Yield Loss and Quality Effects of Peanut Combine Speed Settings for 2018 and 2019 Seasons Across Varying Peanut Varieties

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YIELD LOSS AND QUALITY EFFECTS OF PEANUT COMBINE SPEED SETTINGS FOR 2018 AND 2019 SEASONS ACROSS VARYING PEANUT VARIETIES

A Thesis
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Master of Science
Plant and Environmental Science

by
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May 2021

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ABSTRACT

A research project was conducted to understand and quantify yield losses and grade/quality associated with peanut combine speed settings. On a peanut harvester, there are two main avenues for potential of peanut losses: losses as associated with the header (where vines enter) and losses associated with the cleanout (where the tailings/trash exit). Variables tested in the three studies included: PTO speed, ground speed, and header speed. These variables were the only settings that were changed throughout the three studies; other important operational settings, such as threshing aggression and cleaning air adjustments, were set to normal operational settings. Results from the PTO speed, ground speed, and header speed tests are highlighted in these studies.

The three studies were conducted in Barnwell County, S.C. on commonly grown peanut varieties for regional producers: virginia variety (Bailey) in 2018 and runner variety (FloRun 311) in 2019. Tests were conducted on 4-row wide, 3.86 m (12.67 ft), non-irrigated plots that were 19.20 m (63 ft) in length. Treatments were evaluated using measurements of material throughput, tailings/header losses, grade/quality (loose shelled kernels & foreign material), loan rate value, and yield.

For the PTO speed tests, tailings losses increased by 245 kg ha\(^{-1}\) (219 lb ac\(^{-1}\)) for the 2018 virginia variety testing and 76 kg ha\(^{-1}\) (68 lb ac\(^{-1}\)) for the 2019 runner variety testing per each 10 percent increase in PTO speed, respectively. For the ground speed tests, tailings losses decreased by 44 kg ha\(^{-1}\) for each 1 km hr\(^{-1}\) increase in ground speed (63 lb ac\(^{-1}\) per each 1 mi hr\(^{-1}\) increase in speed) for the 2018 virginia variety testing and
decreased by 18 kg ha\(^{-1}\) for each 1 km hr\(^{-1}\) increase in ground speed (26 lb ac\(^{-1}\) per each 1 mi hr\(^{-1}\) increase in speed) in the 2019 runner variety testing.

For the header speed tests, header losses showed a decline of 22 kg ha\(^{-1}\) (25 lb ac\(^{-1}\)) for every 15% increase in header speed in the 2018 virginia variety testing and negligible for the 2019 runner variety testing. Header losses were determined to be insignificant for both research years in comparison to tailings losses, overall.

Further research across both runner and virginia peanut varieties should be conducted for comparison to the results here and establish a basis for repeatability. The findings from studies such as this one should promote advancements in peanut harvest technologies and increase peanut production profitability, if they are applied to improve combine operator adjustments. Knowledge of yield and grade/quality effects of combine settings will assist producers in making economic decisions for peanut combine operation.
DEDICATION

I wish to dedicate my thesis work to my family, wonderful newlywed wife Anne, Clemson University, Amadas Industries, committee members, and our amazing God! I would also like to dedicate this thesis to four extraordinary individuals for their outstanding and endless efforts to mentor and help me along this journey: Bryan W. Fogle, Gary W. Watson, former Troop 45 scoutmasters, and Kendall R. Kirk.

My grandfather, Bryan W. Fogle, taught me so many invaluable lessons while he was on this Earth, which has contributed to my ambition to complete my thesis work. He was the one that got me interested in agriculture and is responsible for my deep religious beliefs, without his guidance and patience I would not be where I am today! Gary W. Watson was a great mentor and like another grandfather to me over the past 15 years. I will be always be grateful for the talks that we had and the life lessons that you shared with me throughout the years. I will forever be in debt to my former Troop 45 scoutmasters; Bill Huffstetler, Senator Brad Hutto, Dr. Tracy Macpherson, Lawrence Garick, Andy Gunn, and the late Wayne McCormick; for pushing me and challenging me on my path to obtaining the rank of Eagle Scout. I will never forget the extra time and effort that you all put in to help me and the other scouts to become better men. Last, but not least I would like to thank my co-committee chair, boss, and friend, Dr. Kendall R. Kirk. You are an inspiration to everyone that you meet, and you constantly challenge others to be the best they can be. I truly appreciate your friendship and patience over the past several years through this process!
Thank you all again for everything that you all have done for me over the years to get me to this point in my life! I honestly can say that I would not be where I am today without each and every one of you challenging me and pushing me to be the best that I can be.
ACKNOWLEDGEMENTS

I would like to acknowledge all of my committee members for helping me through the graduate program process. A special thanks to Dr. Kendall Kirk for the countless hours of hard work, mentorship, and patience that you showed me throughout the last four years of my research. I would also like to thank Dr. Daniel Anco for having your team plant and manage the peanut fields that my research was in during the 2018 and 2019 seasons. Dr. Nathan Smith, thank you for all of the meetings that we had regarding my research and for your guidance. Dr. Aaron Turner, thank you for agreeing to serve as a committee member on such short notice and for your great feedback on my research work! Thank you also for all your hard work during the 2019 harvest of my project. Mr. Josey Peele, thank you so much for passing along previous research regarding my project and for coming out to help with my research while you were in town. Mr. Warren White, I would also like to thank you for being a mentor while I was an intern at Amadas Industries and for all of your knowledge with anything peanut related. Josey and Warren, I am thankful to have had your expertise while working on this research.

Thanks also goes out to Amadas Industries for supporting not only this project, but also supporting me. I will always be grateful for the time and effort that you all have put in on my behalf over the past several years. Thank you for giving me a chance as an intern for three summers in which I learned so much valuable knowledge that I was able to apply to my research and personal family farm. I am where I am today, career wise and
educationally, because of your company. Without your funding and support, this project would not have been possible, and I am forever grateful to you all!

I would also like to acknowledge all of the hard working individuals that made my research project possible: Justin Hiers, Trevor Zorn, Cash Coker, Perry Loftis, Brennan Teddy, Alex Samenko, Kayla Carrol, Bob Webb, Wendy Buchanan, Hunter Massey, Dr. Aaron Turner, and the Clemson Agricultural Mechanization & Business program. Due to the massive amount of manual labor this research project required; without your help I would still be picking through peanuts now. Thank you all so much!!
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CHAPTER 1. INTRODUCTION TO THE STUDY

Peanut production has always been a labor-intensive process where crop yield and grade/quality can be adversely affected as a function of harvesting systems, environmental conditions, and machine settings. There have been several improvements to the machinery used for peanut harvest since its first mechanization. Presently, a producer of peanuts has two main machines at hand to harvest their crop: a digger (digger-shaker-inverter) and a combine (picker or harvester). Both the digger and the combine introduce opportunity for affecting recovered yield and grade/quality.

Peanut combines are either pull-type or self-propelled. For both the pull-type and self-propelled combines, there is one person (operator) who changes combine settings based on experience, vine conditions, and observations. Some of the settings can be changed in an on-the-go fashion from inside the cab, while others must be done while the combine is stationary. The five main settings that can be changed on-the-go include: PTO speed (Power Take Off/combine speed), ground speed, header speed, header height, and elevator fan air volume (for machines using pneumatic conveyance for crop delivery to the basket). These five settings are critical to an operation’s efficiency and all of which affect profitability; they affect yield recovery, crop grade/quality, and the time to harvest the crop from the field. There are also several combine settings that must be changed while the combine is stationary: aggression of the picking cylinders, cleaning air volume, retention board position, and tail board position.

If someone were to ask producers of peanuts on how to set their combines, their answers would likely differ as a result of: personal preference/ experience and perhaps
the lack of scientific studies investigating optimum settings. While a great deal of academic research has highlighted digger-related yield losses as a function of operation and settings (Bader & Sumner, 2012; Kirk, et al., 2014; Mozingo et al., 1991; Roberson & Jordan, 2014; Warner, et al., 2014; Warner A., 2015; Wright & Porter, 1991), less has been reported on losses and grade/quality as a function of combine operation and settings (Washington DC, US Patent No. 4,142,348, 1979; Washington DC, US Patent No. 4,188,772, 1980; Wright F., 1968). The only recent (within the past 10 years) publications found addressing combine settings were industry operator manual recommendations (Amadas Industries, 2010 & KMC, 2015) and an extension publication by the University of Georgia (Bader & Sumner, 2012).

With regards to effects of PTO speed and ground speed on combine efficiency, the most recent research was a study reported by F. Wright in 1968, about a half a century prior to this study. Wright investigated the effects of combine cylinder speed and feed rate on peanut damage and combining efficiencies. For a given set of crop conditions, feed rate was found to be directly proportional to ground speed. This study looked at how peanut grade/quality was affected by combine PTO speed and the flow rate of material through the combine, but this study did not look at yield losses specifically related to the header and tailings. Wright found that at lower PTO speeds, there were less losses and LSKs (loose shelled kernels) as compared to the higher PTO speeds he tested (Wright F., 1968).

With regards to header speed, Amadas Industries (Suffolk, Va.) recommends in their manuals to “set header speed so that [the] header picks up the windrow completely
as the combine travels down the field” (Amadas Industries, 2015). Kelly Manufacturing Company (KMC) (Tifton, Ga.) recommends adjusting (matching) the pickup speed to ground speed (KMC, 2015). The publication from the University of Georgia recommends adjusting the header speed so that it would “match the forward speed [ground speed]” (Bader & Sumner, 2012). Both the KMC and University of Georgia recommendations are similar, due to similar variety of peanuts being harvested. There have been several systems that used ground-driven speed systems as a gauge for pickup speed (Washington DC, US Patent No. 4,188,772, 1980). The technology for these systems were never widely adopted.

Besides research conducted in 1968 by F. Wright and extension publications, the lack of current research on the effects of peanut combine settings prompted the study presented here to characterize yield losses and grade/quality effects as functions of some of the settings that can be adjusted on-the-go.

**Objectives**

The objectives of this study were for both virginia and runner type peanuts:

1. quantify tailings losses, grade/quality, and peanut loan rate value as a function of PTO speed
2. quantify tailings losses, material throughput, grade/quality, and peanut loan rate value as a function of ground speed
3. quantify header losses as a function of header speed.
References


CHAPTER 2. YIELD LOSS AND QUALITY EFFECTS OF PEANUT COMBINE
PTO SPEED SETTINGS

Abstract

A research project was conducted to understand and quantify yield losses and
grade/quality associated with peanut combine speed settings. On a peanut harvester, there
are two main avenues for potential of peanut losses: losses as associated with the header
(where vines enter) and losses associated with the cleanout (where the tailings exit).
Variables tested in this study included: PTO speed, ground speed, and header speed.
These variables were the only items that were changed throughout this study; other
important operational settings, such as threshing aggression and cleaning air adjustments,
were set to normal operational settings. Results from the PTO speed settings are
highlighted in this study.

The study was conducted in Barnwell County, S.C. on commonly grown varieties
for regional producers, using a virginia variety (Bailey) in 2018 and a runner variety
(FloRun 311) in 2019. Tests were conducted on 4-row wide, 3.86 m (12.67 ft), non-
irrigated plots that were 19.20 m (63 ft) in length. Treatments were evaluated using
measurements of yield, grade/quality, throughput, and tailings losses. Tailings losses
increased by 245 kg ha⁻¹ (219 lb ac⁻¹) for the 2018 virginia variety testing and 76 kg ha⁻¹
(68 lb ac⁻¹) for the 2019 runner variety testing per each 10 percent increase in PTO speed,
respectively. Header losses were not a focus for the PTO speed testing. Knowledge of
yield and grade/quality effects of combine settings will assist producers in making
economic decisions for peanut combine operation.
Introduction

Peanut production has always been a labor-intensive process where crop yield and grade/quality can be adversely affected as a function of harvesting systems, environmental conditions, and machine settings. There have been several improvements to the machinery used for peanut harvest since its first mechanization. Presently, a producer of peanuts has two main machines at hand to harvest their crop: a digger (digger-shaker-inverter) and a combine (picker or harvester). Both the digger and the combine introduce opportunity for affecting recovered yield and grade/quality.

