allan (1978) found that the time required for emergence of wheat nearly doubled for each decrease of water potential of −0.4 MPa, within the range −0.2 to −1.4 MPa. Total stand, coleoptile length, seedling height, and root weight were similarly progressively reduced as water potential decreased.

Possibly one way to improve stand establishment when seeding conditions are dry is injection of water into the seed zone at planting. This could assure rapid seed imbibition and uniform seedling emergence. Information on the effects of adding small amounts of water to the seed zone of wheat at planting is scarce. A study in Wyoming found that water applied to the seed zone of dryland sugarbeets (*Beta vulgaris*) L.) at rates of 420 to 515 L/ha (45 to 55 gal/acre) gave more uniform stands (Anon., 1968). In cotton (*Gossypium hirsutum* L.), water injection increased stand counts 82% over the check and resulted in mean lint yield increase of 41% in 1974 and 26% in 1975 (Fowler, 1979). In a greenhouse study of wheat germination, Estes (1979) found that adding water to the seed zone increased both percent emergence and the rate of emergence over the range of soil water potential of −0.5 to −2.0 MPa.

Because of relatively low annual precipitation in Oregon's Columbia Basin (270 mm), a wheat-fallow rotation is generally used as a way to store some moisture from the fallow year in the subsurface soil so it can be used by the wheat in the following year. The surface soil in the fallowed land can become extremely dry and sometimes seeding must be done into that dry soil layer, even though there may be moist soil at lower depths. Under those conditions, stand establishment can be a problem. In the area where the field experiments reported herein were conducted, the soil moisture in the seed zone at planting is usually in the range of 7 to 9% by weight. This is equivalent to a soil water potential of −1.5 to −0.5 MPa.

In this experiment the effect of water injection on stand establishment and grain yield of winter wheat planted in dry soil was measured to determine the potential usefulness of water injection as a crop cultural practice.

MATERIALS AND METHODS

Experiments were conducted during the 1979–1980, 1980–1981, and 1981–1982 growing seasons at Oregon State University's Sherman Experiment Station at Moro, OR to determine the effect on the emergence and yield of wheat by water injection along with the seeds when seeding wheat in dry soil. We conducted our study on fallowed land in all 3 yr and also on nonfallowed land (nf) in 1981–1982.

The annual precipitation in the year preceding each crop (the fallow year) was 217, 275, and 307 mm, respectively. This resulted in average seed zone (0.05 to 0.15 m depth) soil water contents at seeding in the fallowed soil of 7.5, 7.9, and 8.5% (determined gravimetrically), for the 3 yr. These soil water contents were equivalent to soil water potentials of −1.1, −0.9 and −0.6 MPa, estimated from the moisture retention curve for the Walla Walla silt loam soil (a mixed mesic Typic Haploxeroll). In the 1981–1982 crop year, we also seeded into nonfallowed soil from which a wheat crop had just been harvested. It had a seed zone soil water content of 8.0% and soil water potential of −0.8 MPa.

In all the experiments reported herein the wheat was planted using an experimental tiller/drill, which was equipped to till the soil, plant the seed, and inject a measured amount of water into the seed furrow as the seed were dropped. The tiller/drill was equipped with rotary tiller blades, which tilled a 0.10-m wide band of soil. These blades were spaced 0.45 m apart. The soil between the tilled strips was left undisturbed. Disc openers opened a seed furrow in the narrow tilled strip, the seed were dropped in the furrow, and the water was injected into the bottom of the furrow. The seed was then covered with soil and a compacting wheel compacted the soil around the seed. Sixty seeds were dropped per meter of row (65 kg/ha). After compacting the soil, the seed were at a depth of 0.05 m below the soil surface.

Uniform-sized seed were selected for planting. Germination tests showed that > 96% of the seed were viable. The cultivar used was Stephens, a soft, white awned, semidwarf winter wheat with superior yield potential.

