Field Crops Research 125 (2012) 109–116

Contents lists available at SciVerse ScienceDirect

Field Crops Research

journal homepage: www.elsevier.com/locate/fcr

Can using polymer-coated seed reduce the risk of poor soybean emergence in no-tillage soil?☆

R.W. Gesch[a,*], D.W. Archer[b], K. Spokas[c]

[a] USDA-ARS-North Central Soil Conservation Research Lab, 803 Iowa Ave., Morris, MN 56267, USA
[b] USDA-ARS-Northern Great Plains Research Lab, Mandan, ND, USA
[c] USDA-ARS-Soil and Water Management Research Unit, St. Paul, MN, USA

ARTICLE INFO

Article history:
Received 4 May 2011
Received in revised form 1 September 2011
Accepted 2 September 2011

Keywords:
Soybean
Seedling emergence
Polymer seed coating
Sowing date
No-tillage

ABSTRACT

Adoption of no-tillage in the northern Corn Belt has lagged behind other regions because of slow warming and drying of soils early in the spring coupled with a short growing season. Cold, wet soil can lead to seed damage resulting in poor stand establishment. Because of slow warming and drying, no-tilled soils are typically sown later than conventionally tilled systems thus often requiring the use of early maturing crop cultivars. Temperature-activated polymer seed coatings might allow soybean [*Glycine max* (L.) Merr.] to be sown earlier than normal under no-tillage while protecting seed against damage caused by cold, wet soil and perhaps allow the use of later maturing cultivars. These ideas were tested during 2005 and 2006 in west central MN on a Barnes loam no-tilled soil previously cropped in corn (*Zea mays* L.). Polymer-coated seed of a maturity group (MG) 0 and I soybean were sown as early as possible (early- to mid-April) and at an average recommended time (mid-May) for the study site. Only in 2005 did the polymer coating significantly increase emergence ($p < 0.0001$), where maximum emergence of early sown polymer-coated seed of the MG 0 and I cultivars was 51 and 35% greater than their uncoated counterparts. Conversely, for the average sowing date in 2006, under unusually dry conditions, the polymer coating slowed seedling emergence and reduced maximum emergence, although yield was not affected. Laboratory incubations confirmed that the germination delay of soybean caused by the polymer-coating increased by decreasing initial osmotic moisture potentials. The MG I soybean out yielded the earlier maturing cultivar in both years, but sowing date did not have a significant effect either year. Results indicate that temperature-activated polymer-coated seed may reduce the risk of poor stand establishment in no-tilled soil in instances where low soil temperatures cause seed to remain in the soil for an extended time before emerging.

1. Introduction

No-tillage in cropping systems has become a relatively common practice. No-tillage or reduced tillage practices prevent soil erosion (Lal et al., 2007) and can help conserve and/or build soil carbon and reduce CO_2 emissions (Al-Kaisi and Yin, 2005; Gesch et al., 2007). Reduced tillage can also lead to greater profitability in corn–soybean rotation systems (Buman et al., 2004; Archer and Reicosky, 2009). Yet, the adoption of no-tillage in the northern Corn Belt has lagged seriously behind other regions primarily because of the slow warming and drying of soils in early spring coupled with a short growing season. In west central MN, soil can remained covered in snow until mid-April or frozen until mid-May (Sharratt, 2002). Johnson and Lowery (1985) compared soil temperatures at depths from 5 to 15 cm for different tillage systems in Wisconsin and found that soil temperatures decreased with reduced tillage. They reported that daily average temperature was as much as 5.9 °C lower in no-tilled compared to moldboard plowed soil in early May. Because no-tillage soils take longer to warm they are often sown later, thus requiring earlier maturing crop cultivars that have less yield potential than later ones (Popp et al., 2002).

Timely establishment of crops such as corn and soybean, especially in regions with short growing seasons, is critical for maximizing seed yields. Moreover, sowing as early as possible optimizes the use of full-season crop cultivars (Torbert et al., 2001). However, sowing too early when soil temperatures are not conducive for good germination can lead to poor emergence and hence stand establishment. Increasing the time that seed or seedlings

☆ Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture. USDA is an equal opportunity provider and employer.

* Corresponding author. Tel.: +1 320 589 3411x132; fax: +1 320 589 3787.
E-mail address: russ.gesch@ars.usda.gov (R.W. Gesch).

0378-4290/$ – see front matter. © 2011 Published by Elsevier B.V.
doi:10.1016/j.fcr.2011.09.005

remain in the soil prior to emergence increases the occurrences of damage leading to death or decreased seedling growth rates (Shaw, 1977; Gesch and Archer, 2005). Sparse or uneven plant stands can reduce yields in crops such as corn (*Zea mays* L.) (Nafziger et al., 1991; Ford and Hicks, 1992), although soybean tends to be less affected (Egli, 1993) due to its yield plasticity (Egli, 1988). The optimum temperature range for soybean seed germination is about 25–35 °C with 10 and 40 °C being the lower and upper limits, respectively (Hatfield and Egli, 1974). Soil moisture in addition to temperature can be an important determinant of soybean emergence. As demonstrated by Helms et al. (1996), low soil water content at sowing for an extended period can significantly reduce soybean emergence, which is exacerbated by temperature stress.

