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Effects of Plant Spacing Variability and Non-Uniform Emergence on Corn Yield

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EFFECTS OF PLANT SPACING VARIABILITY AND NON-UNIFORM EMERGENCE ON CORN YIELD

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ABSTRACT

Plant spacing variability and non-uniform emergence in corn (*Zea mays L.)* is not uncommon in Louisiana corn fields. Variation in planting depth, non-uniform surface crop residue distribution in no-tillage systems, microsite variation in the seed bed condition, and seed vigor are major factors responsible for non-uniform emergence. Also, planters with low precision in seed placement and careless planting operations can cause non-uniform spacing. Two studies were conducted to quantify the effects of plant spacing variability and non-uniform emergence on grain yield in corn. Six plant spacing treatments at 47,770 plants ha^{-1} were evaluated. Uniform spacing, seed skip, double seeded, seed offset by ¼, seed offset by ½, and seed offset by ¾. Although seed skips produced an increase of 12% g ear^{-1}, the absence of a plant within the subplot collectively resulted in a 25% yield reduction compared to uniform spacing. A 15% yield decrease was observed in double seeded treatments compared to uniform spacing. There were no significant differences in yield for uniform spacing, seed offset by ¼, ½, or ¾ treatments, respectively. A second study was conducted to evaluate the impact of zero, two, and four leaf delays in corn emergence on yield. Two and four-leaf delay treatments reduced grain weights by 55% and 92%, respectively, compared to the zero-leaf delay

CHAPTER 1. INTRODUCTION.

Row crop production has been around for centuries. Agronomic practices, genetic advancements, integrated pest management strategies, and marketing tactics have all been subjects of evolution within the industry, but the goal has remined the same: optimizing yields. Over 3.3 billion metric tons of grains, oilseed, and cotton were produced in 2019 compared to 2.2 billion metric tons in 2000 (USDA NASS, 2021). Global demand correlates with an increasing population as it relates to products of row crop agriculture being utilized. In the United States, cropland decreased 4.1% from 2007 to 2012 (USDA NASS, 2012). Growers are having to produce more food and fiber on less land, which puts an emphasis on yield optimization.

The outputs of existing row crops rely heavily on the inputs applied. Inputs could be classified as variety selection, fertilizer sources and their respective rates, pest management and the respective timings of pesticide applications, as well as dozens of other factors and choices involved in producing a profitable crop. The concept of optimum yield needs to be examined from various points of view (Keller, 1982). Plant growth and crop yield are conditioned by two sets of factors: (1) the external factors such as light, temperature, water, nutrient supply, management and the incidence of pests and diseases and (2) internal factors, mainly nutritive but also hormonal (Bould, 1965).

Maintenance and management of soil fertility is central to the development of sustainable food and fiber production systems (Prasad and Power, 1997). Currently, there are six soil-derived macronutrients essential for plant growth: nitrogen, phosphorus, potassium, sulfur, calcium, and magnesium. The six soil-derived macronutrients are present in plants at relatively high concentrations—normally exceeding 0.1 percent of total dry weight (Mahler, 2004). Luce (2018) suggests that nitrogen (N) is the most limiting nutrient for crop production and is usually applied in the largest quantities. Limited N supply can prevent the crop from fully exploiting its yield potential, reducing the possibility of higher income for farmers (Morari et al., 2020). Phosphorus is the most important plant macronutrient second to nitrogen, and it plays a role in many aspects of plant structure and function (Leggett et al., 2014). Potassium is an essential nutrient for plant growth and is associated with the movement of water, nutrients, and carbohydrates in plant tissue (Kaiser and Rosen 2018). Research throughout the world has defined ideal fertilizer rates and application timings for specific crops. The advancements of precision agriculture have resulted in the inception of variable rate technology which modifies application amounts specific to existing nutrient levels in fields.

Pest management continues to be an integral part of the success or demise of a crop. It is most time-sensitive due to the nature of insects and diseases and their abilities to exponentially increase if favorable conditions exist without remediation. The efficient management of insect pests should be high priority given insects still account for 15% out of 42% yield loss from pests in global row crop production (Yudulmen et al., 1998). Additionally, managing weeds is essential in optimizing yield. A study conducted in corn reported that initial slow growth and wider row spacing coupled with congenial environmental conditions allows luxuriant weed growth, with yield reduction from 28-100% (Dass et al., 2012). Furthermore, a study from 2016-2019, Mueller et al. (2020) found corn diseases caused an average of \$138/ha^{-1} yield loss in the United States and Ontario.

