Precision Planting:
Soil Texture Effect on Corn Emergence

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Proposal submitted to:	Dr. Tyson Ochsner Oklahoma State University, Department of Soil Physics Course Director of SOIL 5110 "Soil Physics Practicum"

Project Overview

Corn seed planting depth has been identified to be one of the major factors determining emergence rate and emergence uniformity. Liu et al. (2004b) showed that temporal emergence variability of corn significantly impacts yield. Corn producers throughout the world follow their instincts, experience, guidelines and best-practice recommendations (Clay et al. 2009) to plant their valuable seeds at the optimal depth for an ideal start towards maximized harvest. The eventual stand uniformity depends to a large degree on factors that cannot be influenced like the weather conditions in the ten to fifteen days post-seeding: soil temperature and available moisture are central ingredients to a successful germination and emergence of the corn plant (Alessi et al., 1971, Carter et al., 1989) and have to date dictated the guidelines for planting depth. On-going research efforts in precision planting of corn at Oklahoma State University's Department of Biosystems and Agricultural Engineering are targeted at minimizing emergence variability by tightly controlling an optimal planting depth based on those soil properties that drive the emergence variability. While crude models for soil moisture and temperature with respect to planting depth exist, the effect of soil texture on emergence with respect to planting depth is unknown (Figure 1). The availability of a correlated model for corn planting depth depending on soil texture would bring forward the understanding of design requirements for machinery supporting precision depth planting.

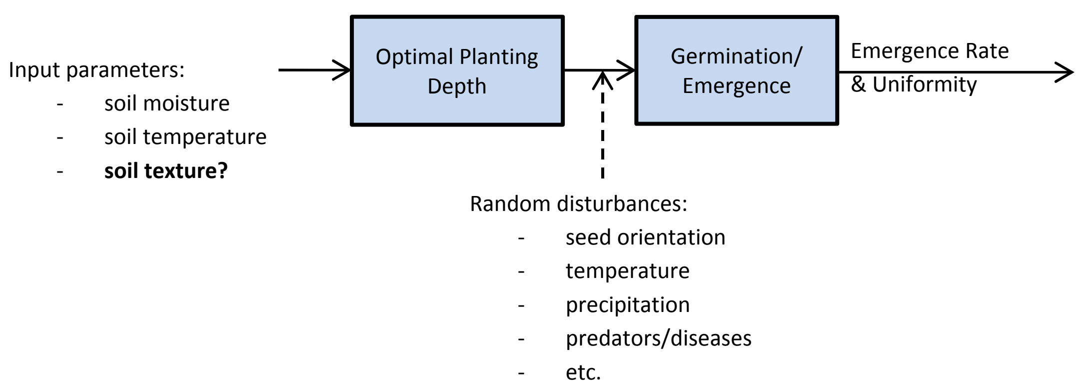

Figure 1: The relationship between soil texture and corn emergence rate and uniformity due to planting depth is not known.

Nature, Scope, and Objectives of the Project

The *long term* goal of the Precision Planting Team at Oklahoma State University's Department of Biosystems and Agricultural Engineering is to develop and implement corn precision planting equipment that eventually leads to increased yield per input. With planting standing at the very beginning of the corn production cycle, the quality of the seeding is a precondition for maximum yield. Precision depth and in-row position as well as seed orientation control, resulting in uniform plant spacing, emergence, and leaf azimuth alignment, are expected to result in significant yield benefit.

By identifying the effect of soil texture on corn emergence, this team can contribute in the context of this class a crucial building block towards the establishment of a correlated model that describes the complex relationship between soil properties and corn emergence in dependence of planting depth. The proposal team is well prepared to succeed with this project due to its unique combination of skills and experience in soil analysis methods, experiment design, and project management.

Therefore, the following specific research objectives are proposed for this project:

Specific Objective #1: Determine the fundamental properties of three soil textures commonly considered suitable for corn production. In-field and lab experiments will be conducted to characterize each soil type.

Specific Objective #2: Determine the effect of these soil textures on emergence rate and emergence uniformity of corn. Growth chamber experiments will be conducted for three different soil textures, and emergence rate and uniformity will be documented.

