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Laboratory Method to Evaluate Wheat Seedling Emergence from Deep Planting Depths

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ABSTRACT

Planting depth effect on seedling emergence is an important concern for many crops grown around the world. Farmers in the low-precipitation (<300 mm annual) winter wheat (*Triticum aestivum* L.) (WW) production region of the Inland Pacific Northwest of the United States (PNW) plant seed as deep as 20 cm below the surface of summer-fallowed soils with deep-furrow drills to reach adequate seed-zone moisture. Seedlings need to emerge through 12 to 15 cm of soil cover, most often under marginal seed-zone water potentials. Successful stand establishment is the most critical factor affecting WW grain yield potential in the region. We developed a laboratory method to accurately assess WW emergence from deep planting depths in pots. To test the methodology, we first conducted a 4-yr field experiment to measure emergence of four WW cultivars having either standard-height or semi-dwarf growth habit. Depth of soil cover over the seed was 14 cm and seed-zone water potential over the 4 yr ranged from very dry (−0.69 MPa) to wet (−0.40 MPa). Next, a factorial laboratory pot experiment was conducted using the same WW cultivars and soil seed-zone water potentials similar to those during the 4 yr in the field. Statistical comparison between field and laboratory emergence data showed a strong correlation ($r = 0.71$, $p < 0.01$) for median time to emerge. We describe the step-by-step procedure for conducting a laboratory pot experiment to measure WW emergence from deep planting depths under a wide range of water potentials.

Core Ideas

- Stand establishment is the biggest factor afffecting winter wheat yield in the low-precipitation region.
- Winter wheat seed is planted as deep as 20 cm below the soil surface to reach adequate soil moisture.
- Determination of a cultivar's emergence ability in the field is limited to a short time window once a year.
- We developed a laboratory method to to accurately measure emergence in pots from deep planting depths.
- Laboratory and field results were strongly correlated under a wide range of soil water potentials.

Deep planting of wheat after long fallow periods is common in many rainfed Mediterranean cropping regions of the world including the PNW (Douglas et al., 1992), several countries surrounding the Mediterranean Sea (Mahdi et al., 1998), southeastern and southwestern Australia (Rebetzke et al., 2007), and central Chile (Brunel et al., 2013). Farmers in the low-precipitation region of the PNW use deep-furrow drills to place seed 10 to 20 cm beneath the soil surface with as much as 15 cm of soil covering the seed.

A 2-yr winter wheat–summer fallow (WW–SF) rotation is practiced on >90% of the 1.56 million rainfed cropland hectares in the low-precipitation region of east-central Washington and north-central Oregon. Winter wheat is harvested in July through early August and the field then left fallow for 13 to 14 mo until WW is again planted in late August or early September into water stored in the soil during the fallow period. The climate is Mediterranean-like with cool, wet winters and hot, dry summers. Considerable surface soil drying occurs during July through September (Jury and Miller, 1974); thus the need for deep placement of WW seed to reach adequate seed-zone water (Donaldson, 1996).

If satisfactory WW stands cannot be achieved from deep planting in late August–early September, farmers will plant WW at a shallow depth of 2 to 3 cm into dry soil around mid-October and wait for the onset of fall rains. Such late planting reduces WW grain yields by 35 to 40% compared to early planted WW in east-central Washington (Higginbotham et al., 2011; Higginbotham et al., 2013), but this delay is not nearly as detrimental to grain yield potential in north-central Oregon (Bolton, 1983; Machado et al., 2015) where temperatures are warmer in the fall, winter, and spring.

Winter wheat cultivars grown in the PNW can germinate at water potentials as low as −1.25 MPa (Wuest and Lutcher, 2012; Singh et al., 2013), but a minimum water potential of −0.55 to −0.65 MPa is generally required for WW seedling emergence through 12 to 15 cm of soil cover (Lindstrom et al., 1976; Schillinger et al., 1998). Due to thick soil cover over the seed, it is not the coleoptile that emerges from the soil but rather the first leaf after pushing through the tip of the coleoptile. The first leaf is thin, has weak structural support and, since most often emerging under low soil moisture conditions, lacks much emergence force or lifting capacity (Arndt, 1965).

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Abbreviations: DAP, days after planting; PNW, Inland Pacific Northwest of the United States; SF, summer fallow; WSU, Washington State University; WW, winter wheat.