Corn (*Zea Mays L.*) was the most planted crop in the United States with over 37 million hectares planted in 2020. (USDA NASS, 2020) The United States has consistently remained the top exporter and producer of corn in the world with 336 metric tons produced in 2019, 14.3% of which were exported to more than 73 different countries (U.S. Grains Council, 2021). A combination of genetic advances and improved management has allowed the ability to seed field corn from population densities below 30,000 plants hectare^{-1} in the 1930s (Duvick, 2005) to more than 100,000 plants hectare^{-1} in the last decade (Stanger and Lauer, 2006). Corn is the second most common crop planted in Louisiana, behind soybeans (USDA NASS, 2020). In 2020, Louisiana planted 457,735 acres of corn in 33 parishes, 69.7% of which was irrigated (LSU AgCenter, 2020). The yield average from 2010-2017 was 177 bu./A (LSU AgCenter, 2018). Rising input costs, specifically seed, are coercing growers to adopt practices that optimize production. This includes the objective to achieve uniform plant emergence and within-row spacing. Potential yield benefits from improving within-row plant spacing and plant emergence variability in corn production are often questioned by growers (Liu et al., 2004). Agronomists and corn producers have assumed that evenly spaced stands of corn have greater yield potential than unevenly spaced stands (Carlson et al., 2002). In corn production, uniformity of plant distribution within the row, along with plant density and row spacing, has been a subject that has received much attention in the past. An emerged stand of emerged corn may appear to be uniform, but upon closer examination it often becomes evident that within-row corn stands are not uniformly spaced or emerged. A field may contain crowded plants (doubles or clusters), long or short gaps, and combinations thereof. Additionally, non-uniform emergence may be common in fields where optimal germination conditions were not present (Liu et al., 2004).

Improved uniformity of within-row plant spacing is expected to decrease plant-to-plant competition and increase grain yield through more efficient use of available light, water, and nutrients by the plants (Shubeck and Young, 1970). Duncan (1984) proposed a theoretical basis for plant competition effects on corn grain yield. The yield of a single corn plant is reduced by the presence of competing neighbors, and the amount of yield reduction for a given environment depends on how near and how numerous the neighboring plants are. Conversely, Lue et al. (2004) reported corn grain yields were not significantly affected by plant spacing variability that were averaged across locations and years. Although several factors can contribute to irregular spacing of corn, faulty equipment is cited the most. Spacing irregularities are often related to the ability of the planter to singulate and uniformly transfer seeds from the seed box into the seed furrow. Most farmers and agronomists agree that uniform stand establishment is ideal and can be achieved by a well-calibrated planter and sound agronomic practices (Lauer and Rankin, 2004). Equipment speed can affect the singulation process in older planters that are still used in operations. Conversely, advancements in the precision agriculture industry have allowed producers access to precision planters that are efficient at singulating seed at the right ratio during high operating speeds (Li, Y., et al., 2016).

In addition to spacing variability, a corn stand may also emerge nonuniformly. Nafziger et al. (1991) reported that delayed emergence reduced grain yield 6 to 22%. Many do not realize there is an abundance of circumstances that can cause uneven stand emergence and its potential negative effect on yield. Variation in planting depth, non-uniform surface crop residue distribution in no-tillage systems, microsite variation in the seed bed, and seed vigor are major factors responsible for uneven seedling emergence in the field (Andrade and Abbate, 2005). While many factors are involved with producing a successful crop, uniform emergence establishes a solid foundation for optimizing yields based on the principal that each plant is equal in its photosynthesis capabilities and consistent in growth stage, which is essential for future plant processes like tasseling and pollination. There is widespread agreement that large plants exhibiting well-synchronized silk emergence and pollen shed produce the largest and most consistent-sized ears (Kovács and Vyn, 2014; Pagano et al., 2007). Small differences in plant size during early plant development are usually amplified as the season progresses and competition for resources intensifies (Maddonni and Otegui, 2004).

Soil moisture at planting, is another factor that can negatively impact early season corn growth and development (Wells et al., 2016). Inadequate or excessive moisture can cause variant corn stands due to the disruption of the germination process. Soil moisture can differ within a field because of differences in soil type or topography or from uneven distribution of moist and dry soil by secondary tillage (Carter et al., 1989). Kirk and Wilson (1960) confirmed negative effects on seed germination when excessive moisture is present and reported seed viability was adversely affected, regardless of the various fungicide treatments applied, citing that anaerobic soil conditions caused by excessive rainfall prevent essential gas exchange, which disrupts the seed germination process.