The Peanut Harvest Process

To completely understand the process that peanuts undergo, a more detailed illustration into the process of peanut harvesting will be discussed. First, a producer must establish the proper time to dig the crop from the ground. Wright & Porter found in 1991 that peanut yields and grade/quality were significantly affected by improper digging date (Wright & Porter, 1991). Proper digging time is important to maximizing yield recovery at time of digging and it is also key to improving the grade of the peanuts, where higher grades equate to higher values. Additional evidence from Mozingo et al. found that not only does proper digging time matter, but in harsh environmental conditions during crucial developmental periods, i.e. pegging and flowering, grade, yield, and value in peanuts were adversely affected (Mozingo et al., 1991). After a producer determines that the crop is ready to be harvested, a digger is used to lift the pods from beneath the ground surface. During this process of digging, the peanuts are raised from the ground, shaken of
dirt that may be adhered to the crop, and flipped upside down (inverted) to expose the crop to the sun for drying.

A research publication produced by the University of Georgia titled *Peanut Digger and Combining Efficiency*, stated that usually after two to three days after digging, peanuts can be combined with minor mechanical damage; windrowed peanuts have reached a moisture content of 18 to 24 percent (Bader & Sumner, 2012). After drying the crop to the desired moisture content, the producer harvests the peanuts with a peanut combine. There are different techniques in how peanut combines separate the crop from their vines, conventional or rotary, but the overall process is essentially the same. The combine completes all of the following throughout the harvest process: lifts the crop into the machine with what is known as a header, picks the pods from the vines, separates pods from remaining vine and trash material, and conveys the pods to a holding reservoir (basket) on the combine. From there, the peanuts are unloaded on to trailers or wagons and carried to a buying point to be sold into the market.

**Combine Settings**

Peanut combines are either pull-type or self-propelled. For both the pull-type and self-propelled combines, there is one person (operator) who changes combine settings based on experience, vine conditions, and observations. Settings are generally adjusted to maximize yield recovery and grade/quality while also maintaining a reasonable harvest timeliness. According to Bader and Sumner, “An improperly set combine can result in reduced peanut yield and a product with excessive pod damage, loose-shelled kernels (LSKs) and foreign material (FM)” (Bader & Sumner, 2012). Some of the settings can be
changed in an on-the-go fashion from inside the cab, while others must be done while the combine is stationary. The five main settings that can be changed on-the-go include: PTO speed (combine speed), ground speed, header speed, header height, and elevator fan air volume (for machines using pneumatic conveyance for delivery to the basket). These five settings are critical to an operation’s efficiency and all of which affect profitability; they affect yield recovery, crop grade/quality, and the time to harvest the crop from the field. There are also several combine settings that must be changed while the combine is stationary: aggression of the picking cylinders, cleaning air volume, retention board position, and tail board position. These settings can vary by machine model, (Amadas Industries, 2010 & KMC, 2015) and could have just as much effect on harvest efficiency as those that can be changed on-the-go. These combine settings are often set at the beginning of a harvest season and are usually left unchanged throughout the harvest season, unless vine or crop conditions change significantly.

If someone were to ask producers of peanuts on how to setup their combines, their answers would likely differ as a result of: personal preference/experience and perhaps the lack of scientific studies investigating optimum settings. While a great deal of academic research has highlighted digger-related yield losses as a function of operation and settings (Bader & Sumner, 2012; Kirk, et al., 2014; Mozingo et al., 1991; Roberson & Jordan, 2014; Warner, et al., 2014; Warner A., 2015; Wright & Porter, 1991), less has been reported on losses and grade/quality as a function of combine operation and settings (Washington DC, US Patent No. 4,142,348, 1979; Washington DC, US Patent No. 4,188,772, 1980; Wright F., 1968). The only recent publications (within the past 10
years) found addressing combine settings, were industry operator manual
recommendations and an extension publication by the University of Georgia (Bader &
Sumner, 2012). The lack of research suggests an opportunity for benefiting the peanut
industry through scientific research of yield recovery and grade/quality as a function of
combine settings. The potential for grade/quality effects can occur throughout the peanut
combine and the potential for losses are at two main locations: the header (where vines
and peanuts enter the combine) and cleanout (where tailings/trash exit the combine).
These two areas have varying opportunities for yield loss and effects as combine harvest
settings are changed.

Though published research for peanut combines proved to be limited, there are
several research studies conducted on grain/conventional combines regarding harvest
efficiencies (Andrews, S. et al., 1993; Mesquita, C. et al., 2006; & Paulsen, M. et al.,
2014). One study by Mesquita, C. et al. in 2006 looked at how harvest efficiency in
soybeans was controlled by operational and crop characteristics and found an optimal
ground speed and cylinder speed setting for reducing losses (Mesquita, C. et al., 2006).
Another research study using conventional combines, though in rice harvesting, by
Andrews et al. in 1993 looked at the effects of feed rate, combine speed, and concave
settings and found that all three played a role in rice harvest efficiency (Andrews, S. et
al., 1993). As seen in the research found for grain combines, ground and combine speeds
are critical to reducing yield losses.

With regards to effects of PTO speed and ground speed on combine efficiency,
the most recent research was a study reported by F. Wright in 1968, about half a century
ago. Wright investigated the effects of combine cylinder speed and feed rate on peanut damage and combining efficiencies. For a given set of crop conditions, feed rate was found to be directly proportional to ground speed. This study looked at how peanut quality was affected by combine PTO speed and the flow rate of material through the combine, but this study did not look at yield losses specifically related to the header and tailings. Wright found that at lower PTO speeds, there were less losses and LSKs as compared to the higher PTO speeds he tested (Wright F., 1968). It is important to note that Wright changed only the cylinder speed of the 1966 Roanoke 2-row combine used. He did this by varying sprocket sizes to increase and decrease cylinder speeds; -27%, normal, +27% cylinder speeds. Wright held PTO speed, ground speed, and all other variables constant throughout the study. The cleaning fan was decreased in “dry” conditions in order to account for moisture.

With regards to header speed, Amadas Industries (Suffolk, Va.) recommends in their manuals to “set header speed so that [the] header picks up the windrow completely as the combine travels down the field” (Amadas Industries, 2015). Kelly Manufacturing Company (KMC) (Tifton, Ga.) recommends adjusting (matching) the pickup speed to ground speed (KMC, 2015). The publication from the University of Georgia recommends adjusting the header speed so that it would “match the forward speed [ground speed]” (Bader & Sumner, 2012). Both the KMC and University of Georgia recommendations are similar, due to similar variety of peanuts being harvested. These recommendations are likely based on years of experience and observation, although none appear to be supported by scientific research.
There have been several systems that used a ground-driven speed system as a gauge for pickup speed. For example, Jordan and Mitchell developed a “hydraulic speed control system for the pickup reel of a peanut combine,” in which they used a gauge wheel driven by one of the tires of the harvester to match the pickup speed to ground speed (Washington DC, US Patent No. 4,188,772, 1980). The technology for these systems were never widely adopted.

Besides research conducted in 1968 by F. Wright, the lack of current research on the effects of peanut combine settings prompted this study to characterize yield losses and grade/quality effects as functions of some of the settings that can be adjusted on-the-go. Specific objectives of this study were to complete the following for both virginia and runner type peanuts: quantify tailings losses, grade/quality, and peanut loan rate value as a function of PTO speed.

**Methods and Materials**

Peanut varieties that were used for testing in the 2018 and 2019 crop years were Bailey, a virginia type peanut, and FloRun 311, a runner type peanut. The tests from 2018 and 2019 will be referred to as the *Virginia Study* and the *Runner Study*, respectively. Peanuts were planted on 97 cm (38 in) row spacing and were managed in accordance with Clemson Extension recommendations. Traffic rows were excluded from the tests to avoid the effects of compaction; traffic rows being the four rows adjacent to tire tracks for the sprayer used throughout the growing season. The fields that were used for the study, ‘C4’ and ‘G3B,’ were located at the Edisto Research and Education Center, Edisto REC, in Barnwell County, S.C. Field ‘C4’ was used for the *Virginia Study* and field
‘G3B’ was used for the Runner Study. Both of the fields used for this research project consisted predominately of Barnwell loamy sand (Soil Survey Staff, 2019). Weather data was collected using a Davis Vantage Pro 2 weather station (Davis Instruments Corporation, Hayward, CA) located at the EREC. The tractor that was used for these studies was a John Deere 7920 model and the combine was an Amadas 2108 4-row model. The combine used for the testing was a ‘conventional’ threshing harvester, which is the most commonly used combine trashing method for S.C. producers.

The weather that was present in 2018 from the end of October to the end of November was not well-suited for field drying of peanuts, since after digging peanuts one should generally expect suitable drying within one week (Bader & Sumner, 2012). This drying period is dictated by weather conditions present after digging. Digging of the peanuts for the Virginia Study was conducted on 3 November 2018 and harvest of these peanuts was not until 28-30 November 2018, 25-27 days after digging. This vast time difference was due to receiving approximately 9.88 cm (3.89 in) of rain and an average mean temperature of 11°C (52°F) during the period the peanuts were on top of the ground, 3 November to 28 November. With the increased time that the peanuts were on top of the ground, losses as a function of field drying time and exposure to weather were potential, but were not directly assessed for this research, since all treatments were exposed to the same conditions.

For the Runner Study, the peanuts were dug on 4 November 2019 and harvested on two separate occasions—a wet harvest and a dry harvest. Having two different harvest times enabled the study to reflect results for different vine and crop moisture conditions.
The first harvest period, the Runner Study (wet) harvest, was 7 and 8 November 2019, 3 to 4 days after digging. During this time period, rainfall was approximately 1.55 cm (0.61 in) and temperature averaged 15°C (59°F). The second harvest, the Runner Study (dry) harvest, was 22 November 2019, 18 days after digging. During this time period, rainfall was approximately 5.54 cm (2.18 in) and temperature averaged 10°C (50°F).

Digging losses were not a part of this research, though to keep consistency, all peanut rows were dug in the same direction within a given replication. For all test plots, combine travel direction matched the digger travel direction to mitigate any potential effects of combining opposite of digging direction. Currently there is no absolute data proving the effects of harvesting peanuts in an opposite direction of digging. Peanuts were dug with a KMC 2-row digger at a ground speed of 4.0 km hr⁻¹ (2.5 mi hr⁻¹).

**Experimental design**

The combine settings that are most commonly altered during the peanut harvest, and the ones tested here, included three of the five settings that can be changed on-the-go: PTO speed, ground speed, and header speed. Elevator air volume, header height, and the settings normally not set on-the-go, stated in previous section, were set to normal peanut producer and machinery manufacturer specifications for the harvested crop conditions. Plots for the virginia and runner studies were set up similarly, as randomized block designs with five replications, the Virginia Study including 25 treatments (Table 1) and the Runner Study including a wet harvest with 15 treatments (Table 2) and a dry harvest with 15 treatments (Table 3). The data was collected, normalized, and analyzed using JMP statistical software by SAS. A one-way ANOVA and means comparison test,
student’s t-test, were performed at the 95% confidence level for each study to assess statistical differences and trends within the data collected.

