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Planting Date and Maturity Group Interaction for Soybean Productivity and Seed Quality in East Central Kansas

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Abstract

Soybean seed quality is an important component for soybean meal. Different factors affect seed quality, such as genetics, environment, and management (G × E × M). The objectives of this study were to 1) evaluate the effect of planting date and maturity group in soybean seed quality (protein and oil concentrations) and 2) investigate the relationship between soybean seed quality and productivity (seed weight and yield). Three field experiments were conducted during the 2018 growing season evaluating the combination of two factors, planting date and maturity group, with three levels of each one (early, medium, and late). Field measurements included: seed yield, seed weight, and seed quality, mainly represented by determination of seed protein and oil concentrations. The main outcomes of this study were: 1) early planting date resulted in the highest protein and oil concentrations, while late planting date presented the lowest concentrations for those seed quality components; and 2) protein concentration was negatively correlated with seed yield (r = -0.66).

Keywords

soil health, cover crops, enzymes, microbial activity

Authors

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Summary

Soybean seed quality is an important component for soybean meal. Different factors affect seed quality, such as genetics, environment, and management (G × E × M). The objectives of this study were to 1) evaluate the effect of planting date and maturity group in soybean seed quality (protein and oil concentrations) and 2) investigate the relationship between soybean seed quality and productivity (seed weight and yield). Three field experiments were conducted during the 2018 growing season evaluating the combination of two factors, planting date and maturity group, with three levels of each one (early, medium, and late). Field measurements included: seed yield, seed weight, and seed quality, mainly represented by determination of seed protein and oil concentrations. The main outcomes of this study were: 1) early planting date resulted in the highest protein and oil concentrations, while late planting date presented the lowest concentrations for those seed quality components; and 2) protein concentration was negatively correlated with seed yield (r = -0.66).

Introduction

Soybean as an oil seed crop serves as a source of feed for animals, protein for human consumption, and biofuel feedstock (Masuda and Goldsmith, 2009). Besides the seed yield of the crop, seed quality and its composition are key points for soybean meal. Soybean seed quality is affected by genetic, environment, and management factors (G × E × M) and their interactions (Medic et al., 2014).

The main environmental factors affecting soybean seed productivity (seed weight and seed yield) and seed quality (protein and oil concentrations) are temperature, solar radiation, water availability, and soil nutrient supply (Rotundo et al., 2009), while crop management such as irrigation (Bellaloui and Mengistu, 2008), planting date, and maturity group also may affect soybean seed quality (Assefa et al., 2018).

The first step to improve seed nutritional quality is to explore potential impacts of specific management practices on soybean seed quality. The objectives of this study were to 1) evaluate the effect of planting date and maturity group on soybean seed quality (protein and oil concentrations) and 2) investigate the relationship between soybean seed quality and productivity (seed weight and yield).

Procedures

Site Characteristics

The experiments were conducted in three locations in Kansas-Manhattan, Topeka, and Ottawa. Soil samples were collected from 0- to 6-in. soil depth layer in each location, to characterize initial conditions. The soil parameters analyzed were pH, clay content, soil organic matter (SOM), and phosphorus (P) (Mehlich). Results of soil tests are shown in Table 1.

Experimental Design

Treatments consisted of the combination of two factors (planting date and maturity group) with three levels of each one (early, medium, and late) (Table 1). Planting date and maturity group were treated as categories for having the same levels of each factor across locations (Table 1). The three locations in this study were considered as the random effect.

The experiment was conducted in a completely randomized block design with four replications for each treatment. The plots were 5- × 40-ft, with 4 rows in 30-in. row spacing. The experimental area was kept free of weeds, pests, and diseases during the growing season.

Measurements

Soybean seed yield was determined with a plot combine (by harvesting the two central rows, 40-ft long) and expressed at 13.5% seed moisture content. Seed weight, protein, and oil concentration were measured in a sample collected from the plot combine. Concentration of protein and oil (dry basis) were determined by NIR spectroscopy technique (Pazdernik, et al., 1997).

Weather Information

The weather information was retrieved from Kansas Mesonet Weather Data Library, Kansas State University. The maximum and minimum temperatures, precipitation, and solar radiation for the growing season are shown in Figure 1.

Statistics

Results were subjected to an analysis of variance (ANOVA) to test the effect of planting date, maturity groups, and their interaction with all the measured variables. After analysis, treatments were compared by Tukey test analysis ($P < 0.05$). Relationships between soybean seed quality (protein and oil concentrations) and productivity (seed yield and weight) were analyzed with Pearson ′s correlation, and when relationships had significant differences, linear regression was performed.

Results

Seed Yield and Weight

Soybean seed yield was not affected by planting date or maturity group (Table 2). However, seed weight was affected by planting date but not by the maturity group factor (Table 2). The largest seed weight was obtained with early planting date

(173.1 mg), while the late planting date produced the smallest seed weight (160.9 mg), expressed in mg per seeds.