Additionally, soil temperature plays a vital role in successful seed germination and consistency within a field. Root system development is a function of growth and development which is temperature dependent (Kaspar and Bland, 1992). Temperature changes may affect several processes controlling seed germinability, including membrane permeability and the activity of membrane-bound and cytosolic enzymes (Bewley and Black, 1994). Coffman (1923) showed corn germinated best at temperatures above 10°C. Alessi and Power (1971) found a sharp decrease in germination when soil temperatures drop below 10°C. Ennen and Jeschke (2019) showed optimal soil temperature for corn emergence ranged from 32.2°C to 35°C. Of the primary factors affecting soil temperature only soil moisture, at times, and soil cover are subject to any degree of manual control (Willis et al., 1957). Furthermore, soil texture can have direct effect on temperatures. Dark colored soils absorb more radiant heat than light colored soils (Sandor and

Fodor, 2012), therefore, darker soils are subject to higher soil temperature than lighter soils (Onwuka and Mang, 2016).

Tillage practices can also influence emergence variability and impact soil health. Relatively clean seed beds at planting are often recommended for most crops. Residue positioned directly over the row can lower temperatures in the seed zone, delay germination and early growth, and reduce stands and yields (Lund et al., 1993). A clean seed bed can optimize seed to soil contact to allow proper germination for corn (Nielson, 1993). Crop rotation is another factor that can affect stand uniformity (Raoufat and Mahmoodieh, 2005). In the Southern U.S., corn is usually rotated with soybean. This is done for a variety of reasons, most of which is directly related to soil health, such as improving plant available nutrients from planting a legume the prior season (Behnke et al., 2020). Crop rotation can aid in minimizing the occurrence of soil borne diseases and combatting herbicide resistant weeds. Corn produces more residue than soybean, therefore, monocultures can sometimes cause issues for production systems that do not incorporate crop rotation. Excessive corn residue can result in cooler soil temperatures, higher soil moistures at planting and inadvertently reduce seed to soil contact when conservation tillage practices are implemented (Shen et al., 2018).

Furthermore, planting depth can influence the germination rate and emergence. Most agronomists will agree that planting corn too shallow leads to more frequent problems than planting too deep (Luce, 2016). Cox (2014) referenced corn experiencing variant emergence when planted less than 3.8 cm deep in dry conditions. Additionally, corn plants exhibited delayed emergence patterns when planted at depths greater than 5.08 cm, noting cooler soil conditions not being conducive to germination preferences.

This research has two objectives. First, to quantify the effects and interactions of plant spacing variability and plant emergence variability on growth and grain yield of corn. Second, to determine how the growth and grain yield of individual corn plants within a row are impacted by variations in emergence timing or spacing.

CHAPTER 2.
EFFECTS OF PLANT SPACING VARIABILITY AND NON-UNIFORM EMERGENCE ON CORN YIELD.

Introduction

Corn (*Zea Mays L.*) has remained the crop with the most planted hectares in the United States for the past several years. Furthermore, the United States is renowned for its corn production and exportation, which is the most in the world (USDA-NASS, 2020). Corn production has been modernized through diligent research and genetic improvements dating back decades. Yield optimization has become paramount in a world that requires more food and fiber to be produced on less land than years past. Additionally, advances in integrated pest management strategies and best management practices have increased yields on farms. With innovations occurring annually, production efficiency has continued to increase throughout the country, but there is also a correlating rise in input costs. Seed is one of the most expensive inputs for corn producers, therefore, efficient and consistent growth is essential (Foreman, 2014). Optimization regarding the successful planting and establishment of corn often involves ideal population and plant emergence (Neild and Newman, 1990). Corn has a distinctive response to stand density, with a sharp decline in kernel number per plant, and a substantial increase in plant bareness at plant populations beyond the threshold that maximizes grain yield (Tetio-Kagho and Gardner, 1988). Doerge (2015) identifies that uniformity of plant emergence and evenness of plant spacing are two of four outcomes from planting that can influence final corn yield.

Plant spacing variability in corn has historically caused concerns for producers and industry professionals. While competition for resources within and among plants is understood to affect yield per plant and unit area, direct effects of crop management on plant competition are not always well understood (Nafziger, 2006). Multiple studies have conflicting results regarding the effects of plant spacing variability on corn yield (Doerge and Hall 2000; Doerge et al. 2002; Krall 1977; Lauer and Rankin 2004; Liu et al. 2004; Nafziger 1996; Nielson 2001). Inefficient equipment is thought to be the primary cause surrounding variant plant spacing scenarios in commercially grown corn. Planter type, condition, and speed can directly affect the ability to singulate seed from the seed box into the seed furrow, thus affecting consistent uniform spacing (Lui et al., 2004). Seed spacing variability is typically related to misadjusted or malfunctioning planter mechanisms (Neilson, 2001).