Table 1. Combine setting treatments tested in Virginia Study.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>PTO Speed, %&lt;sup&gt;[a]&lt;/sup&gt;</th>
<th>Ground Speed, km hr&lt;sup&gt;-1&lt;/sup&gt; (mi hr&lt;sup&gt;-1&lt;/sup&gt;)</th>
<th>Header Speed, %&lt;sup&gt;[b]&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>0.8 (0.5)</td>
<td>70</td>
</tr>
<tr>
<td>2</td>
<td>100</td>
<td>0.8 (0.5)</td>
<td>85</td>
</tr>
<tr>
<td>3</td>
<td>100</td>
<td>0.8 (0.5)</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>100</td>
<td>0.8 (0.5)</td>
<td>115</td>
</tr>
<tr>
<td>5</td>
<td>100</td>
<td>0.8 (0.5)</td>
<td>130</td>
</tr>
<tr>
<td>6</td>
<td>100</td>
<td>1.3 (0.8)</td>
<td>70</td>
</tr>
<tr>
<td>7</td>
<td>100</td>
<td>1.3 (0.8)</td>
<td>85</td>
</tr>
<tr>
<td>8</td>
<td>100</td>
<td>1.3 (0.8)</td>
<td>100</td>
</tr>
<tr>
<td>9</td>
<td>100</td>
<td>1.3 (0.8)</td>
<td>115</td>
</tr>
<tr>
<td>10</td>
<td>100</td>
<td>1.3 (0.8)</td>
<td>130</td>
</tr>
<tr>
<td>11</td>
<td>100</td>
<td>1.8 (1.1)</td>
<td>70</td>
</tr>
<tr>
<td>12</td>
<td>100</td>
<td>1.8 (1.1)</td>
<td>85</td>
</tr>
<tr>
<td>13</td>
<td>100</td>
<td>1.8 (1.1)</td>
<td>100</td>
</tr>
</tbody>
</table>

<sup>[a]</sup> PTO speed expressed as a percentage of manufacturer design speed.

<sup>[b]</sup> Header speed expressed as a percentage of ground speed, measured at 7.0 cm from tip of header tooth.

Table 2. Combine setting treatments tested in Runner Study (wet) harvest.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>PTO Speed, %&lt;sup&gt;[a]&lt;/sup&gt;</th>
<th>Ground Speed, km hr&lt;sup&gt;-1&lt;/sup&gt; (mi hr&lt;sup&gt;-1&lt;/sup&gt;)</th>
<th>Header Speed, %&lt;sup&gt;[b]&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>90</td>
<td>1.2 (0.75)</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>90</td>
<td>1.6 (1.0)</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>90</td>
<td>2.0 (1.25)</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>90</td>
<td>2.4 (1.5)</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>100</td>
<td>1.2 (0.75)</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>100</td>
<td>1.6 (1.0)</td>
<td>100</td>
</tr>
<tr>
<td>7</td>
<td>100</td>
<td>2.0 (1.25)</td>
<td>100</td>
</tr>
<tr>
<td>8</td>
<td>100</td>
<td>2.4 (1.5)</td>
<td>100</td>
</tr>
</tbody>
</table>

<sup>[a]</sup> PTO speed expressed as a percentage of manufacturer design speed.

<sup>[b]</sup> Header speed expressed as a percentage of ground speed, measured at 7.0 cm from tip of header tooth.
Table 3. Combine setting treatments tested in Runner Study (dry) harvest.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>PTO Speed, %[^a]</th>
<th>Ground Speed, km hr⁻¹ (mi hr⁻¹)</th>
<th>Header Speed, %[^b]</th>
<th>Treatment</th>
<th>PTO Speed, %[^a]</th>
<th>Ground Speed, km hr⁻¹ (mi hr⁻¹)</th>
<th>Header Speed, %[^b]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>90</td>
<td>1.6 (1.0)</td>
<td>100</td>
<td>9</td>
<td>110</td>
<td>1.6 (1.0)</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>90</td>
<td>2.4 (1.5)</td>
<td>100</td>
<td>10</td>
<td>110</td>
<td>2.4 (1.5)</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>90</td>
<td>3.2 (2.0)</td>
<td>100</td>
<td>11</td>
<td>110</td>
<td>3.2 (2.0)</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>90</td>
<td>4.0 (2.5)</td>
<td>100</td>
<td>12</td>
<td>110</td>
<td>4.0 (2.5)</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>100</td>
<td>1.6 (1.0)</td>
<td>100</td>
<td>13</td>
<td>100</td>
<td>4.8 (3.0)</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>100</td>
<td>2.4 (1.5)</td>
<td>100</td>
<td>14</td>
<td>100</td>
<td>4.8 (3.0)</td>
<td>100</td>
</tr>
<tr>
<td>7</td>
<td>100</td>
<td>3.2 (2.0)</td>
<td>100</td>
<td>15</td>
<td>100</td>
<td>4.8 (3.0)</td>
<td>100</td>
</tr>
<tr>
<td>8</td>
<td>100</td>
<td>4.0 (2.5)</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[^a]: PTO speed expressed as a percentage of manufacturer design speed.
[^b]: Header speed expressed as a percentage of ground speed, measured at 7.0 cm from tip of header tooth.

The ground speeds tested were determined at the beginning of each harvest date and were assigned based on the crop moisture conditions present on the given harvest dates, setting the upper ground speed near machine capacity. Ground speeds used in the Virginia Study were lower than typical speeds as a result of wet peanut vines, though, as discussed, they had been on top of the ground for a long period of time, not being dry enough for normal combining ground speeds. In the Runner Study, since there were two harvest dates, there were two separate ground speed ranges used.

Plot width for both studies was set at four rows (two windrows), 3.86 m (12.67 ft), to match the combine width and the plot length was set at 19.2 m (63 ft) in order to maximize steady-state combine loading conditions while minimizing loading and unloading conditions. Yield data was collected with a pre-production prototype peanut yield monitoring platform jointly developed by Clemson University and Amadas Industries. The first and last 3.65 m (12 ft) of yield monitor data from each plot was deleted to reduce effects of combine loading and unloading. From previous research with
the combine used in these studies, mass flow sensor response data suggested that combine loading and unloading both occur within about 10 seconds of steady state loading conditions, reflecting ramp up and ramp down to steady state. At the range of ground speeds used in these studies, the plot length implemented ensured that the combine was at steady state loading for more than half of the plot length for all plots (i.e., ~40 ft).

**Tailings loss collection**

To effectively capture and quantify combine tailing losses, a tailings collection trailer was developed. This trailer was made to attach to the combine’s axle and travel with the combine, supported at the rear by a pair of casters. The trailer system included a containment bin that held all tailings from each 19.2 m (63 ft) long plot. There was a tarp attached to the trailer positioned directly on top of the containment chamber so that when harvesting of each plot was completed, unloading of the trailer was simplified. An image of the tailings collection trailer is shown in Figure 1a. After the plot was harvested, the combine was shut down and the total tailings (including any peanut losses) were weighed. Subsequently, the peanut losses and vine material in the tailings were separated using a stationary peanut combine (Henan Xuanhua Import & Export Trading Company, Ltd., China) (Figure 1b). After running through the stationary combine, the separated peanuts (tailings losses) were collected, bagged up for storage, dried for a minimum of 10 days at 75°C (167°F), and weights were taken to determine losses of each plot. The ASABE standard, S410.2, for drying peanuts was not followed due to the capabilities of
the dryers present at the EREC, a modified drying schedule was adopted to account for the higher temperatures required by the standard (ASABE Standards, 2010).

![Image](image1.jpg)

![Image](image2.jpg)

Figure 1. Tailings collection trailer system as the combine travelled across the header loss collection tarp (a) and stationary peanut combine operation for separation of peanut losses from vine material in tailings (b).

**Vine moisture measurement**

A 0.5 kg (1 lb) vine moisture sample was taken from each of the plots at the time of separation of the peanuts using the stationary peanut combine. This sample was bagged up in a sealed plastic bag, weighed within four hours of harvest, dried for a minimum of 10 days at 75°C (167°F), and weighed again to determine the vine moisture content of each plot. Similar drying method as tailings losses performed.

**Grade/quality sampling**

A 0.9 kg (2 lb) grade/quality sample was collected from the combine during harvest at the center of each plot. This sample was collected by holding a fishing bait net in the path of the peanuts entering the basket. Once the bait net was full, the sample was bagged up for dry storage and grade/quality was determined for each of the samples. The USDA standards for grading virginia and runner type peanuts were used (USDA, 2019).
**Yield data collection**

As previously stated, peanut yield data was collected with a pre-production prototype peanut yield monitoring platform jointly developed by Clemson University, Amadas Industries, and John Deere. The peanut yield monitor used a John Deere microwave sensor, used in John Deere’s cotton yield monitoring system. The microwave sensor response related to mass flow moving across the sensing field. The accuracy of this platform has not been demonstrated for plot trials. The stability of the calibration is also not known across a wide range of combine operational parameters. For these reasons, the yield data using this system was reported here to demonstrate relative yield averages across treatments, but not for comparison between treatments.

**Implications of Observed Effects**

While an operator would normally adjust settings on the combine (e.g. threshing aggression, pneumatic separation velocity, and pneumatic conveying velocity) to address some of the effects measured and discussed here, those settings remained constant throughout the study so that only the parameters that were changed were PTO, ground, and header speeds. It is important to note that though the other settings remained constant, volumetric output of the fans and air velocities changed based on the ratio of changes in PTO speed. More research is needed to determine the effects of changing the other adjustments on a peanut combine, relative to the observed effects discussed here.

**Tailings Losses**

Tailings losses are produced when whole pod peanuts are moved through the combine and out of the rear of the combine, resulting in a yield loss. This reduction in
yield creates a decrease in the amount of recovered yield from a field, resulting in a total value reduction of buying point payout for the crop to a producer. Increased threshing aggression and pneumatic separating velocities could cause the whole pod peanuts to move through the combine at a faster rate and blown out the rear of the combine due to the cleaning air fan blowing faster. Alternatively, lesser threshing aggression could also result in increased tailings losses from clumps of vine material being discharged, from which pods had not yet been separated.

*Loose Shelled Kernels (LSKs)*

Loose shelled kernels (LSKs) are defined on pages 73-76 of Clemson’s *Peanut Production Guide* as “kernels and parts of kernels which are free from the hull in a load of farmers’ stock peanuts” (Anco & Thomas, 2020). When PTO speed increases, threshing aggression and pneumatic conveying velocities increase proportionality, which may increase the number of LSKs found in the basket. Increased LSKs would result in a total value reduction of buying point payout for the crop to a producer, due to not receiving the premium amount per kilogram (pound) for Sound Mature Kernels (SMKs); the value for LSKs is approximately $0.15 kg⁻¹ ($0.07 lb⁻¹) of LSKs or $127 tonne⁻¹ ($140 ton⁻¹). It is reported that for each percent increase of LSKs in a grade/quality sample, there is a $2.00 tonne⁻¹ ($2.20 ton⁻¹) loss in value of the stock peanuts.

*Foreign Material (FM)*

Foreign material (FM) is defined as any “dirt, sticks, rocks, trash & raisins” in a peanut grade sample (FSA, 2018 & FSA, 2019). In general, FM and LSKs are directly proportional since with an increase in LSKs there is inherently an increase in loose hulls,
which contribute to FM. Increased FM would result in a reduction of buying point payout for the crop to the producer, resulting in a steep loss. The deduction value of FM is approximately $1 per percent of FM per ton after a value of 4% FM per ton. This deduction is used to find the ‘total discount value’ of peanuts. The ‘total discount value is the sum of the Sound Splits (SS), Damaged Kernels (DK), and the Foreign Material (FM) on a per tonne (ton) basis. All of which deduct final value per tonne (ton) from the total loan rate value of the peanuts.

*Yield Data*

Peanut yield data was collected with a pre-production prototype peanut yield monitoring platform jointly developed by Clemson University, Amadas Industries, and John Deere. Like all yield monitoring systems, the prototype peanut yield monitoring system used in this study performed well in demonstrating relative yield changes across a large area of interest, but its accuracy and performance is unknown across plot sized areas of interest, 3.86 m by 19.20 m (12.67 ft by 63 ft). Furthermore, the stability of a given calibration is unknown when implemented across a wide range of operational parameters, such as those performed in this study. For these reasons, average yield data across treatments was presented for each loading range analysis but yield monitor-indicated yield was not used as a basis for comparison between treatments for both the *Virginia Study* and *Runner Study*.