These results led to analysis of the environmental factors during the soybean growing season. The daily temperature and solar radiation were greater with the early planting date, while precipitation was greater with the late planting date (Figure 1). The temperature with early planting date was around 17% higher compared to late planting date, and with 55% more solar radiation, while the late planting date presented 30% more precipitation relative to early planting date. These weather conditions could increase the seed weight with early planting date, because high temperatures and radiation stimulates crop growth primarily through increased photosynthesis and leaf area.

Protein and Oil Concentrations

There were not interactions between the factors evaluated in this study with the seed quality, protein, and oil concentrations. Protein and oil concentrations differed among planting dates. Early planting date showed the highest protein and oil concentrations (43.5% and 22.0%, respectively), while late planting date presented the lowest (41.7% and 21.4%, respectively). However, there was no effect of maturity group on these variables (Table 2).

The environmental factors such as temperature, solar radiation, and precipitation may have influenced protein and oil concentrations as well as seed weight. In addition, the higher precipitation with the late planting date could affect the quality of the seeds if more precipitation is received due to a delay in the optimal harvest time.

Relationship Between Soybean Seed Quality and Productivity (Seed Weight and Yield)

The relationship between seed protein concentration and yield was significant. Protein concentration was negatively correlated with soybean seed yield ($r = -0.66$) (Figure 2). Factors such as dilution of tissue nutrients due to increased photosynthesis and plant size (biomass and yield) may contribute to this lower protein concentration as yields improved.

Since seed quality (protein and oil concentration) is dependent on other factors ($G \times E \times M$) and their interactions, future studies should explore the effect of these factors to separate their potential influence and contribution to seed quality formation.

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Table 1. Soil characterization before planting time and experimental factors in the three locations

					Experimental factors					
	Soil characterization				Planting date			Maturity group		
Location	pH	Clay	SOM	P	Early	Medium	Late	Early	Medium	Late
		-------- % --------		ppm						
Manhattan	7.1	32	2.8	36.6	20-Apr	7-May	23-May	3.0	3.4	4.1
Topeka	7.5	16	1.3	46.3	30-Apr	18-May	6-Jun	3.2	3.9	4.3
Ottawa	6.6	30	2.8	44.1	10-May	4-Jun	29-Jun	3.4	4.1	4.5

SOM = soil organic matter.

Table 2. Analysis of variance and means for seed yield, seed weight, protein and oil concentrations. Means from Manhattan, Topeka, and Ottawa, KS

Factor	Seed yield	Seed weight	Protein	Oil
	bu/a	mg	---------- % ----------	
Planting date				
Early	39.6 *ns	173.1 a	43.5 a	22.0 a
Medium	41.9	167.8 ab	42.1 b	21.9 a
Late	39.3	160.9 b	41.7 b	21.4 b
Maturity group				
Early	37.4 *	167.5 *	42.6 *	21.9 *
Medium	41.4	166.6	42.4	21.8
Late	42.1	167.7	42.3	21.7
ANOVA				
Planting date	*ns	$P = 0.017$	$P < 0.0001$	$P = 0.003$
Maturity group	ns	ns	ns	ns
Planting date × maturity group	ns	ns	ns	ns

*ns = no significant difference.