Additionally, uneven emergence has historically been documented to have variant negative yield impacts on corn yield (Ford and Hicks 1992; Liu et al. 2004; Nafziger et al. 1991) The causes of non-uniform emergence can include a variety of factors and combinations thereof. Situations such as inadequate or excessive moisture at planting, poor seed planting depth, and the presence of surface residue on the seed bed can all negatively affect consistent, uniform plant emergence. Furthermore, germination failure from poor seed quality can also be cause for non-uniform emergence across stands.

Although research evaluating the effect of plant spacing variability and non-uniform emergence has been conducted, these topics have not been investigated in corn grown in Louisiana. Therefore, to quantify the effect of plant spacing variability and non-uniform emergence, separate studies were conducted to evaluate the effect on corn yield.

Materials and Methods

Two studies were conducted at the Louisiana State University Agricultural Center Dean Lee Research and Extension Center located near Alexandria, Louisiana in 2017 and 2018. The soil type is as a Coushatta silt loam (fine-silty, mixed, superactive, thermic Fluventic Entrudept), with a pH of 8.0 and 1.5% organic matter. The experimental design for both studies was a randomized complete block that included six replications. Plot size in both studies were four 14 m rows, spaced 0.97 m apart.

Plant Spacing Variability. The first study evaluated the effects of plant spacing variability on yield. Treatments included uniform spacing, skip, double plant, plant offset by 1/4, 1/2, and 3/4 of uniform spacing (Figure 2.1).

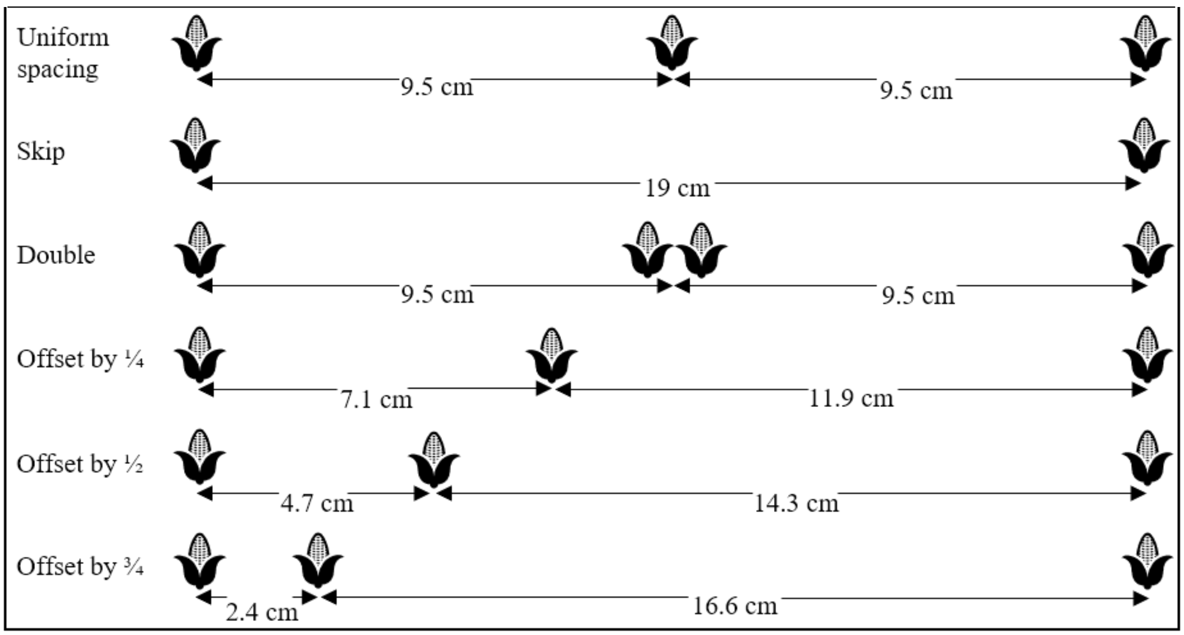

Figure 2.1. Target plant spacing variation treatments. Adapted from Doerge et al. (2015).

DeKalb corn hybrid, DK67-72, was seeded at 222,395 seed ha^{-1} 4 to 5 cm deep with a John Deere 7300 vacuum planter on April 4, 2017, and March 26, 2018. Each plot represented a treatment and contained eight subplots placed on rows two and three of each four row plot. All treatments were implemented via hand-thinning 1 week after emergence. Within each subplot, the first, second, and third plants were marked for data collection at harvest. In the double treatment, the second plant was designated as plant 2a and 2b. The existing plants not within a subplot were all hand thinned to uniform spacing to eliminate unrealistic growing conditions among the bordering plants.