*Loan Rate & Value*

While yield and peanut value on a per area basis proved to be a highly variable source for data comparisons, peanut loan rate was used to compare PTO speed settings
across each loading range for both the Virginia Study and Runner Study. Loan rate was calculated based on the grade/quality of the peanuts. The USDA standards for grading virginia and runner type peanuts were used, as previously stated in the Material and Methods, for the peanut grading process (USDA, 2019). Loan rate was determined on a value per weight rate, $ tonne⁻¹ ($ ton⁻¹). Loan rate was calculated as the difference of the ‘total kernel value’ and the ‘total discount value.’ The ‘total kernel value’ is the sum of the Sound Mature Kernels (SMK), Other Kernels (OK), Extra-Large Kernels (ELK), and Loose Shelled Kernels (LSKs) on a per tonne (ton) basis. The ‘total discount value’ is the sum of the Sound Splits (SS), Damaged Kernels (DK), and the Foreign Material (FM) on a per tonne (ton) basis. Further definitions and value calculations/deductions for SMK, OK, ELK, LSK, SS, DK, and FM are provided by the USDA Farm Service Agency (FSA, 2018 & FSA, 2019). Using loan rate shows the effects of grade/quality due to changes in PTO speed settings and is independent of yield.

Peanut value per unit area was projected for each of the treatments by assuming a base yield of 2.2 tonne ha⁻¹ (2.0 ton ac⁻¹), deducting tailings losses, and applying observed loan rate. These projections suggest the cumulative effects of tailings losses, quality, and loan rate, rather than looking at them independently of one another.

Results and Discussion

In 2018 and 2019, research was conducted on virginia and runner type peanuts to determine the effects of PTO speed on several factors that affect the yield losses, grade/quality and loan rate value of peanuts. The effects of PTO speed were split into four different categories: tailings losses, % LSKs, % FM, and loan rate.
PTO speed settings for harvest conditions will either speed up or slow down the mechanical (threshing and material separating) parts of the combine. On modern combines, the header and ground speeds are adjusted independently of the PTO speed and are not directly addressed here. The rotational speed of the combine is determined by the combine speed or PTO speed. According to Amadas Industries recommendations for normal operation, combine speeds for peanut harvest range from 90% - 110% combine [PTO] speeds (Amadas Industries, 2010), which correspond to tractor PTO speeds ranging from 711 – 869 rev min\(^{-1}\) on a 1,000 rev min\(^{-1}\) PTO shaft. The percentage speeds stated above are specified by the manufacturer based on the design of the combine.

In 2018, research was conducted on virginia type peanuts, the *Virginia Study*, and only one harvest timing was performed. Harvesting of the *Virginia Study* was conducted 25-27 days after digging, as a result of weather-related conditions preventing in field harvest at any earlier time. This vast time delay after digging may have caused weather-related losses and grade/quality effects, but those losses were not determined since they were not a part of this research. At the time of harvest in 2018, the average vine moisture content was approximately 32% wet basis. The treatments that were used in the *Virginia Study* were developed several weeks before the harvest date. The range of harvest speeds tested could have possibly been increased for this test, although this was difficult to predict prior to testing, given the weather conditions at the time.

In 2019, research was conducted on runner type peanuts, the *Runner Study*, where two harvest timings were performed: *Runner Study (wet)* and *Runner Study (dry)*. Dividing the *Runner Study* into two separate harvest timings allowed better
understanding of the effects that vine moisture played in the harvesting process. Both Runner Study tests were dug at the same time, but they were harvested on different dates, to simulate the differing effects vine moisture had on combining. The Runner Study (wet) test was harvested 3-4 days after digging, a time at which many of the vines were still green; vine moisture content of 49% wet basis. The Runner Study (dry) test was harvested 18 days after digging, at which there were some vines that still showed signs of green biomass, but the majority of the vines did not show signs of green biomass. The time between digging and harvesting for the Runner Study (dry) test had periods of rain and on the day of harvest, there was a light fog/mist that did not lift until the next day, vine moisture content of 47% wet basis. This light fog/mist may have caused vine moisture content to be higher than what one would have expected for the period over which the peanuts were inverted, however, there was no prior basis for vine moisture content in the literature for comparison. The data collected from the Runner Study tests specifically test combine adjustments, but also show how harvest conditions play a role in a successful and efficient harvest.

**Effect of PTO Speed: Virginia Study**

In 2018, research was conducted on virginia type peanuts, for the purposes of this paper it will be referred to as the Virginia Study, to determine the effects of PTO speed on several factors, including tailings losses, grade/quality, yield, and peanut loan rate. To better understand the effects of PTO speed, the Virginia Study was split into three different ‘loading’ categories: low loading, medium loading, and high loading. These three categories were created by separating the testing parameters into groups based on
ground speed. Dividing them into these groups was hypothesized to be the best way to understand the collected data under differing throughput on the combine. The treatments that were used and analyzed for the Virginia Study were from Table 1.

The Low Loading Range consisted of all data for the ground speeds ranging from 0.8 - 1.3 km hr\(^{-1}\) (0.5 - 0.8 mi hr\(^{-1}\)). The Medium Loading Range consisted of all data for the ground speed of 1.8 km hr\(^{-1}\) (1.1 mi hr\(^{-1}\)). The High Loading Range consisted of all data for the ground speed of 2.3 km hr\(^{-1}\) (1.4 mi hr\(^{-1}\)). The data is shown in a series of three consolidated tables, Table 4 through Table 9. These tables describe the treatments that were tested, the effects of the tested treatments, and the results the treatments had on tailings loss and grade/quality effects overall. Differences may have been more detectable if the sample sizes of each of the PTO speeds were larger, but the findings presented reflect the collected data for the Virginia Study.

Low Loading Range

The treatments that were used and analyzed for the Low Loading Range were treatments 3, 8, 21, and 22 from Table 1. These treatments had the lowest ground speed range of 0.8-1.3 km hr\(^{-1}\) (0.5-0.8 mi hr\(^{-1}\)); had PTO speed settings of 90 and 100%; and had a consistent header speed, as related to ground speed, of 100%. The average throughput for this range was approximately 5,427 kg hr\(^{-1}\) (4,842 lb hr\(^{-1}\)). Results showing the effects of PTO speed for the Virginia Study, Low Loading Range are provided in Table 4.
Table 4. Measured effects of PTO speed for the Virginia Study, Low Loading Range (0.8 and 1.3 km hr⁻¹; 5,427 kg hr⁻¹ average material throughput). Uses treatments 3, 8, 21, and 22 from Table 1. Means with different letters are significantly different (student’s t-test, p<0.05).

<table>
<thead>
<tr>
<th>PTO Speed [%]</th>
<th>n</th>
<th>Tailings Losses kg ha⁻¹ (lb ac⁻¹)</th>
<th>LSK %</th>
<th>FM %</th>
<th>Loan Rate $ tonne⁻¹ ($ ton⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>SE [b]</td>
<td>Mean</td>
<td>SE</td>
</tr>
<tr>
<td>90</td>
<td>6</td>
<td>61 (54) b</td>
<td>20</td>
<td>3.90 a</td>
<td>0.87</td>
</tr>
<tr>
<td>100</td>
<td>9</td>
<td>179 (160) a</td>
<td>16</td>
<td>4.62 a</td>
<td>0.71</td>
</tr>
</tbody>
</table>

[a] PTO speed expressed as percentage of manufacturer’s recommendations
[b] SE = standard error

Tailings Losses

Tailings losses were significantly affected by PTO speed settings seen in Table 4 (F₁,₁₄=17.12, p=0.0012). There were significant differences between both PTO speed settings tested, 90% and 100%. These data show that at a higher PTO speed, an increased amount of yield losses were found in the tailings that exited the combine. Tailings losses were lowest at the lowest PTO speed, the increase in tailings losses at higher PTO speeds also may be due to the cleaning air fan blowing more peanuts out the rear of the combine.

Loose Shelled Kernels (LSKs)

The percentage of LSKs were not significantly affected by PTO speed settings seen in Table 4 (F₁,₁₄=0.41, p=0.5311). These data, though not significant, show that at a higher PTO speed, an increased amount of LSKs were found in the basket of the combine.

Foreign Material (FM)

The percentage of FM was not significantly affected by PTO speed settings seen in Table 4 (F₁,₁₄=0.10, p=0.7611). The decrease in percent FM at higher PTO speeds, despite an increase in LSKs, may be due to the cleaning fan air blowing more of the FM...
out the rear of the combine. Similarly, the cleaning fan could also be blowing more peanuts out the back of the combine, as pointed out earlier.

**Loan Rate & Value**

Peanut loan rate was not significantly affected by PTO speed settings seen in Table 4 ($F_{1,14}=0.1639, p=0.6922$). Projected value per unit area was not significantly affected by PTO speed settings as shown in Table 5 ($F_{1,14}=1.2911, p=0.2764$), despite significant differences in tailings losses (Table 4). There were numeric differences with an increase in value at the 90% PTO speed, which was expected due to lower tailings losses.

Table 5. Measured effects of PTO speed on value per unit area for the Virginia Study, Low Loading Range.

<table>
<thead>
<tr>
<th>PTO Speed %</th>
<th>Value $ ha⁻¹ ($ ac⁻¹)</th>
<th>Mean</th>
<th>SE [b]</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>6</td>
<td>1,761 (713) a</td>
<td>10</td>
</tr>
<tr>
<td>100</td>
<td>9</td>
<td>1,725 (698) a</td>
<td>8</td>
</tr>
</tbody>
</table>

[a] PTO speed expressed as percentage of manufacturer’s recommendations  
[b] SE = standard error

**Medium Loading Range**

The treatments that were used and analyzed for the Medium Loading Range were treatments 13, 23, and 24 from Table 1. These treatments had the medium ground speed of 1.8 km hr⁻¹ (1.1 mi hr⁻¹); had PTO speed settings of 90, 100, and 110%; and had a consistent header speed, as related to ground speed, of 100%. The average throughput for this range was approximately 9,353 kg hr⁻¹ (8,345 lb hr⁻¹). Results showing the effects of PTO speed for the Virginia Study, Medium Loading Range are provided in Table 6.
Table 6. Measured effects of PTO speed for Virginia Study, Medium Loading Range (1.8 km hr⁻¹; 9,353 kg hr⁻¹ average material throughput). Uses treatments 13, 23, and 24 from Table 1. Means with different letters are significantly different (student’s t-test; p<0.05).

<table>
<thead>
<tr>
<th>PTO Speed % [a]</th>
<th>Tailings Losses kg ha⁻¹ (lb ac⁻¹)</th>
<th>LSK %</th>
<th>FM %</th>
<th>Loan Rate $ tonne⁻¹ ($ ton⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Mean</td>
<td>SE [b]</td>
<td>Mean</td>
</tr>
<tr>
<td>90</td>
<td>4</td>
<td>52 (46) b</td>
<td>26</td>
<td>4.51 a</td>
</tr>
<tr>
<td>100</td>
<td>2</td>
<td>133 (119) b</td>
<td>37</td>
<td>5.00 a</td>
</tr>
<tr>
<td>110</td>
<td>3</td>
<td>373 (333) a</td>
<td>30</td>
<td>3.57 a</td>
</tr>
</tbody>
</table>

[a] PTO speed expressed as percentage of manufacturer’s recommendations
[b] SE = standard error

Tailings Losses

Tailings losses were significantly affected by PTO speed settings seen in Table 6 (F₂,₈=26.89, p=0.0010). The 90% and 100% speed range did not show significant differences, though the 110% as compared to the 90% and 100% did show significant differences. These data show that as PTO speed increased, an increased amount of yield losses were found in the tailings that exited the combine. The relationship between tailings losses and PTO speed was approximately linear; for every 10% increase in PTO speed, there was an increase of 161 kg ha⁻¹ (142 lb ac⁻¹) in tailings losses (R²=0.93, respectively). Tailings losses were lowest at the lowest PTO speed, the increase in tailings losses at higher PTO speeds also may be due to the cleaning air fan blowing more peanuts out the rear of the combine.

Loose Shelled Kernels (LSKs)

The percentage of LSKs were not significantly affected by PTO speed settings seen in Table 6 (F₂,₈=0.40, p=0.6848). The relationship between mean LSKs and PTO speed was not found to be linear (R²=0.42).
**Foreign Material (FM)**

The percentage of FM was not significantly affected by PTO speed settings seen in Table 6 ($F_{2,8}=1.74$, $p=0.2539$). The relationship between mean FM and PTO speed was not shown to be linear ($R^2=0.29$).