The experimental design for all of the experiments was a randomized block with four replications. Each plot consisted of six rows, 0.45 m apart and 10 m long. Three interior rows were harvested for yield. The experiments each year were conducted and analyzed separately. Also, in 1981–1982 the

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experiments on fallowed and nonfallowed soil were independent experiments.

The water injection treatments used in the field trials were different in each of the 3 yr. In 1979–1980, two treatments were used, 0 and 50 mL water/m row. In 1980–1981 three treatments were used, 0, 20, and 40 mL water/m row. In 1981–1982 the experiments on both the fallowed and the unfallowed soil consisted of four treatments: 0, 20, 40, and 60 mL water/m row.

The plots were planted on 20 Sept. 1979 and 1980 and 9 Oct. 1981.

The number of seedlings that had emerged from the soil were counted 14 days after planting. These data have been called *initial emergence.* They show the differences in the rate of germination between the treatments. Stand counts were made later in the fall or in early spring, after germination was complete, and the percentage of seed that resulted in established seedlings was calculated. These data are called *final emergence.*

Measurements of seed imbibition and of the seed zone water contents were made on the 1981–1982 crop at 0, 6, 12, 24, and 48 h after seeding. Soil moisture was obtained gravimetrically by taking a soil probe in the row at a depth of 0.05 to 0.15 m. The samples were dried at 105 °C for 1 day. The seed moisture content was determined by weighing seed recovered from 1 m of row before and after drying for 2 days in a forced-air oven at 60 °C.

RESULTS AND DISCUSSION

The effect of the water injection treatments on the percentage of seedlings that had emerged from the soil 2 weeks after planting (initial emergence) and on the percentage of seed that finally germinated (final emergence) are shown in Fig. 1 and 2. All water injection rates gave greater initial and final emergence than the check treatment (0 mL/m row). All of these responses were significantly different from the check, except the effect of the 20 mL/m row rate on final emergence in the nonfallowed soil in 1981–1982. The seed zone soil moisture potential ranged from −0.6 MPa in the fallowed soil in 1981–1982 to −1.1 MPa in the 1979–1980 experiment. Thus, injecting small amounts of water with the seed affected germination of wheat over a range of soil moisture potentials.

In the relatively wet 1981–1982 fallowed soil plots, injecting 20 mL water/m row had the same effect on both initial emergence and final emergence as injecting greater amounts of water. In contrast, in 1980–1981, when the soil moisture potential was −0.9 MPa, there was a large difference between the effect of 20 and 40 mL/m row injection rates on initial emergence, and the final stands were also significantly different (Fig. 1 and 2). Thus, it is clear that the rate of water injection necessary to obtain maximum stands depends on the amount of moisture in the soil at seeding.

The effect of these relatively small amounts of water on germination and stand establishment were impressive. In the 1981–1982 growing season we at-

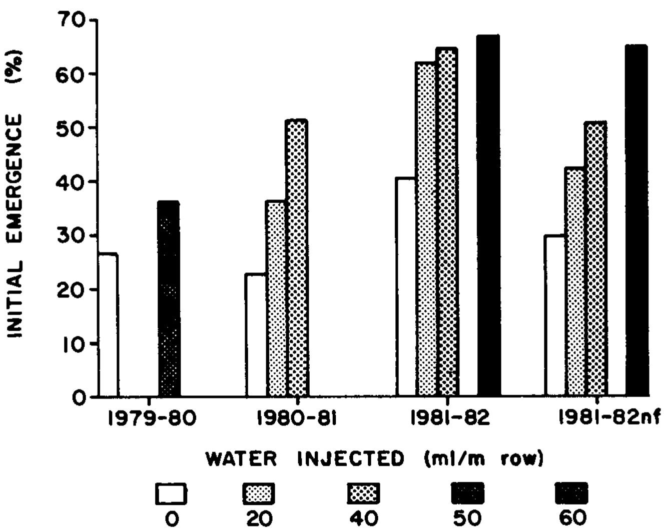

Fig. 1. Emerged wheat seedlings 2 weeks after planting (initial emergence), as a percent of the seeds planted, for the various rates of water injection in three different growing seasons. Two experiments were conducted in 1981–1982, one on previously fallowed soil as in the other 2 yr, and one on nonfallowed soil (designated *nf*).