At physiological maturity, all corn ears within each subplot were hand harvested. Ears from plants designated as first, second, or third from each subplot were combined into a single bag for processing for a total of 8 corn ears per bag. This procedure was followed for all other subplots. Following hand harvesting, grain was removed with an Almaco model 97001 motorized corn sheller. Grain weight, moisture, and test weight were recorded to calculate yield. Moisture was adjusted to 15.5% and grain weight data as weight per ear and as percent of the uniform stand yield were calculated prior to analysis.

Yield differences among plants in each treatment were of interest. Therefore, yield as a percent of the uniform stand for each plant were subjected to ANOVA using PROC MIXED in SAS with years and replications nested within years as random effects (Blouin et al. 2011). Plant spacing variability treatments were considered a fixed effect. Least-square means were calculated, and mean separation ($P \leq 0.05$) was produced using PDMIX800 in SAS, which is a macro for converting mean separation output to letter groupings (Saxton, 1998). Following this analysis, data for each treatment was averaged across plants within each treatment to determine if differences among plant spacing treatments were observed using the same procedure as previously described.

Delay in Plant Emergence. A second study evaluated the effects of emergence variability on yield in corn. The trial contained three treatments consisting of a zero, two, and four leaf delay in corn emergence. Rows one and four of each four row plot were planted with a John Deere 7300 vacuum planter on April 4, 2017, and March 27, 2018.Additionally, row two in 2017 and rows two and three in 2018 were hand planted on April 4, 2017 and March 27, 2018. In the two-leaf (Figure 2.2) and four-leaf (Figure 2.3) delay treatments, the second, or middle plant, of each subplot was planted late to obtain either the two or four leaf delay. Two-leaf delay treatments were planted on April 11, 2017, and four-leaf delay treatments were planted on April 18, 2017. In 2018, two-leaf delay treatments were planted on April 5th and four-leaf delay treatments were planted on April 16th.

Planting timings were determined by the growth stage of the two bordering plants within the subplot. In the zero-leaf delay, hand planting occurred on the same day rows one and four were planted. In the two-leaf and four-leaf delay treatments, plant two was planted when plant one and plant three of the subplot were VE and V1 growth stages, respectively. To maintain accuracy and consistency throughout the plot, a tape measure was used to determine uniform spacing between plants that were hand-planted. Additionally, border plants were present between subplots to mimic ideal growing conditions throughout the rest of the plot

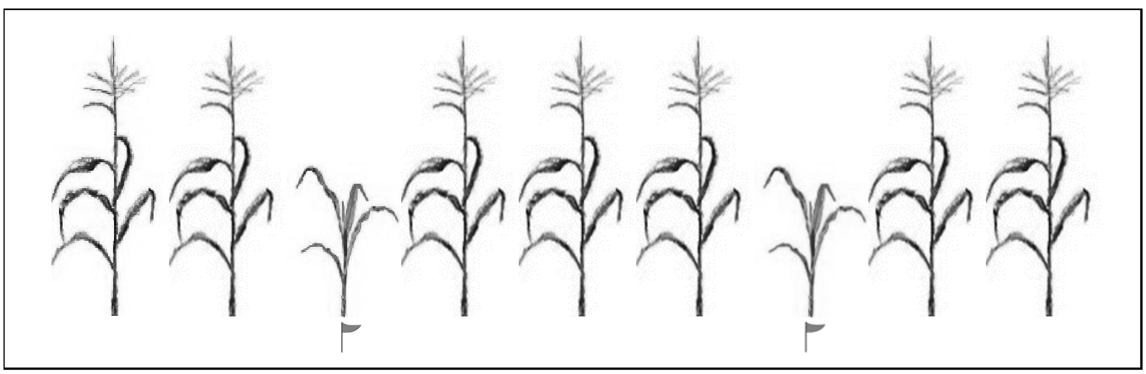

Figure 2.2. Subplot sequence for two-leaf treatment.

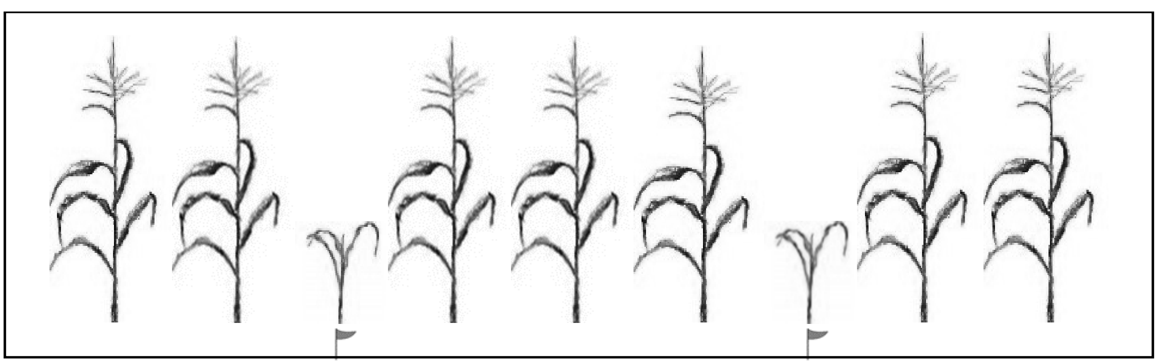

Figure 2.3. Subplot sequence for four-leaf delay.