**Loan Rate & Value**

Peanut loan rate was not significantly affected by PTO speed settings seen in Table 6 ($F_{2,8}=0.1940$, $p=0.8286$). Though there were no significant differences, these data showed that peanut loan rate increased as a function of PTO speed, overall. This increase may be due to achieving proper combine loading thresholds that allow the combine to run at its designed capacity, though the relationship between loan rate and PTO speed was linear ($R^2=0.75$). There was a strong negative relationship with loan rate as a function of %FM ($R^2=0.79$). Increased loan rate proved to be associated with fewer FM.

The value of peanuts per unit area was significantly affected by PTO speed settings as shown in Table 7 ($F_{2,8}=6.5515$, $p=0.0310$). This test showed similar trends as the Tailings Losses seen in Table 6. The relationship between acreage value and PTO speed was approximately linear ($R^2=0.88$), equating to roughly $59 \text{ ha}^{-1}$ ($24 \text{ ac}^{-1}$) loss in value per each 10% increase in PTO speed.
Table 7. Measured effects of PTO speed on value per unit area for the Virginia Study, Medium Loading Range. Means with different letters are significantly different (student’s t-test, p<0.05).

<table>
<thead>
<tr>
<th>PTO Speed % [a]</th>
<th>n</th>
<th>Value $ ha⁻¹ ($ ac⁻¹)</th>
<th>Mean</th>
<th>SE [b]</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>4</td>
<td>1,776 (719) a</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>100</td>
<td>2</td>
<td>1,756 (711) ab</td>
<td></td>
<td>13</td>
</tr>
<tr>
<td>110</td>
<td>3</td>
<td>1,658 (671) b</td>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>

[a] PTO speed expressed as percentage of manufacturer’s recommendations  
[b] SE = standard error

High Loading Range

The treatments that were used and analyzed for the High Loading Range were treatments 18 and 25 from Table 1. These treatments had the highest ground speed of 2.3 km hr⁻¹ (1.4 mi hr⁻¹); had PTO speed settings of 100 and 110%; and had a consistent header speed, as related to ground speed, of 100%. The average throughput for this range was approximately 13,191 kg hr⁻¹ (11,769 lb hr⁻¹). Results showing the effects of PTO speed for the Virginia Study, High Loading Range are provided in Table 8.

Table 8. Measured effects of PTO speed for Virginia Study, High Loading Range (2.3 km hr⁻¹; 13,191 kg hr⁻¹ average material throughput). Uses treatments 18 and 25 from Table 1. Means with different letters are significantly different (student’s t-test, p < 0.05).

<table>
<thead>
<tr>
<th>PTO Speed % [a]</th>
<th>Tailings Losses kg ha⁻¹ (lb ac⁻¹)</th>
<th>Mean</th>
<th>SE [b]</th>
<th>LSK %</th>
<th>Mean</th>
<th>SE</th>
<th>FM %</th>
<th>Mean</th>
<th>SE</th>
<th>Loan Rate $ tonne⁻¹ ($ ton⁻¹)</th>
<th>Mean</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>2</td>
<td>121 (108) b</td>
<td>32</td>
<td>2.46 a</td>
<td>0.73</td>
<td>2.27 a</td>
<td>0.51</td>
<td>331 (365) a</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>110</td>
<td>3</td>
<td>367 (327) a</td>
<td>26</td>
<td>3.90 a</td>
<td>0.60</td>
<td>2.16 a</td>
<td>0.42</td>
<td>328 (361) a</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[a] PTO speed expressed as percentage of manufacturer’s recommendations  
[b] SE = standard error
**Tailings Losses**

Tailings losses were significantly affected by PTO speed settings seen in Table 8 ($F_{1,4}=27.47$, $p=0.0135$). Consistent with the results of the other two loading ranges, these data show that at a higher PTO speed, an increased amount of yield losses were found in the tailings that exited the combine. The results suggested that for the 10% increase in PTO speed tested, there were an increase of 245 kg ha$^{-1}$ (219 lb ac$^{-1}$) in tailings losses. As shown in the other loading ranges, the increase in tailings losses at higher PTO speeds also may be due to the cleaning air fan blowing more peanuts out the rear of the combine.

**Loose Shelled Kernels (LSKs)**

The percentage of LSKs were not significantly affected by PTO speed settings seen in Table 8 ($F_{1,4}=2.32$, $p=0.2254$). These data, though not significant, show that at a higher PTO speed, an increased amount of LSKs were found in the basket of the combine. The results suggested that for the 10% increase in PTO speed tested, there was an increase of approximately 1.44% in LSKs found. LSKs may have increased proportionately with PTO speed because of increased aggression and/or increased pneumatic conveying velocities.

**Foreign Material (FM)**

The percentage of FM was not significantly affected by PTO speed settings seen in Table 8 ($F_{1,4}=0.03$, $p=0.8804$). Likelihood of significance in the differences observed is too low to suggest any trend that may or may not have been observed.
Loan Rate & Value

Mean peanut loan rate was not significantly affected by PTO speed settings seen in Table 8 ($F_{1,4}=0.3541, p=0.5937$). It is worth noting that at the higher PTO speed, loan rate decreased, and LSKs increased. The value of peanuts per unit area was not significantly affected by PTO speed settings as shown in Table 9 ($F_{1,4}=4.8131, p=0.1158$), although there were significant differences in tailings losses (Table 8). There were numeric differences with an increase in value at the 90% PTO speed, which was expected due to lower tailings losses.

Table 9. Measured effects of PTO speed on value per unit area for the Virginia Study, High Loading Range. Means with different letters are significantly different (student’s t-test, $p<0.05$).

<table>
<thead>
<tr>
<th>PTO Speed %</th>
<th>n</th>
<th>Value $/ha^{(a)}$ ($/ac^{(a)}$)</th>
<th>Mean</th>
<th>SE $^{(b)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>2</td>
<td>1,758 (711) a</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>110</td>
<td>3</td>
<td>1,637 (663) a</td>
<td>14</td>
<td></td>
</tr>
</tbody>
</table>

$^{(a)}$ PTO speed expressed as percentage of manufacturer’s recommendations
$^{(b)}$ SE = standard error

Effect of PTO Speed: Runner Study (wet)

In 2019, research was conducted on runner type peanuts with relatively wet (green) vine conditions, for the purposes of this paper it will be known as the Runner Study (wet), to determine the effects of PTO speed on several factors, including tailings losses, grade/quality, yield, and peanut loan rate. The Runner Study (wet) tests were split into four different loading categories: all loadings, low loading, medium loading, and high loading. These four categories were established by dividing all the tested ground speeds into separate groups based on the ground speeds that were tested. Dividing them
into these groups aided in understanding the collected data under differing material throughput levels. Ground speeds are directly proportional to loading, or throughput, on the combine, with lower speeds being associated with lower loading. Improperly, or insufficiently loading a combine is known to increase yield losses and grade/quality effects of the peanuts, which could lead to a loss in profit for the producer. Treatments that were used and analyzed for the *Runner Study* (*wet*) were from Table 2.

The *All Loadings Range* consisted of all data for all the ground speeds tested, which ranged from 1.2-2.4 km hr⁻¹ (0.75-1.5 mi hr⁻¹). The *Low Loading Range* consisted of data for the ground speeds ranging from 1.2-1.6 km hr⁻¹ (0.75-1.0 mi hr⁻¹). The *Medium Loading Range* consisted of data for the ground speeds ranging from 1.6-2.0 km hr⁻¹ (1.0-1.25 mi hr⁻¹). The *High Loading Range* consisted of all data for the ground speeds ranging from 2.0-2.4 km hr⁻¹ (1.25-1.50 mi hr⁻¹). Tailings loss, grade/quality, and loan rate value effects as a function of PTO speed are presented in Table 10 through Table 17, with one table for each loading group.

*All Loadings Range*

The treatments that were used and analyzed for the *All Loadings Range* were treatments 1-12 from Table 2. These treatments consisted of the ground speed range of 1.2-2.4 km hr⁻¹ (0.75-1.5 mi hr⁻¹); had PTO speed settings of 90, 100, and 110%; and had a consistent header speed, as related to ground speed, of 100%. The average throughput for this range was approximately 5,554 kg hr⁻¹ (12,245 lb hr⁻¹). Average yield for this loading range was found to be 2,943 kg ha⁻¹ (2,726 lb ac⁻¹) with an estimated acreage
value of $1,105 ha\(^{-1}\) ($447 ac\(^{-1}\)). Results showing the effects of PTO speed for the Runner Study (wet), All Loadings Range are provided in Table 10.

### Table 10. Measured effects of PTO speed for Runner Study (wet), All Loadings Range (1.2, 1.6, 2.0, and 2.4 km h\(^{-1}\); 5,552 kg h\(^{-1}\) average material throughput). Uses treatments 1 through 12 from Table 2.

Means with different letters are significantly different (student’s t test, \(p < 0.05\)).

<table>
<thead>
<tr>
<th>PTO Speed [%]</th>
<th>Tailings Losses kg ha(^{-1}) (lb ac(^{-1}))</th>
<th>LSK %</th>
<th>FM %</th>
<th>Loan Rate $ tonne(^{-1}) ($ ton(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (n)</td>
<td>SE</td>
<td>Mean</td>
<td>SE</td>
</tr>
<tr>
<td>90</td>
<td>65 (58) c</td>
<td>7</td>
<td>4.68 b</td>
<td>0.69</td>
</tr>
<tr>
<td>100</td>
<td>94 (84) b</td>
<td>7</td>
<td>6.59 b</td>
<td>0.69</td>
</tr>
<tr>
<td>110</td>
<td>194 (173) a</td>
<td>7</td>
<td>9.33 a</td>
<td>0.69</td>
</tr>
</tbody>
</table>

[a] PTO speed expressed as percentage of manufacturer’s recommendations
[b] Number of samples. As an exception, \(n=19\) for tailings loss data at 110% PTO speed.
[c] SE = standard error

**Tailings Losses**

Tailings losses were significantly affected by PTO speed settings seen in Table 10 \((F_{2,58}=80.4413, \ p<0.0001)\). These data show that for each increase in PTO speed, a significantly increasing amount of yield losses were found in the tailings that exited the combine. The relationship between mean tailings losses and PTO speed was approximately linear \((R^2=0.91, \ \text{respectively})\); for every 10% increase in PTO speed, there was an increase of 64 kg ha\(^{-1}\) (58 lb ac\(^{-1}\)) in tailings losses. Tailings losses were lowest at the lowest PTO speed. The increase in tailings losses at higher PTO speeds also may be due to the cleaning air fan blowing more peanuts out the rear of the combine, as stated in the Virginia Study.

**Loose Shelled Kernels (LSKs)**

The percentage of LSKs were significantly affected by PTO speed settings in Table 10 \((F_{2,59}=11.3258, \ p<0.0001)\). These data show that at a higher PTO speed, an
increased amount of LSKs were found in the basket of the combine; the relationship between mean LSKs and PTO speed was approximately linear ($R^2=0.99$). For every 10% increase in PTO speed, there was an increase of approximately 2.33% in LSKs.

**Foreign Material (FM)**

The percentage of FM was not significantly affected by PTO speed settings in Table 10 ($F_{2,59}=0.7825, p=0.4621$). The least FM occurred at the lowest PTO speed, although due to the lack of significant differences, these data suggest that adjustment of PTO speed may not be effective in manipulating foreign material.

**Loan Rate & Value**

Peanut loan rate was significantly affected by PTO speed in Table 10 ($F_{2,59}=3.4262, p=0.0393$). These data showed that peanut loan rate decreased as a function of PTO speed, overall. This decrease may be due to not achieving proper combine loading thresholds that allow the combine to run at its designed capacity. The relationship between loan rate and PTO speed was linear ($R^2=0.99$); for every 10% increase in PTO speed, there was a decrease of $7.3 \text{ tonne}^{-1}$ in loan rate value ($8 \text{ ton}^{-1}$). There was a visible relationship with loan rate as a function of %LSKs and % FM. There was a strong negative relationship with loan rate as a function of %LSKs ($R^2=0.9991$) and a negative relationship between loan rate and FM ($R^2=0.47$). Decreased loan rate proved to be associated with higher LSKs and FM.