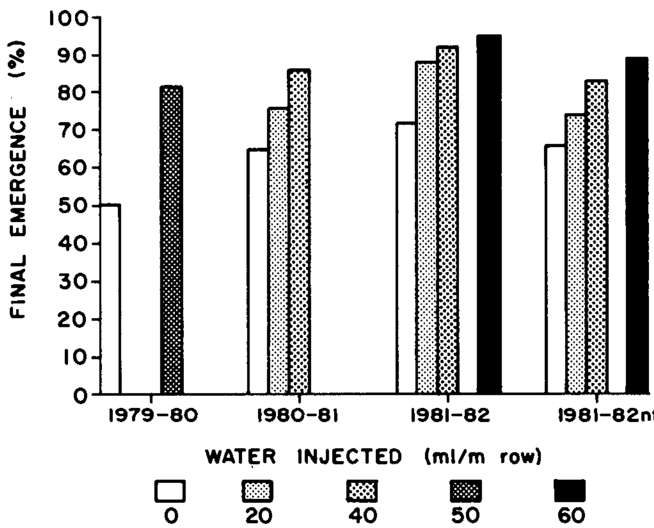

Fig. 2. The final emergence of wheat seedlings as a percent of the seeds planted, for the various rates of water injection in three different growing seasons. Two experiments were conducted in 1981–1982, one on previously fallowed soil as in the other 2 yr, and one on nonfallowed soil (designated *nf*).

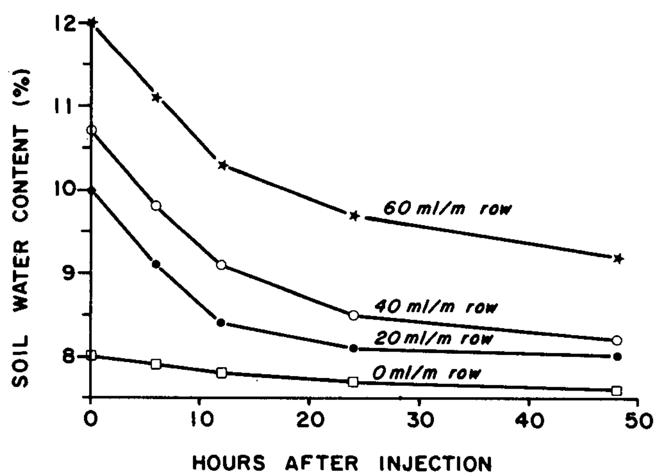

Fig. 3. Percent soil water content, after injection of water at various rates, in relation to time (hours) after injection into the previously nonfallowed soil in 1981–1982. The soil cores for determining water content were taken in the row at a depth of 0.05 to 0.15 m, which included the point where the water was injected and the soil immediately beneath it.

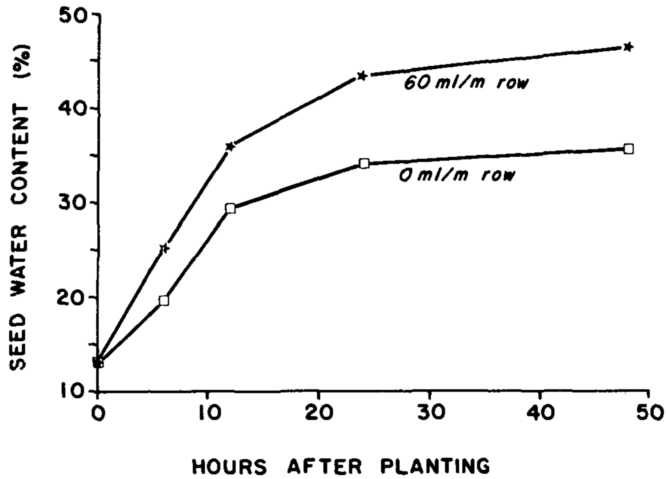

Fig. 4. Percent seed water content in relation to time (hours) after planting for the 0 and 60 mL/m row injection rates into the nonfallowed soil in 1981-1982. The results for other water injection rates were intermediate to the results for these two treatments and are not shown.