Statement of Results or Benefits

The proposed research project is a truly unique research opportunity for a class setting because it provides the opportunity to train students on soil physical analysis methods while making a significant contribution to an existing high-profile research project that is on-going at this institution. This project will provide students with opportunities to learn to use a wide range of laboratory equipment and apply fundamental soil analysis methods. They will acquire skills using a hydrometer, electrical conductivity and pH probes, and methods to calculate germination rates, bulk density, and soil moisture content. Furthermore, the conduction of an entire growth chamber experiment will enhance the students' overall knowledge foundation for future research endeavors beyond soil science by introducing them to experiment design and project management. At the completion of this investigation, it is expect that the relationship between soil texture and corn emergence in dependence of planting depth is described and correlated to such a degree that it can be implemented in higher-order models that eventually enable closed-loop control of precision depth planting.

Related Research and Significance of the Proposed Work

Intuitively, planting quality affects plant stand uniformity which influences yield results. Liu et al. (2004a) documented the impact of planter and planting quality on yield and found that variability in emergence lowers yield significantly. Precision seed placement (Nielson, 2004) and orientation (Patten et al., 1970; Toler et al., 1999) are expected to result in significant improvement in corn yield per input. Precise control of the optimal seeding depth in dependence of the local soil properties is expected to contribute significantly towards emergence rate and uniformity. While Nasr et al. (1994) showed that aggregate size, bulk density, and penetration resistance affect emergence of wheat, the effects of soil texture on corn emergence are unknown. The identification of this model makes a significant contribution towards the development of soil property dependent models of optimal planting depth for corn, eventually enabling the closed-loop control of planting depth.

Materials and Methods

Germination Test

A germination test will be first conducted to verify the germination rate of the seeds using the rolled paper towel test (ISU-STL) at 25^{o}C on the maize (Zea mays L.) hybrid DeKalb 6172.

Growth Chamber Experiment

Three soil types (clay loam, silt loam, loamy sand) will be located with of the use of the Web Soil Survey (NRCS, 2009) on the Oklahoma State University Agronomy Farm in Stillwater, OK and various locations in Payne County, if needed, to represent the different field textures experienced by corn farmers in Oklahoma. After location of the selected soils, hand tools will be used to collect enough samples from the top 15 cm of soil surface to represent our seed beds in the growth chamber experiment. The soil will be sampled for bulk density using the core method for comparison with the seed beds later.

After collection of soils, each soil type will be analyzed using the hydrometer method (Gee and Bauder, 1986) to verify the textural class. Soils will also be analyzed for electrical conductivity (1:1) and pH (1:1) at this time. Soils to be used in the experiment will be sieved prior to drying from the field through an 8 mm sieve to assure a more uniform aggregate size between the soil types, thereby producing a more typical seedbed resembling real life conditions. Soils will then be air dried to assure a consistent moisture level. Multiple samples of the air dried soils will be analyzed for moisture content with the thermogravimetric method (Topp and Ferre, 2002) to assure proper moisture additions after seed planting. After drying, the soils will be placed in 2.4 L plastic containers (painter's mixing buckets) to a total depth of the 15 cm and packed to a desired bulk density of 1.3-1.4 g/cm^3.

Five corn seeds (Dekalb 6172) will be planted per container with all seeds placed at the same depth on a container basis. Four different depths of planting will be used (1.27, 2.54, 3.81, 5.08 cm). Seeds will be planted by inserting and removing a sharp pencil into the proper soil depth resulting in a hole where the seed will be placed proximal end down with tweezers. The seeds will be covered with soil in the best possible manner to resemble typical field conditions and maintain consistent bulk density. After planting soil moisture will be adjusted to and held at 30 % moisture for the rest of experiment. Watering will be performed from the bottom up.

The containers will be placed in a growth chamber with 12 hours of dark at 12.8 ^{o}C and 12 hours of light at 18.3 ^{o}C for 10 days or until all seeds have emerged. The entire experiment will be conducted twice at different time periods to eliminate any temporal errors, following the same procedures and reusing all materials.

Budget

The project is expected to accumulate the cost depicted in Table 1.

Table 1: Project budget breakdown.