Peanut value per unit area was significantly affected by PTO speed settings as shown in Table 11 ($F_{2,58}=7.3022, p=0.0015$). This test showed similar trends as the Tailings Losses seen in Table 10. The relationship between value and PTO speed was
approximately linear ($R^2=0.98$), equating to roughly $57 \text{ ha}^{-1}$ ($23 \text{ ac}^{-1}$) loss in value per each 10% increase in PTO speed.

Table 11. Measured effects of PTO speed on value per unit area for the Runner Study (wet), All Loadings Range. Means with different letters are significantly different (student’s t-test, $p<0.05$).

<table>
<thead>
<tr>
<th>PTO Speed %</th>
<th>n</th>
<th>Value $\text{ ha}^{-1}$ ($\text{ ac}^{-1}$)</th>
<th>SE$^{(b)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>20</td>
<td>1,540 (623) a</td>
<td>8</td>
</tr>
<tr>
<td>100</td>
<td>20</td>
<td>1,496 (605) a</td>
<td>8</td>
</tr>
<tr>
<td>110</td>
<td>19</td>
<td>1,427 (577) b</td>
<td>9</td>
</tr>
</tbody>
</table>

$^{[a]}$ PTO speed expressed as percentage of manufacturer’s recommendations  
$^{[b]}$ SE = standard error

**Low Loading Range**

The treatments that were used and analyzed for the Low Loading Range were treatments 1, 2, 5, 6, 9, and 10 from Table 2. These treatments consisted of the ground speed range of 1.2-1.6 km hr$^{-1}$ (0.75-1.0 mi hr$^{-1}$); had PTO speed settings of 90, 100, and 110%; and had a consistent header speed, as related to ground speed, of 100%. The average throughput for this range was approximately 4,315 kg ha$^{-1}$ (9,512 lb ac$^{-1}$). Average yield for this loading range was found to be 3,056 kg ha$^{-1}$ (2,727 lb ac$^{-1}$) with an estimated acreage value of $1,108 \text{ ha}^{-1}$ ($448 \text{ ac}^{-1}$). Results showing the effects of PTO speed for the Runner Study (wet), Low Loading Range are provided in Table 12.
Table 12. Measured effects of PTO speed for Runner Study (wet), Low Loading Range (1.2 and 1.6 km hr⁻¹; 4,315 kg ha⁻¹ average material throughput). Uses treatments 1, 2, 5, 6, 9, and 10 from Table 2. Means with different letters are significantly different (student’s t-test, p < 0.05).

<table>
<thead>
<tr>
<th>PTO Speed % [a]</th>
<th>Tailings Loss kg ha⁻¹ (lb ac⁻¹)</th>
<th>LSK % Mean</th>
<th>Mean SE [b]</th>
<th>FM % Mean</th>
<th>Mean SE</th>
<th>Loan Rate $ tonne⁻¹ ($ ton⁻¹) Mean</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>69 (62) c</td>
<td>9</td>
<td>4.57 b 1.05</td>
<td>7.60 a 1.06</td>
<td>296 (326) a 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>102 (91) b</td>
<td>9</td>
<td>6.95 ab 1.05</td>
<td>9.57 a 1.06</td>
<td>298 (328) a 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>110</td>
<td>201 (179) a</td>
<td>9</td>
<td>9.75 a 1.05</td>
<td>9.04 a 1.06</td>
<td>301 (332) a 4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[a] PTO speed expressed as percentage of manufacturer’s recommendations
[b] SE = standard error

Tailings Losses

Tailings losses were significantly affected by PTO speed settings seen in Table 12 (F2,29=42.59, p<0.0001). These data show that for each increase in PTO speed, a significantly increasing amount of yield losses were found in the tailings that exited the combine. The relationship between mean tailings losses and PTO speed was approximately linear (R²=0.92, respectively); for every 10% increase in PTO speed, there was an increase of 66 kg ha⁻¹ (59 lb ac⁻¹) in tailings losses.

Loose Shelled Kernels (LSKs)

The percentage of LSKs were significantly affected by PTO speed settings seen in Table 12 (F2,29=6.11, p=0.0065). There were significant differences between the lowest and the highest PTO speed settings, 90% and 110%. These data show that at a higher PTO speed, an increased amount of LSKs were found in the basket of the combine; the relationship between mean LSKs and PTO speed was approximately linear (R²=0.998). For every 10% increase in PTO speed, there was an increase of approximately 2.59% in
LSKs. Note that this percent change was similar to the percentage increase in the *Runner Study (wet), All Loadings Range.*

*Foreign Material (FM)*

The percentage of FM was not significantly affected by PTO speed settings seen in Table 12 ($F_{2,29}=0.94, p=0.4047$). The lowest FM occurred at the lowest PTO speed, although due to the lack of significant differences, these data suggest that adjustment of PTO speed may not be effective in manipulating FM.

*Loan Rate & Value*

Mean peanut loan rate was not significantly affected by PTO speed settings seen in Table 12 ($F_{2,29}=0.7928, p=0.4628$). These data may show that at a higher PTO speed, a decreased peanut loan rate was observed. The relationship was approximately linear ($R^2=0.99$); for every 10% increase in PTO speed, there was a decrease of $\$4.5$ tonne$^{-1}$ in loan rate value ($\$5$ ton$^{-1}$). There was a visible relationship with loan rate as a function of %LSKs and %FM. There was a strong negative relationship with loan rate as a function of %LSKs ($R^2=0.995$) and a negative relationship between loan rate and FM ($R^2=0.38$). Decreased loan rate proved to be associated with higher LSKs and FM.

A one-way ANOVA suggested that value of peanuts per unit area was not significantly affected by PTO speed settings as shown in Table 13 ($F_{2,29}=3.0052, p=0.0663$), but a means comparison test showed significant differences. This test showed similar trends as the *Tailings Losses* seen in Table 12. The relationship between value and PTO speed was approximately linear ($R^2=0.97$), equating to roughly $\$45$ ha$^{-1}$ ($\$18$ ac$^{-1}$) loss in value per each 10% increase in PTO speed.
Table 13. Measured effects of PTO speed on value per unit area for the Runner Study (wet), Low Loading Range. Means with different letters are significantly different (student’s t-test, p<0.05).

<table>
<thead>
<tr>
<th>PTO Speed %</th>
<th>n</th>
<th>Value $/ha ($/ac)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>10</td>
<td>1,523 (616) a</td>
<td>11</td>
</tr>
<tr>
<td>100</td>
<td>10</td>
<td>1,491 (603) ab</td>
<td>11</td>
</tr>
<tr>
<td>110</td>
<td>10</td>
<td>1,432 (580) b</td>
<td>11</td>
</tr>
</tbody>
</table>

(a) PTO speed expressed as percentage of manufacturer’s recommendations
(b) SE = standard error

Medium Loading Rate

The treatments that were used and analyzed for the Medium Loading Range were treatments 2, 3, 6, 7, 10, and 11 from Table 2. These treatments consisted of the ground speed range of 1.6-2.0 km hr\(^{-1}\) (1.0-1.25 mi hr\(^{-1}\)); had PTO speed settings of 90, 100, and 110%; and had a consistent header speed, as related to ground speed, of 100%. The average throughput for this range was approximately 5,512 kg hr\(^{-1}\) (12,151 lb hr\(^{-1}\)). Average yield for this loading range was found to be 3,080 kg ha\(^{-1}\) (2,748 lb ac\(^{-1}\)) with an estimated acreage value of $1,114 ha\(^{-1}\) ($451 ac\(^{-1}\)). Results showing the effects of PTO speed for the Runner Study (wet), Medium Loading Range are provided in Table 14.

Table 14. Measured effects of PTO speed for Runner Study (wet), Medium Loading Range (1.6 and 2.0 km hr\(^{-1}\); 5,510 kg hr\(^{-1}\) average material throughput). Uses treatments 2, 3, 6, 7, 10, and 11 from Table 2. Means with different letters are significantly different (student’s t-test, p < 0.05).

<table>
<thead>
<tr>
<th>PTO Speed %</th>
<th>n</th>
<th>Tailings Losses kg ha(^{-1}) (lb ac(^{-1}))</th>
<th>LSK %</th>
<th>FM %</th>
<th>Loan Rate $/tonne(^{-1}) ($/ton(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>10</td>
<td>59 (53) c 10 4.24 b 0.83 8.08 a 0.93 289 (319) a 7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>10</td>
<td>93 (83) b 10 6.57 ab 0.83 9.26 a 0.93 277 (305) a 7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>110</td>
<td>10</td>
<td>212 (189) a 10 7.89 a 0.83 7.90 a 0.93 279 (307) a 7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(a) PTO speed expressed as percentage of manufacturer’s recommendations
(b) Number of samples. As an exception, n=9 for tailings loss data at 110% PTO speed.
(c) SE = standard error
Tailings Losses

Tailings losses were significantly affected by PTO speed settings seen in Table 14 ($F_{2,28}=48.66$, $p<0.0001$). These data show that at a higher PTO speed, an increased amount of yield losses were found in the tailings that exited the combine. The relationship between mean tailings losses and PTO speed was approximately linear ($R^2=0.91$, respectively); for every 10% increase in PTO speed, there was an increase of 76 kg ha$^{-1}$ (68 lb ac$^{-1}$) in tailings losses.

Loose Shelled Kernels (LSKs)

The percentage of LSKs were significantly affected by PTO speed settings seen in Table 14 ($F_{2,29}=4.94$, $p=0.0148$). There were significant differences between the lower and the higher PTO speed settings, 90% and 110%. These data show that at a higher PTO speed, an increased amount of LSKs were found in the basket of the combine; the relationship between mean LSKs and PTO speed was approximately linear ($R^2=0.98$). For every 10% increase in PTO speed, there was an increase of approximately 1.83% in LSKs.

Foreign Material (FM)

The percentage of FM was not significantly affected by PTO speed settings seen in Table 14 ($F_{2,29}=0.63$, $p=0.5395$). The lowest FM occurred at the lowest PTO speed, although due to the lack of significant differences, these data suggest that adjustment of PTO speed may not be effective in manipulating foreign material.
Loan Rate & Value

Mean peanut loan rate was not significantly affected by PTO speed settings seen in Table 14 (F_{2,29}=0.6142, \ p=0.5485). These data may show that at a higher PTO speed, a decreased peanut loan rate was observed. The relationship was not approximately linear (R^2=0.63). There was a strong negative relationship with loan rate as a function of %LSKs (R^2=0.77). Decreased loan rate proved to be associated with higher LSKs.

Peanut value per unit area was not significantly affected by PTO speed settings as shown in Table 15 (F_{2,28}=2.3591, \ p=0.1144). This test showed similar trends as the Tailings Losses seen in Table 14. The relationship between value and PTO speed was approximately linear (R^2=0.84), equating to roughly $45 \ ha^{-1}$ ($18 \ ac^{-1}$) loss in value per each 10% increase in PTO speed, similar to Table 13.

<table>
<thead>
<tr>
<th>PTO Speed</th>
<th>n</th>
<th>Value $ \ ha^{-1}$ ($ \ ac^{-1}$)</th>
<th>Mean</th>
<th>SE[b]</th>
</tr>
</thead>
<tbody>
<tr>
<td>90%</td>
<td>10</td>
<td>1,553 (629) a</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>100%</td>
<td>10</td>
<td>1,475 (597) a</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>110%</td>
<td>9</td>
<td>1,463 (592) a</td>
<td>13</td>
<td></td>
</tr>
</tbody>
</table>

[a] PTO speed expressed as percentage of manufacturer’s recommendations
[b] SE = standard error

High Loading Range

The treatments that were used and analyzed for the High Loading Range were treatments 3, 4, 7, 8, 11, and 12 from Table 2. These treatments consisted of the ground speed range of 2.0-2.4 km hr^{-1} (1.25-1.5 mi hr^{-1}); had PTO speed settings of 90, 100, and 110%; and had a consistent header speed, as related to ground speed, of 100%. The
average throughput for this range was approximately 6,837 kg hr\(^{-1}\) (15,072 lb hr\(^{-1}\)).