Unlike the first study, which had eight subplots within a treatment, this study utilized the entirety of row two in 2017 and rows two and three in 2018 to maximize the number of subplots per treatment. The number of subplots varied per treatment due to the nature of the planting method and objective of the study, which was to obtain accurately depicted delayed emergence scenarios. In 2017, some subplots were destroyed from bird damage shortly after emergence. This led to the plot being revised and expanding to rows two and three in 2018. The average number of uniform-emergence subplots per year was 105. The two-leaf delay contained an average of 103 subplots per year and the four-leaf delay averaged 113 subplots per year. Data collection procedures were similar to the first study.

Grain weight per ear, increase or decrease in yield, and yield as a percent of the uniform emergence yield were subjected to ANOVA using PROC MIXED in SAS with years and replications nested within years as random effects (Blouin et al., 2011). Plant emergence variability treatments were considered a fixed effect. Least-square means were calculated, and mean separation ($P \leq 0.05$) was produced using PDMIX800 in SAS, which is a macro for converting mean separation output to letter groupings (Saxton, 1998).

Results and Discussion

Plant Spacing Variation. The first study, which evaluated plant spacing variability, yielded no differences between three of the six treatments. Similar to Doerge et al. (2015), yield is negatively impacted in non-ideal spacing outcomes, specifically consistent skips and doubles, while plant misplacements by ¼, ½, and ¾ do not bear significant effect on yield. Uniform spacing and seed misplaced by ¼, ½, and ¾ of uniform spacing yielded 145, 133, 144, and 139 g ear^{-1}, respectively. The treatments that contained skips yielded 109 g ear^{-1}. The double treatments yielded 123 g ear^{-1} (Table 2.1).

Table 2.1. Corn yield as g per ear and percent of the uniform stand yield averaged across plants within each respective subplot.

Plant spacing variability treatment	g ear^{-1}	% of uniform stand yield
Uniform spacing	145 a	100 ab
Skip	109 d	75 d
Double	123 c	85 cd
Offset by 1/4	133 bc	92 bc
Offset by 1/2	144 ab	104 a
Offset by 3/4	139 ab	96 ab

Although skip treatments provided evidence of higher yield per plant (Figure 2.4) due to suspected decreases in plant to plant competition, commercial fields that display numerous skips may not efficiently maximize production due to a low plant population. Additionally, scenarios that display considerable amounts of doubles will see an increase in plant population; however, decreased quality will likely occur resulting in yield reduction, which negatively impacts production optimization. Frequently occurring doubles may also lead to increased seed costs, which could negatively impact profitability. Furthermore, plants for each treatment exhibited no difference as it relates their respective plant order within the subplots.