Supplies and Equipment		
Item		*Cost* (USD)
Controlled Environment Room, Oven	0	
Hydrometer, pH meter, Electrical Conductivity (EC) meter	0	
Brass Rings (7.62x7.62 cm)	0	
Three soil types	0	
48 2.4 L Planting containers, water dispersing pipes,	110	
5 20 L buckets	30	
1000 Dekalb 6172 corn seeds	0	
Subtotal: Supplies and Equipment		**140**
Travel Expenses		
Item		*Cost* (USD)
Two days for soil collection (USD 45/day)	90	
100 miles trip	45	
Subtotal: Travel Expenses		**135**
Total Project Cost		**275**

Timeline of Activities

Subsequently, the proposed project schedule is depicted in Figure 2.

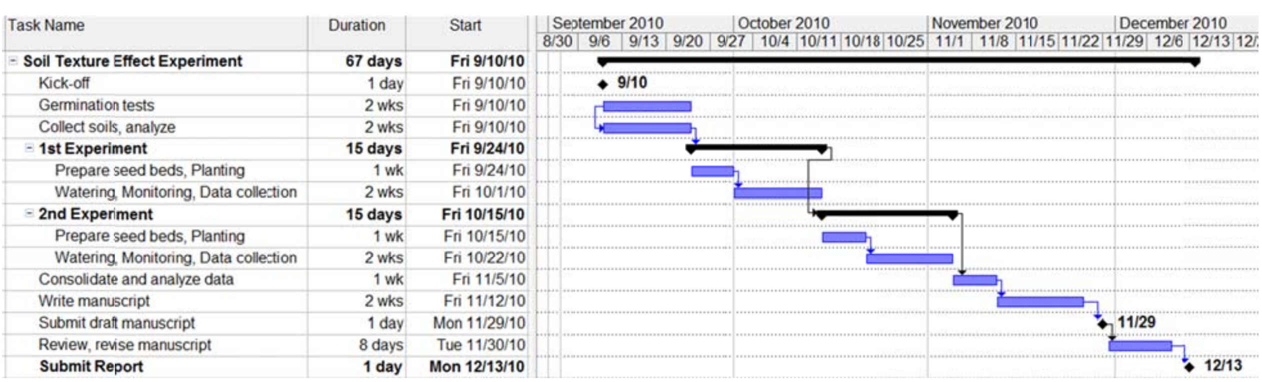

Figure 2: Project timeline of activities.

References

Alessi, J., and Power, J. F., 1971. Corn Emergence in Relation to Soil Temperature and Seeding Depth, *Agronomy Journal*, 63, pp.717-719.

Carter, P.R., and Nafziger, E.D., 1989. Uneven Emergence in Corn, *North Central Regional Extension Publication*, No. 344.

Clay, D.E., Clay, S.A., and Reitsma, K., 2009. Best Management Practices for Corn Production in South Dakota, *South Dakota State University, South Dakota Cooperative Extension Service*, Brookings, SD.

Gee, G.W. and Bauder, J.W., 1986. Particle size analysis. pp. 386-423. *In* A. Klute (ed.) Methods of soil analysis. Part 1. 2nd ed. Agron Monogr, 9. ASA and SSSA, Madison, WI.

ISU Seed Testing Laboratory - Test Methods, *Seed Science Center, Iowa State University*. 02 Sept. 2010 <http://www.seeds.iastate.edu/seedtest/test/index.html>.

Liu, W., Tollenaar, M., Stewart, G. and Deen, W., 2004a. Impact of Planter Type, Planting Speed, and Tillage on Stand Uniformity and Yield of Corn, *Agronomy Journal*, 96, pp. 1668–1672.

Liu, W., Tollenaar, M., Stewart, G., and Deen, W., 2004b. Within-Row Plant Spacing Does Not Affect Corn Yield, *Agronomy Journal*, 96, pp. 275-280.

Nasr, H.M. and Selles, F., 1994. Seedling emergence as influenced by aggregate size, bulk density, and penetration resistance of the seedbed. *Soil and Tillage*, 34, pp.61-76.

Nielson, R. L., 2004. Effect of Plant Spacing Variability on Corn Grain Yield, *Chat 'n Chew Café-Corny News Network*.