Average yield for this loading range was found to be approximately 3,056 kg ha\(^{-1}\) (2,727 lb ac\(^{-1}\)) with an estimated acreage value of $1,102 ha\(^{-1}\) ($446 ac\(^{-1}\)). Results showing the effects of PTO speed for the Runner Study (wet), High Loading Range are provided in Table 16.

Table 16. Measured effects of PTO speed for Runner Study (wet), High Loading Range (2.0-2.4 km hr\(^{-1}\); 6,832 kg hr\(^{-1}\) average material throughput). Uses treatments 3, 4, 7, 8, 11, and 12 from Table 2. Means with different letters are significantly different (student’s t-test, p < 0.05).

<table>
<thead>
<tr>
<th>PTO Speed %</th>
<th>n</th>
<th>Tailings Losses kg ha(^{-1}) (lb ac(^{-1}))</th>
<th>LSK %</th>
<th>FM %</th>
<th>Loan Rate $ tonne(^{-1}) ($ ton(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>10</td>
<td>59 (53) b</td>
<td>9</td>
<td>4.80 b</td>
<td>0.96</td>
</tr>
<tr>
<td>100</td>
<td>10</td>
<td>86 (77) b</td>
<td>9</td>
<td>6.23 ab</td>
<td>0.96</td>
</tr>
<tr>
<td>110</td>
<td>10</td>
<td>185 (165) a</td>
<td>9</td>
<td>8.92 a</td>
<td>0.96</td>
</tr>
</tbody>
</table>

\(\text{[a]}\) PTO speed expressed as percentage of manufacturer’s recommendations

\(\text{[b]}\) Number of samples. As an exception, n=9 for tailings loss data at 110\% PTO speed.

\(\text{[c]}\) SE = standard error

**Tailings Losses**

Tailings losses were significantly affected by PTO speed settings seen in Table 16 (\(F_{2,28}=36.69, p<0.0001\)). There were only significant differences between the 90-100\% and the 110\%. These data show that at a higher PTO speed, an increased amount of yield losses were found in the tailings that exited the combine. The relationship between mean tailings losses and PTO speed was approximately linear (\(R^2=0.90\), respectively); for every 10\% increase in PTO speed, there was an increase of 63 kg ha\(^{-1}\) (56 lb ac\(^{-1}\)) in tailings losses as a function of mean yield collected for these treatments.
Loose Shelled Kernels (LSKs)

The percentage of LSKs were significantly affected by PTO speed settings seen in Table 16 ($F_{2,29}=4.80$, $p=0.0165$). There were significant differences between the lower and higher PTO speed settings, 90% and 110%. These data show that at a higher PTO speed, an increased amount of LSKs were found in the basket of the combine; the relationship between mean LSKs and PTO speed was approximately linear ($R^2=0.97$). For every 10% increase in PTO speed, there was an increase of approximately 2.06% in LSKs.

Foreign Material (FM)

The percentage of FM was not significantly affected by PTO speed settings in Table 16 ($F_{2,29}=0.06$, $p=0.9414$). The lowest FM occurred at the lowest PTO speed, although due to the lack of significant differences, these data suggest that adjustment of PTO speed may not be effective in manipulating foreign material.

Loan Rate & Value

Mean peanut loan rate was significantly affected by PTO speed settings in Table 16 ($F_{2,29}=2.6067$, $p=0.0922$) but a means comparison test showed significance. These data show that at a higher PTO speed, a decreased peanut loan rate was observed; the relationship between loan rate and PTO speed was approximately linear ($R^2=0.99$); for every 10% increase in PTO speed, there was a decrease of $10$ tonne$^{-1}$ in loan rate value ($11$ ton$^{-1}$). There was a strong negative relationship with loan rate as a function of %LSKs ($R^2=0.995$) and a negative relationship between loan rate and FM ($R^2=0.57$). Decreased loan rate proved to be associated with higher LSKs and FM.
Peanut value per unit area was significantly affected by PTO speed settings as shown in Table 17 ($F_{2,28}=3.9971, p=0.0306$). This test showed similar trends as the Tailings Losses seen in Table 16. The relationship between value and PTO speed was approximately linear ($R^2=0.99$), equating to roughly $68 \text{ ha}^{-1}$ ($28 \text{ ac}^{-1}$) loss in value per each 10% increase in PTO speed.

Table 17. Measured effects of PTO speed on value per unit area for the Runner Study (wet), High Loading Range. Means with different letters are significantly different (student’s t-test, $p<0.05$).

<table>
<thead>
<tr>
<th>PTO Speed</th>
<th>Value $\text{ha}^{-1}$ ($ ac$^{-1}$)</th>
<th>Mean</th>
<th>SE$^{[b]}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>1,558 (630) a</td>
<td>1,558</td>
<td>13</td>
</tr>
<tr>
<td>100</td>
<td>1,501 (607) ab</td>
<td>1,501</td>
<td>13</td>
</tr>
<tr>
<td>110</td>
<td>1,421 (575) b</td>
<td>1,421</td>
<td>14</td>
</tr>
</tbody>
</table>

$^{[a]}$ PTO speed expressed as percentage of manufacturer’s recommendations  
$^{[b]}$ SE = standard error

Effect of PTO Speed: Runner Study (dry)

In 2019, research was conducted on runner type peanuts with relatively dry vine conditions, for the purposes of this paper it will be known as the Runner Study (dry), to determine the effects of PTO speed on several factors, including grade/quality, yield, and peanut loan rate. The Runner Study (dry) tests were split into four different loading categories: all loadings, low loading, medium loading, and high loading. These four categories were established by dividing the tested ground speeds into separate groups based on ground speeds that were tested. Dividing them into these groups helped to understand the collected data under differing material throughput levels. Ground speeds are directly proportional to loading, or throughput, on the combine, with lower speeds
being associated with lower loading. Improperly, or insufficiently loading a combine is known to increase yield losses and grade/quality effects of the peanuts, which could lead to a loss in profit for the producer. The treatments that were used and analyzed for the Runner Study (dry) were from Table 3.

The All Loadings Range consisted of all data for all the ground speeds tested ranging from 1.6-4.0 km hr\(^{-1}\) (1.0-2.5 mi hr\(^{-1}\)). The Low Loading Range consisted of all data for the ground speeds ranging from 1.6-2.4 km hr\(^{-1}\) (1.0-1.5 mi hr\(^{-1}\)). The Medium Loading Range consisted of all data for the ground speeds ranging from 2.4-3.2 km hr\(^{-1}\) (1.5-2.0 mi hr\(^{-1}\)). The High Loading Range consisted of all data for the ground speeds ranging from 3.2-4.0 km hr\(^{-1}\) (2.0-2.5 mi hr\(^{-1}\)). Grade/quality, yield, and loan rate value effects as a function of PTO speed are presented in Table 18 through Table 21, with one table for each loading group. Though the average throughput and tailings losses were determined for the Virginia Study and Runner Study (wet) they were not collected for this study due to harvest time constraints and lack of labor for the collection processes.

**All Loadings Range**

The treatments that were used and analyzed for the All Loadings Range were treatments 1-12 from Table 3. These treatments consisted of the ground speed range of 1.6-4.0 km hr\(^{-1}\) (1.0-2.5 mi hr\(^{-1}\)); had PTO speed settings of 90, 100, and 110%, and had a consistent header speed, as related to ground speed, of 100%. Average yield for this loading range was found to be 3,493 kg ha\(^{-1}\) (3,117 lb ac\(^{-1}\)) with an estimated acreage value of $1,326 ha\(^{-1}\) ($537 ac\(^{-1}\)). Results showing the effects of PTO speed for the Runner Study (dry), All Loadings Range are provided in Table 18.
Table 18. Measured effects of PTO speed for Runner Study (dry), All Loadings Range (1.6, 2.4, 3.2, and 4.0 km hr⁻¹). Uses treatments 1 through 12 from Table 3. Means with different letters are significantly different (student’s t test, p < 0.05).

<table>
<thead>
<tr>
<th>PTO Speed % [a]</th>
<th>n</th>
<th>Mean LSK %</th>
<th>SE [b]</th>
<th>Mean FM %</th>
<th>SE</th>
<th>Loan Rate $ tonne⁻¹ ( $ ton⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>20</td>
<td>10.88 b</td>
<td>1.38</td>
<td>8.18 a</td>
<td>0.85</td>
<td>276 (304) a 6</td>
</tr>
<tr>
<td>100</td>
<td>20</td>
<td>13.47 b</td>
<td>1.38</td>
<td>7.65 a</td>
<td>0.85</td>
<td>275 (303) a 6</td>
</tr>
<tr>
<td>110</td>
<td>20</td>
<td>18.08 a</td>
<td>1.38</td>
<td>9.85 a</td>
<td>0.85</td>
<td>260 (287) a 6</td>
</tr>
</tbody>
</table>

[a] PTO speed expressed as percentage of manufacturer’s recommendations
[b] SE = standard error

**Loose Shelled Kernels (LSKs)**

The percentage of LSKs were significantly affected by PTO speed settings in Table 18 (F₂,₅₉=7.02, p=0.0019). There were no significant differences between the two lower PTO speed settings tested, 90 and 100%, but LSKs for the 110% PTO speed were significantly higher than those for both the 90 and 100% PTO speed. These data show that at a higher PTO speed, an increased amount of LSKs were found in the basket of the combine; the relationship between mean LSKs and PTO speed was approximately linear (R²=0.97). For every 10% increase in PTO speed, there was an increase of approximately 3.6% in LSKs.

**Foreign Material (FM)**

The percentage of FM was not significantly affected by PTO speed settings in Table 18 (F₂,₅₉=1.83, p=0.1690). The lowest FM occurred at the middle PTO speed, although due to the lack of significant differences, these data suggest that adjustment of PTO speed may not be effective in manipulating foreign material.
Loan Rate

Mean peanut loan rate was not significantly affected by PTO speed settings in Table 18 ($F_{2,59}=2.3520$, $p=0.1043$). These data may show that at a higher PTO speed, a decreased peanut loan rate was observed. The relationship was approximately linear ($R^2=0.79$); for every 10% increase in PTO speed, there was a decrease of $7.7$ tonne$^{-1}$ in loan rate value ($8.5$ ton$^{-1}$). There was a visible relationship with loan rate as a function of %LSKs and %FM. There was a strong negative relationship with loan rate as a function of %LSKs ($R^2=0.91$) and FM ($R^2=0.92$). Decreased loan rate proved to be associated with higher LSKs and FM.

Low Loading Range

The treatments that were used and analyzed for the Low Loading Range were treatments 1, 2, 5, 6, 9, and 10 from Table 3. These treatments consisted of the ground speed range of 1.6-2.4 km hr$^{-1}$ (1.0-1.5 mi hr$^{-1}$); had PTO speed settings of 90, 100, and 110%; and had a consistent header speed, as related to ground speed, of 100%. Average yield for this loading range was found to be 3,831 kg ha$^{-1}$ (3,418 lb ac$^{-1}$) with an estimated acreage value of $1,465$ ha$^{-1}$ ($593$ ac$^{-1}$). Results showing the effects of PTO speed for the Runner Study (dry), Low Loading Range are provided in Table 19.
Table 19. Measured effects of PTO speed for Runner Study (dry), Low Loading Range (1.6-2.4 km hr⁻¹).

Uses treatments 1, 2, 5, 6, 9, and 10 from Table 3. Means with different letters are significantly different (student’s t test, p < 0.05).

<table>
<thead>
<tr>
<th>PTO Speed % [a]</th>
<th>n</th>
<th>LSK %</th>
<th>SE [b]</th>
<th>FM %</th>
<th>SE</th>
<th>Loan Rate $ tonne⁻¹ ($ ton⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>10</td>
<td>12.10 a</td>
<td>1.73</td>
<td>7.21  a</td>
<td>0.75</td>
<td>276 (304) a 7</td>
</tr>
<tr>
<td>100</td>
<td>10</td>
<td>15.26 ab</td>
<td>1.73</td>
<td>7.87  a</td>
<td>0.75</td>
<td>272 (300) a 7</td>
</tr>
<tr>
<td>110</td>
<td>10</td>
<td>18.29 b</td>
<td>1.73</td>
<td>8.86  a</td>
<td>0.75</td>
<td>264 (291) a 7</td>
</tr>
</tbody>
</table>

[a] PTO speed expressed as percentage of manufacturer’s recommendations
[b] SE = standard error

**Loose Shelled Kernels (LSKs)**

The percentage of LSKs were significantly affected by PTO speed settings in Table 19 (F₂,₂⁹=3.1286, p=0.0558) but a means comparison did show significance between the lowest and the highest PTO speed settings, 90% and 110% (p=0.0173). These data show that at a higher PTO speed, an increased amount of LSKs were found in the basket of the combine; the relationship between mean LSKs and PTO speed was approximately linear (R²=0.999). For every 10% increase in PTO speed, there was an increase of approximately 3.1% in LSKs.