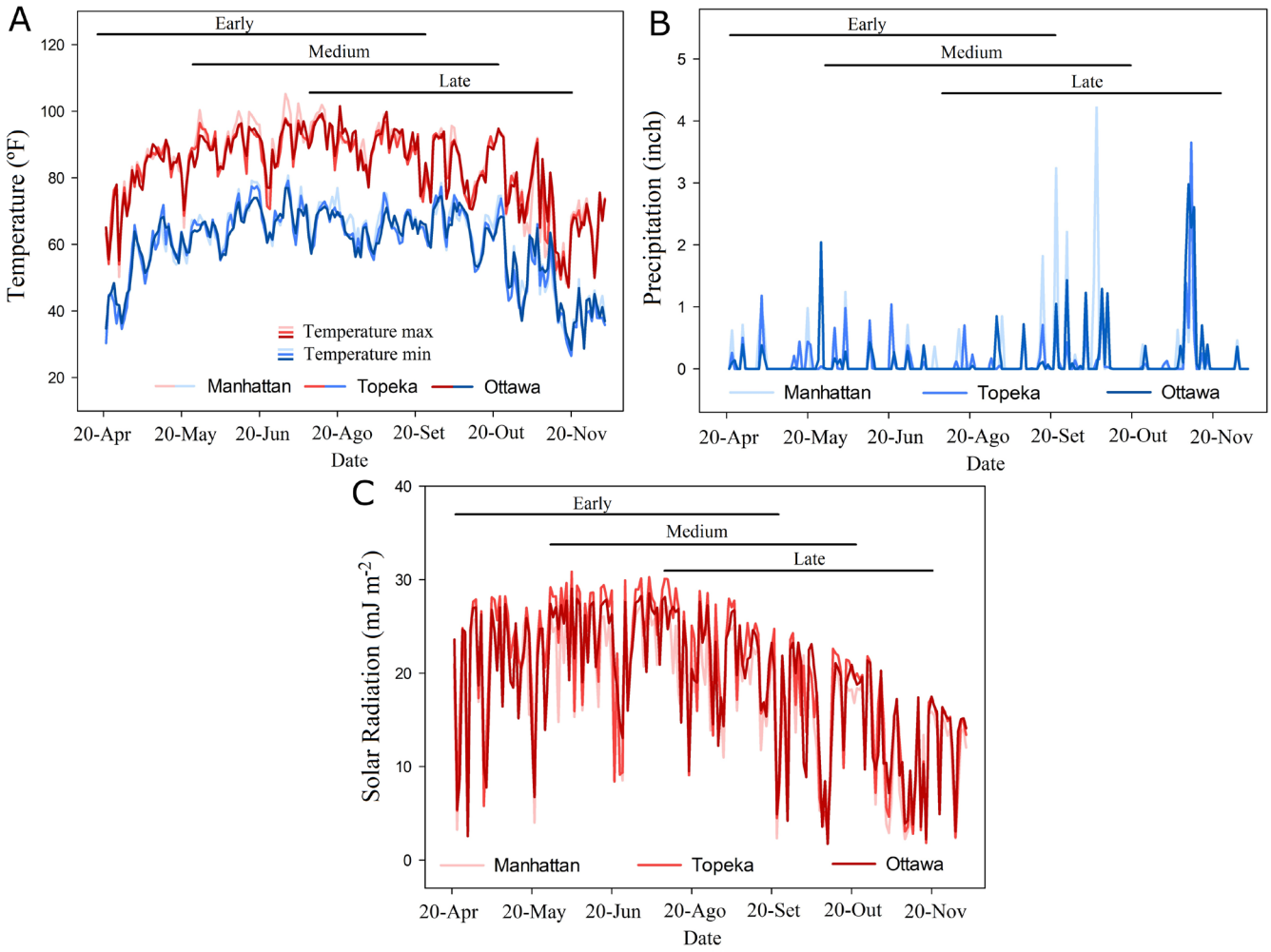

Figure 1. Daily maximum and minimum temperatures for the growing season (A), daily precipitation (B), and daily solar radiation (C) in Manhattan, Topeka, and Ottawa, KS. Horizontal lines represent the medium dates for growing season for each planting date.

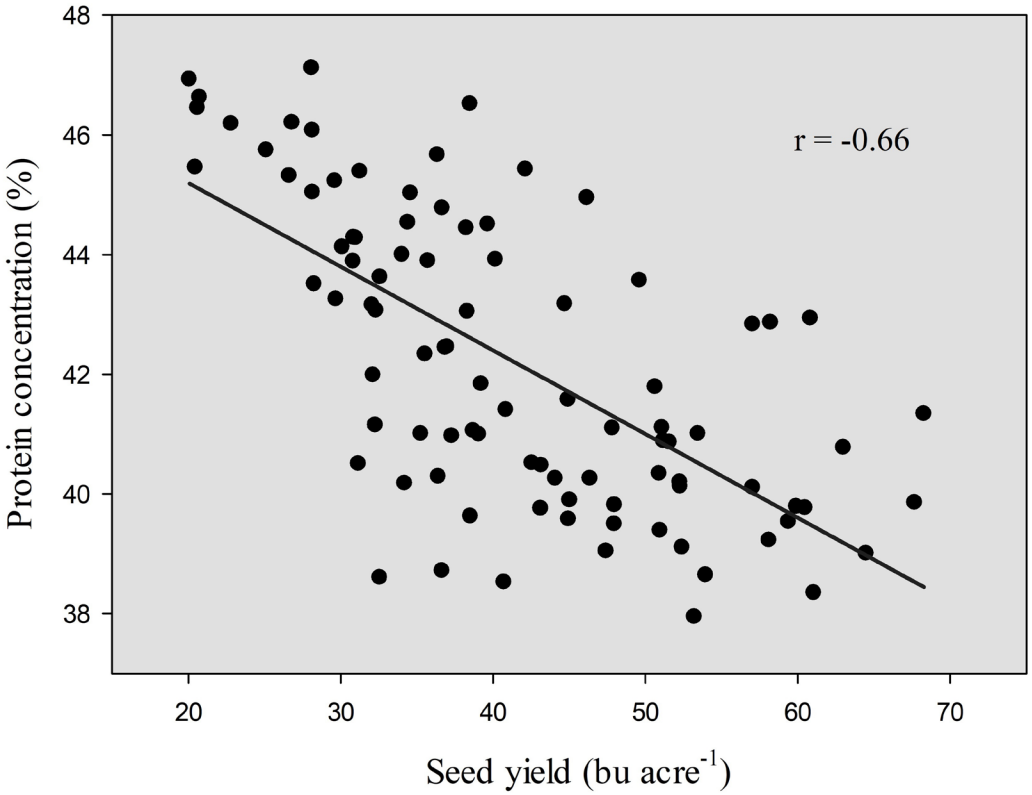

Figure 2. Relationship between protein concentration and soybean seed yield. Protein concentration presented as %, dry basis; and seed yield was expressed in 13.5% moisture content.