Topp, G.C. and Ferre, P.A., 2002. Thermogravimetric using conventional over-drying, pp. 422-424. *In* J.H. Dane and G. C. Topp (eds.) Methods of soil analysis. Part 4. Physical methods. Soil Science Society of America, Madison, WI.

Patten, G. P. and Van Doren, D. M., 1970. Effect of Seed Orientation on Emergence and Growth of Corn, *Agronomy Journal*, 62, pp. 592-595.

Toler, J. E., Murdock, E. C., Stapelton, G. S. and Wallace, S. U., 1999. Corn Leaf Orientation Effects on Light Interception, Intraspecific Competition, and Grain Yield, *Journal of Production Agriculture,* 12, pp. 396–399.

Malarie J. Barrett

Contact Information

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Education and Training

Institution	***Major***	***Degree***	***Year***
Oklahoma State University	Environmental Science	B.S.	2010
Oklahoma State University	Plant and Soil Science	M.S.	(cand.)

Professional Experience

Graduate Research Assistant

Oklahoma State University, Department of Plant and Soil Sciences, Stillwater, OK 74074

Responsible for aiding in design and management of a greenhouse and field study, analyzing data sets. Knowledge of laboratory equipment and procedures including, ICP, pH meter, EC meter, Lachet QuickChem 8000, and mineral digestion.

Supervisor: Dr. Hailin Zhang, 2010-present

Wheat Genetics Lab Assistant

Oklahoma State University, Department of Plant and Soil Sciences, Stillwater, OK 74074

Prepared soil and planted wheat for greenhouse experiments. Learned importance of quality control. Extracted DNA for use in research related to nitrogen efficient wheat.

Supervisor: Dr. Liuling Yan

Scott T. Fine

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159 Agricultural Hall
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Education and Training

Institution	***Major***	***Degree***	***Year***
Oklahoma State University	Plant and Soil Science	B.S.	2008
Oklahoma State University	Plant and Soil Science	M.S.	2010
Oklahoma State University	Plant and Soil Science	Ph.D.	(cand.)

Professional Experience

Graduate Research Assistant

Oklahoma State University, Department of Plant and Soil Sciences, Stillwater, OK 74074
Member of the Agronomic Environment Chemistry Lab
Responsible for field operations, soil chemical and physical laboratory analysis, co-management of greenhouse studies, analysis of large data sets.
Supervisor: Dr. Chad J. Penn – 2008 through 2010.

Graduate Research Assistant

Oklahoma State University, Department of Plant and Soil Sciences, Stillwater, OK 74074
Member of the Soil Genesis and Morphology Team.
Responsible for organizing large field operations (soil sample collections)
Supervisor: Dr. Brian J. Carter – 2010 through present.

Adrian A. Koller

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Stillwater, OK 74074		

Education and Training

Institution	***Major***	***Degree***	***Year***
University of Michigan	Aerospace Engineering	B.S.	2002
The Georgia Institute of Technology	Aerospace Engineering	M.S.	2005
Oklahoma State University	Biosystems and Agri. Eng.	Ph.D.	(cand.)

Professional Experience (last 5 years)

Graduate Research Assistant

Oklahoma State University, Dept.of Biosystems and Agri. Engineering, Stillwater, OK 74074
Member of the Precision Planting Research Team.
Supervisor: Drs. Michael Buser, Bill Raun, Randy Taylor, Paul Weckler – 2010 to present.

Project Manager

RUAG Space AG, Zurich, Switzerland. Research & Development – Space Mechanisms and Instruments.
Responsible for the development of an ultra-precision two-axis laser pointing mechanism for inter-satellite optical data communication.
Supervisor: D. Manzoni – 2007 through 2010.

Project Manager

weControl AG, Zurich, Switzerland.
Responsible for the implementation of autopilot and ground control software for unmanned aerial vehicles.
Supervisor: Dr. Markus Möckli – 2006 through 2007.

System Engineer

ESG-Elektroniksystem & Logistik GmbH, Munich, Germany.
Responsible for the development of system specifications for a sense-and-avoid system for unmanned aerial vehicles.
Supervisor: Dr. René Knorr – 2005 through 2006.