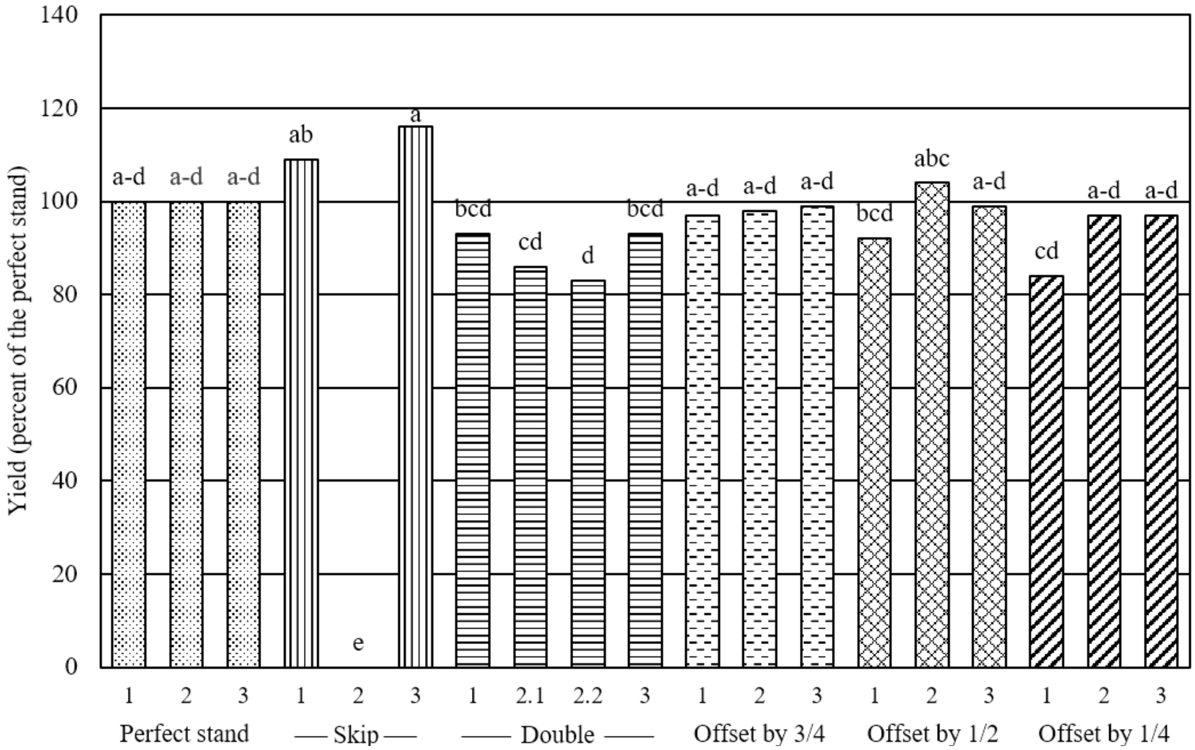

Figure 2.4. Corn yield as a percent of the uniform stand yield by plant spacing treatment in 2017 and 2018.

Research has been conducted with similar design and methodology as the aforementioned trial (Doerge et al., 2015). Conversly, research that has found plant spacing variability to minimally effect yield has often differed in design and execution of creating variant plant spacing scenerios (Lauer and Rankin 2004; Liu et al. 2004). One study did not incorporate realistic skips or doubles into trials, only hill plant grouping treatments, which would coincide with findings of this research that misplaced seed does not effect yield (Lauer and Rankin 2004). Additionally, plant groupings measured within commercial fields are subject to misrepresentation as the occurrence of planter malfunction and poor germination, as well as other causes of spacing variability, differ from field to field.

Delay in Plant Emergence. The second study, which evaluated non-uniform emergence and its subsequent effects on yield provided evidence plants experiencing two and four-leaf delays in stands are subject to notable yield decreases. The results supported findings of Ford and Hicks

(1992), Liu et al. (2004), and Nafziger et al. (1996), that delayed plants can attribute to significant yield losses. The first treatment, which was labeled as a zero-leaf delay, provided the baseline standard as it relates to yield capability and yielded an average of 158 g^{-1} plant within the subplots. The second treatment, which included plants that experienced a two-leaf delay among its neighboring plants within the subplot, collectively experienced a 55% reduction in wt. ear^{-1} compared to uniform emergence. The third treatment, which included plants that experienced a four-leaf delay among neighboring plants within the subplot, collectively experienced a 93% reduction in wt. ear^{-1} compared to uniform emergence (Table 2.2).

Table 2.2. Effect of delayed corn emergence on weight per ear, increase or decrease in yield, and yield as a percent of the uniform emergence yield.

Delayed emergence treatment	Plant	Wt ear^{-1}	Increase or decrease in yield	% of uniform emergence yield
		g	%	%
Uniform emergence	1	158 c	0 c	100 c
Uniform emergence	2	156 c	0 c	100 c
Uniform emergence	3	160 c	0 c	100 c
2 leaf delay	1	163 bc	4 bc	104 bc
2 leaf delay	2	70 d	-55 d	45 d
2 leaf delay	3	162 bc	2 bc	102 bc
4 leaf delay	1	185 a	18 a	119 a
4 leaf delay	2	11 e	-93 e	8 e
4 leaf delay	3	180 ab	13 ab	114 ab

A notable observation was made regarding plant one and plant three of the two and four-leaf delay treatments. An average wt. ear^{-1} increase of 16% for neighboring plants was observed within the subplot of the four-leaf delay treatment compared to the neighbors of the two-leaf delay treatment. This is likely the product of decreased competition similarly as seen in the first study within the skip treatments.

The current study implemented similar techniques of Liu et al. (2004). Plant delays were determined by the growth stage of neighboring plants as opposed to specific timetables performed in other trials evaluating delayed emergence and effect on yield. Results of these studies indicate that the spacing of corn plants within a row does not impact yield potential to the level producers and many in agricultural industry think. However, missing plants or skips and instances where doubles occur will lead to yield loss. Furthermore, data indicates that corn yield will be decreased following instances of variable corn emergence within a row. Producers should utilize correct seeding rate for their corn hybrid, plant at a proper depth, and ensure that soil and environmental conditions are conducive for corn growth and development.