A temperature-activated polymer coating has been developed for corn and soybean seed that offers the potential to allow for earlier than normal sowing and has been promoted for use in no-tillage systems (Hicks et al., 1996; Lessiter, 2000). Archer and Gesch (2003) reported that the use of polymer-coated seed for early sowing in MN could increase farm profits through reducing yield-loss due to late planting and increasing crop yields by the use of longer season cultivars. The seed coating is designed to restrict water entry by interaction of hydrophilic surface groups on the polymer until a critical temperature is reached, upon which these hydrophilic chains break-down and allow water to pass through the coating (Hicks et al., 1996). Thus, this technology could potentially protect seeds against damaged caused by extended exposure to cold wet soils allowing for early sowing (Watts, 1974; Zaychuk and Enders, 2001). Indeed, Gesch and Archer (2005) found that temperature-activated polymer-coated corn in west central MN could be sown as much as 4–5 weeks earlier than average without significantly sacrificing stand establishment. However, because the polymer coating delays germination and emergence, it may have negative consequences on plant stands, especially for soybean, if sown too late into warm soil (Sharratt and Gesch, 2008).

The objective of this study was to determine the effect of a temperature-activated polymer coating on emergence and yield of soybean sown as early as possible and at an average time in a no-tilled soil; and secondarily, to determine the potential to extend the maturity group (MG) of soybean grown for the region using ultra-early sown polymer-coated seed. In west central MN the average or normal time for sowing soybean is mid-May.

2. Materials and methods

2.1. Cultural practices

The study was conducted during 2005 and 2006 on a Barnes loam soil (fine-loamy, mixed, superactive, frigid Calcic Hapludoll) at the Swan Lake Research Farm located 24 km northeast of Morris, Minnesota (45°35′N, 95°54′W). The experimental design was a split plot randomized complete block with four replications. The main plots were planting date and the subplots consisted of cultivar by seed coating combinations. Individual plot size was 3 m × 7.6 m. Two different maturity group (MG) soybean cultivars were used in the study. An MG 0 cultivar (Croplan Genetics RT0874), which is characteristic of what is typically grown in west central MN, and a later maturing genotype, MG I (Croplan Genetics RC1812). Both cultivars were sown as early as possible in the spring and at an average or typical time based on recommended management practices for the region, which were April 6 and May 20 in 2005 and April 18 and May 16 in 2006. Polymer-coated and uncoated seed were sown at a population of 445,000 ha^{-1} on rows spaced 76 cm apart (four rows per plot) into no-tillage soil previously cropped in corn. The corn stalks were chopped to a height of about 10–15 cm prior to sowing soybean. The coatings were thin enough that they did not affect seed size or sowing. No fertilizer was added to the soil and a post-emergence application of N-(phosphonomethyl)glycine at 1.1 kg ai ha^{-1} was made for controlling weeds.

The temperature-activated polymer coating was made and applied by Intellicoat Corporation (a division of Landec Ag, Menlo Park, CA). Before coating, all seed were treated with mixture of Rival (*N*-(trichloromethylthio)cyclohex-4-ene-1,2-dicarboximide + 2-(4′-thiazolyl)benzimidazole + pentachloronitrobenzene), and RTU-Vitavax-Thiram (5,6-dihydro-2-methyl-N-phenyl-1,4-oxathiin-3-carboxamide + tetramethylthiuram disulfide). Two different coating weights were applied to seed, one consisting of approximately 10 g polymer kg^{-1} seed, referred to as a light coat (L), and the other consisting of approximately 15 g polymer kg^{-1} seed referred to as a heavy coat (H). New seed was received and germination tested each year before sowing (germination was 92–94%).

2.2. Soil temperatures and plant measurements

Soil temperature was measured at depths of 0, 5, and 10 cm within the plant row using thermocouple arrays as described by Gesch and Archer (2005). The thermocouples were installed the same day that the earliest planting was made each year. There were two thermocouple arrays placed in each of three of the four experimental blocks for a total of six arrays. Thermocouple arrays were monitored every 60 s and 15-min averages were recorded with a data logger (CR10X, Campbell Scientific, Logan, UT). After installing the arrays, every effort was made to replace the same amount of residue to the soil surface as was there before installation.

Seedling emergence was measured in 1-m of a center row in each plot which was marked before emergence. Once seedlings began to emerge, emergence was measured daily until there was no change, and the percent emergence reported is based on the number of seed sown in 1-m of row.

Three plants from each plot were sampled at the R6 reproductive stage for measuring total dry matter accumulation, node number, and pod number per plant. Averages of the three plants per plot (i.e., treatment replication) were used for statistical analysis. Soybean was harvested for seed yield and moisture with a plot combine by taking the two center rows. Harvest dates were October 3 and October 11 for the early and average sowing dates, respectively, in 2005 and October 2 for both sowing dates in 2006.

Seed oil and protein content were determined using pulsed NMR (Bruker Minispec pc120, Bruker, The Woodlands, TX). Duplicates of 5-g of whole seed per plot were measured (duplicates were averaged). Before analysis, the instrument was calibrated with pure soybean oil and with seeds of known protein content.

2.3. Laboratory germination tests

Evidence from the field study indicated that soil moisture potential might affect the responsiveness of polymer coatings even when low temperature was not a limiting factor. This prompted us to test the effects water potential on soybean germination under non-limiting temperature. Coated and uncoated soybean seeds were incubated on filter paper (Whatman No. 3) saturated with PEG solutions to simulate water potentials of −0.05, −0.25, and −0.75 MPa (Michel and Kaufmann, 1973). Seeds were germinated in covered Petri dishes (20 seeds/treatment, three replicates) on a laboratory table in a completely random design (average daily temp = 22 °C). Seed germination was counted daily (24 h intervals). An exposed radical length of 2 mm from the seed coat or seed was used as the germination criteria. The number of new seedlings was recorded