Table 1. The effect of injection of water at planting on the grain yield of 'Stephens' winter wheat.

	Soil at seeding			
	1979-1980	1980-1981	1981-1982	
Water injected	Fallowed −1.1 MPa	Fallowed −0.9 MPa	Fallowed −0.6 MPa	Nonfallowed −0.8 MPa
mL/m row	yield, kg/ha			
0	3243	2667	3767	2762
20		2770	4562	2840
40		3659	4547	3485
50	3757			
60			4565	3640
LSD (0.05)	79	54	251	229

tempted to show how these small amounts of water could have these relatively large effects. Our first attempt to analyze the mechanism of the effect of the injected water was made by taking 2.54-cm diam soil cores in the row where the water was injected. These soil cores were 0.1 m in length, giving a core of soil through the injected depth (0.05 m) and immediately below it. The results of these soil probes for the nonfallowed soil in 1981-1982 are shown in Fig. 3 for the check and for the 20, 40, and 60 mL water/m row injection rates. The immediate effect of the injection was to increase the soil water content, of course. The soil then dried over time. The check, which received no water, also was drying over time, probably because it had been tilled and a new equilibrium was being established. The significant point to be derived from Fig. 3, however, is that the added soil moisture raised the moisture content of the seed-zone soil, and that difference, although diminishing in magnitude with time, persisted for at least 48 h.

The soil probes from the wetter fallowed soil in 1981-1982 gave a family of curves essentially the same as those shown in Fig. 3, but displaced by 0.5% greater soil moisture at all points in time. At the same times that we took the soil moisture probes we also recovered the wheat seed from the soil and determined its moisture content. The results for the 0 and 60 mL water/m row rates in the nonfallowed soil are shown in Fig. 4. The results for other injection rates were intermediate to the two curves shown, and the results for the fallowed soil treatments gave similar shaped curves, with the seed moisture content being slightly higher for all injection rates at all times. The seed in the soil increased rapidly in moisture content in all treatments. The increase was most rapid in the wetter soil, of course. In the 60 mL water/m row treatment the seed reached the 40% moisture content needed for germination to commence (Brown, 1965) in about 12 h. In contrast, the moisture content of seeds in the 0 mL/m row treatment had 30% moisture after 12 h. After 12 h the rate of imbibition was much slower in all treatments. In the check treatments the seed contained only 34% moisture after 48 h. Obviously, germination should be much slower in that treatment and the results shown in Fig. 1 demonstrate clearly that expected difference.

Yield in wheat is a complex process and may not necessarily be directly related to stand. Thus, it was of particular interest to see if the differences in germination rate and final emergence induced by the water injection treatments would be reflected in grain yields. Table 1 shows the grain yields for the different water injection treatments conducted over three growing seasons. In 1979-1980, the injection of 50 mL H_2O/m row gave a 16% increase in yield. In 1980-1981, the 20 mL water/m row rate yielded 4% higher than the check, and the 40 mL water/m row rate yielded 37% greater than the checks. In 1981-1982, there were no significant differences in yield in the fallowed soil between 20, 40, and 60 mL water/m row rates, but they averaged 21% greater yield than the 0 mL water/m row rate. In the drier nonfallowed soil, the 20 mL water/m row rate did not affect yield, but the 40 and 60 mL water/m rates yielded 29% greater than the check yields.

These yield differences are surprisingly large for such small amounts of water injected at planting. Thus, it appears possible that water injection with the seed when seeding into dry soil could give significant economic returns, and further testing of this concept seems warranted.

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