CHAPTER 3. SUMMARY.

Corn sits atop the rankings in the United States for the total number of planted hectares throughout all crops. Additionally, the United States has remained the largest exporter of corn in the world for several years. Advancements in agriculture regarding crop genetics, integrated pest management strategies, precision technology, agronomic practices have provided producers with a significant number of tools to optimize yield. Increasing human population has driven the demand of products derived from corn exponentially. Furthermore, significant amounts of farmland are being taken away annually to compensate for the urbanization of the world to meet its growing population demand. Corn producers must counteract by increasing production, while still ensuring those decisions to increase production remain cost-effective. Growing advancements in the agriculture industry are often offset through increased input costs at the expense of the producer. One of the most expensive input costs to corn producers is seed. Seed with innovative genetics through disease and insect resistant packages paired with high yielding capacity and herbicide tolerance are getting more costly each year. To enhance productions while maintaining profitability, producers should adopt best management practices, one of which is centered around having a uniformly space and emerged stand.

Several studies have been conducted in the past that have evaluated the effects of plant spacing variability. Results of these studies have differed, but the majority concluded that fluctuation in spacings are common and if skips are not persistent, significant yield decreases are not likely. However, most research has agreed that delayed emergence is likely to cause yield decreases in corn, depending on the severity and frequency.

Two studies were conducted at the Louisiana State University Agricultural Center Dean Lee Research and Extension Center located near Alexandria, Louisiana in 2017 and 2018. The first study consisted of six treatments, each representing different plant spacing scenarios in corn. These treatments were evaluated for their responding effects on yield. Data indicated that four of the six spacing scenarios did not exhibit significant difference in yield. These treatments included uniform spacing and the three misplaced by a certain percentage of uniform spacing. The remaining treatments did affect yield. Skips provided neighboring plants with an increase of 12% in g ear^{-1}, compared to uniform spacing. This is likely attributed to decreased competition for light and resources. However, the occurrence of plant skips in a commercial field will likely decrease yield capacity as the plant population would be considerably lower. Furthermore, the double showed a 15% decrease in g ear^{-1}, compared to uniform spacing. This is likely attributed to an increase in competition for light and resources, thus negatively affecting the growth and development of the plants involved.

The second study consisted of three treatments that evaluated the effects of delayed emergence in existing corn stands. The zero leaf delay represented a reference for yield capability. The additional treatments consisted of a two-leaf delay and a four-leaf delay. Plants that were delayed by a two-leaf growth stage exhibited a 55% decrease in wt. ear^{-1} compared to the zero-leaf delay treatment. Plants that were delayed by a four-leaf growth stage suffered a 92% reduction in wt. ear^{-1} compared to the zero-leaf delay. Therefore, data indicated in this study provides evidence that producers should adopt best management practices to eliminate the occurrence of delayed emergence within fields.

Results of these studies indicate that the spacing of corn plants within a row does not impact yield potential to the level producers and many in agricultural industry might think. However, missing plants or skips and instances where doubles occur may lead to yield loss. Furthermore, data indicates that corn yield will be decreased following instances of variable corn emergence within a row. Producers should utilize correct seeding rates for corn hybrids, plant at a proper depth, and ensure that soil and environmental conditions are conducive for corn growth and development.

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Vita

Justin Dufour was born and raised in Hessmer, Louisiana, a small town located in Avoyelles Parish. A product of St. Mary's Assumption Catholic School and Bunkie High School, Dufour enrolled at Louisiana State University at Alexandria (LSUA), to seek a bachelor's degree in a science related field. While a college student, Dufour earned the opportunity to be employed as a student worker at the Dean Lee Research Station, which is located adjacent to the LSUA campus. Dufour was employed for 5 years as a student worker under the direction of Dr. Daniel O. Stephenson IV and Mr. Randall Landry in Weed Science. After obtaining his bachelor's degree, Dufour accepted a Research Associate position at Dean Lee in the soybean program under Dr. Ronnie Levy in 2014. Shortly after, Dufour was offered an extension agent position in his home parish of Avoyelles. Dufour enrolled in the School of Plant, Environmental, and Soil Sciences (SPESS) in 2016. He is currently a candidate for the Master of Science degree, which he plans to receive this August 2021, with a focus in Plant, Environmental and Soil Sciences (PEMSS). He has remained as the extension agent in Avoyelles Parish with agronomic row crop responsibilities in 2 additional parishes, Rapides and Grant. Dufour is also the Parish Chair of the Avoyelles Parish Extension Office and has been since 2017.