**Foreign Material (FM)**

The percentage of FM was not significantly affected by PTO speed settings in Table 19 (F₂,₂⁹=1.22, p=0.3096). These data show that at a higher PTO speed, an increased amount of FM were found in the basket of the combine; the relationship between mean FM and PTO speed was approximately linear (R²=0.99). For every 10% increase in PTO speed, there was an increase of approximately 0.8% in FM. The lowest
FM occurred at the lowest PTO speed, although due to the lack of significant differences, these data suggest that adjustment of PTO speed may not be effective in manipulating foreign material.

*Loan Rate*

Mean peanut loan rate was not significantly affected by PTO speed settings in Table 19 ($F_{2,29}=0.8709, \ p=0.4300$). The relationship was approximately linear ($R^2=0.95$); for every 10% increase in PTO speed, there was a decrease of $5.9 \ \text{tonne}^{-1}$ in loan rate value ($6.5 \ \text{ton}^{-1}$). There was a visible relationship with loan rate as a function of %LSKs and % FM. There was a strong negative relationship with loan rate as a function of %LSKs ($R^2=0.95$) and FM ($R^2=0.99$). Decreased loan rate proved to be associated with higher LSKs and FM.

*Medium Loading Range*

The treatments that were used and analyzed for the *Medium Loading Range* were treatments 2, 3, 6, 7, 10, and 11 from Table 3. These treatments consisted of the ground speed range of 2.4 and 3.2 km hr$^{-1}$ (1.5 and 2.0 mi hr$^{-1}$); had PTO speed settings of 90, 100, and 110%; and had a consistent header speed, as related to ground speed, of 100%. Average yield for this loading range was found to be 3,442 kg ha$^{-1}$ (3,071 lb ac$^{-1}$) with an estimated acreage value of $1,296 \ \text{ha}^{-1}$ ($524 \ \text{ac}^{-1}$). Results showing the effects of PTO speed for the *Runner Study (dry)*, *Medium Loading Range* are provided in Table 20.
Table 20. Measured effects of PTO speed for *Runner Study (dry), Medium Loading Range* (2.4 and 3.2 km hr⁻¹). Uses treatments 2, 3, 6, 7, 10, and 11 from Table 3. Means with different letters are significantly different (student’s t test, p < 0.05).

<table>
<thead>
<tr>
<th>PTO Speed %[^a]</th>
<th>n</th>
<th>LSK %</th>
<th>SE[^b]</th>
<th>Mean</th>
<th>SE</th>
<th>FM %</th>
<th>Mean</th>
<th>SE</th>
<th>Loan Rate $ tonne⁻¹ ($ ton⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>10</td>
<td>10.47 b</td>
<td>2.45</td>
<td>9.18 a</td>
<td>1.52</td>
<td>7.59 a</td>
<td>1.52</td>
<td>272 (300) a</td>
<td>11</td>
</tr>
<tr>
<td>100</td>
<td>10</td>
<td>13.66 ab</td>
<td>2.45</td>
<td>7.59 a</td>
<td>1.52</td>
<td>275 (303) a</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>110</td>
<td>10</td>
<td>19.41 a</td>
<td>2.45</td>
<td>10.50 a</td>
<td>1.52</td>
<td>255 (281) a</td>
<td>11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[^a] PTO speed expressed as percentage of manufacturer’s recommendations
[^b] SE = standard error

*Loose Shelled Kernels (LSKs)*

The percentage of LSKs were significantly affected by PTO speed settings in Table 20 (F₂,₂⁹=3.41, p=0.0477). There were significant differences between the lower and the higher PTO speed settings, 90% and 110%. These data show that at a higher PTO speed, an increased amount of LSKs were found in the basket of the combine; the relationship between mean LSKs and PTO speed was approximately linear (R²=0.98). For every 10% increase in PTO speed, there was an increase of approximately 4.47% in LSKs.

*Foreign Material (FM)*

The percentage of FM was not significantly affected by PTO speed settings in Table 20 (F₂,₂⁹=0.93, p=0.4074). The lowest FM occurred at the middle PTO speed like the *Runner Study (dry), Low Loading Range*, although due to the lack of significant differences, these data suggest that adjustment of PTO speed may not be effective in manipulating foreign material.
Loan Rate

Mean peanut loan rate was not significantly affected by PTO speed settings in Table 20 (F2,29=1.2347, p=0.3068). The relationship was not linear (R²=0.63). There was a visible relationship with loan rate as a function of %LSKs and % FM. There was a strong negative relationship with loan rate as a function of %LSKs (R²=0.78) and FM (R²=0.81). Decreased loan rate proved to be associated with higher LSKs and FM.

High Loading Range

The treatments that were used and analyzed for the High Loading Range were treatments 3, 4, 7, 8, 11, and 12 from Table 3. These treatments consisted of the ground speed range of 3.2 and 4.0 km hr⁻¹ (2.0 and 2.5 mi hr⁻¹); had a PTO speed range of 90, 100, and 110%; and had a consistent header speed, as related to ground speed, of 100%. Average yield for this loading range was found to be approximately 3,156 kg ha⁻¹ (2,816 lb ac⁻¹) with an estimated acreage value of $1,188 ha⁻¹ ($481 ac⁻¹). Results showing the effects of PTO speed for the Runner Study (dry), High Loading Range are provided in Table 21.

Table 21. Measured effects of PTO speed for Runner Study (dry), High Loading Range (3.2 and 4.0 km hr⁻¹). Uses treatments 3, 4, 7, 8, 11, and 12 from Table 3. Means with different letters are significantly different (student’s t test, p < 0.05).

<table>
<thead>
<tr>
<th>PTO Speed %</th>
<th>LSK % Mean</th>
<th>SE</th>
<th>FM % Mean</th>
<th>SE</th>
<th>Loan Rate $ tonne⁻¹ ($ ton⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>10</td>
<td>9.66 b</td>
<td>2.16</td>
<td>9.16 a</td>
<td>1.53 277 (305) a 11</td>
</tr>
<tr>
<td>100</td>
<td>10</td>
<td>11.68 ab</td>
<td>2.16</td>
<td>7.42 a</td>
<td>1.53 277 (305) a 11</td>
</tr>
<tr>
<td>110</td>
<td>10</td>
<td>17.87 a</td>
<td>2.16</td>
<td>10.85 a</td>
<td>1.53 257 (283) a 11</td>
</tr>
</tbody>
</table>

[a] PTO speed expressed as percentage of manufacturer’s recommendations
[b] SE = standard error
**Loose Shelled Kernels (LSKs)**

The percentage of LSKs were significantly affected by PTO speed settings seen in Table 21 \((F_{2,29}=3.92, p=0.0320)\). There were significant differences between the lower and the higher PTO speed settings, 90% and 110%. These data show that at a higher PTO speed, an increased amount of LSKs were found in the basket of the combine; the relationship between mean LSKs and PTO speed was approximately linear \((R^2=0.92)\). For every 10% increase in PTO speed, there was an increase of approximately 4.11% in LSKs.

**Foreign Material (FM)**

The percentage of FM was not significantly affected by PTO speed settings in Table 21 \((F_{2,29}=1.2553, p=0.3011)\). The lowest FM occurred at the middle PTO speed like all the Runner Study (dry) tests, although due to the lack of significant differences, these data suggest that adjustment of PTO speed may not be effective in manipulating foreign material.

**Loan Rate**

Mean peanut loan rate was not significantly affected by PTO speed settings in Table 21 \((F_{2,29}=1.4327, p=0.2562)\). The relationship was approximately linear \((R^2=0.75)\); for every 10% increase in PTO speed, there was a decrease of $10 tonne^{-1}$ in loan rate value ($11 ton^{-1}$). There was a visible relationship with loan rate as a function of %LSKs and %FM. There was a strong negative relationship with loan rate as a function of %LSKs \((R^2=0.94)\) and FM \((R^2=0.74)\). Decreased loan rate proved to be associated with higher LSKs and FM.
Conclusions

In this study, the peanut combine operating parameter of PTO speed was varied to investigate its effect on economic factors of peanut harvest (tailings losses, grade/quality, and loan rate). The following conclusions can be drawn from the presented results.

When evaluating the results and conclusions presented here, it is important to do so with respect to the harvest conditions for each test. While it is expected that magnitudes may be inconsistent across years, machines, and conditions, it is hypothesized that general trends may be similar. The harvest season for the *Virginia Study* was not as favorable for peanut research as normal harvest years. Poor drying conditions resulted in a crop for this test that was not harvestable in a timely manner, which also resulted in a reduction in replications for some comparisons. The harvest season for the *Runner Study* proved to be more favorable for peanut production. Further research across both runner and virginia peanut varieties should be conducted for comparison to the results here and to examine consistency. The findings from studies such as this one should promote advancements in peanut harvest technologies and increase peanut production profitability if they can be used to improve combine operator adjustments.

**Tailings Losses**

Overall, in both the *Virginia Study* and *Runner Study (wet)* tests, tailings losses consistently increased as a function of PTO speed at all loading ranges (Figure 2) with significant findings. These findings are consistent with those from the only known study on this subject (Wright F., 1968). Trends and magnitudes in tailings losses as a function
of PTO speed across all loadings were similar within both the *Virginia Study* and the *Runner Study (wet)*. Tailings loss increases were at their greatest at the *Medium Loading Range* for both the *Virginia Study and Runner Study (wet)* tests. The *Virginia Study* found a tailings loss increase of 161 kg ha⁻¹ (142 lb ac⁻¹) and the *Runner Study (wet)* test found a tailings loss increase of 76 kg ha⁻¹ (68 lb ac⁻¹) for each 10% increase in PTO speed. Tailings losses were not measured in the *Runner Study (dry)* test.

The increase in tailings losses at higher PTO speeds may be due to mechanical processes in the picking cylinders or possibly due to the cleaning air fan blowing more peanuts out the rear of the combine. In addition to PTO speed settings, improper aggression adjustments (left unchanged throughout each study) could have resulted in unnecessary increases in tailings losses. This was seen at the *Medium Loading Range* with increased losses over both tests. The small and light material, which is difficult to separate, goes out with the tailings/trash due to excessive amount created by over aggression. Since the cleaning and conveying air adjustments and aggression settings were not manipulated, to account for increases and decreases in PTO speed, losses may have increased more than what a producer would normally see. Producers must use caution running equipment too slow in order to prevent overloading/plugging, which in turn would be costly in equipment repairs.
Figure 2. Summarized mean tailings losses as a function of PTO speed across all loading ranges in the Virginia Study (a) and the Runner Study (wet) (b) test.

Loose Shelled Kernels (LSKs)

The Virginia Study showed no significant differences nor any major trends in LSKs as a function of PTO speed at all loading ranges (Figure 3a). Both the Runner Study (wet) and Runner Study (dry) testing showed increasing LSKs as a function of PTO speed (Figure 3b and Figure 3c) and demonstrated significant differences in LSKs between PTO speed settings for every loading range tested and across all loading ranges, combined. For both the Runner Study tests, greatest overall LSKs were generally observed for the Low Loading Ranges, and rate of change in LSKs as a function of PTO speed was similar across all loading ranges, within each study. For each 10% increase in PTO speed, an increase in percent LSKs of 2.59% was found in the Runner Study (wet), in the Low Loading Range test and an increase in percent LSKs of 4.47% was found in the Runner Study (dry), Medium Loading Range test. These findings are consistent with the only known study on this subject (Wright F., 1968), although more dramatic in magnitude: Wright’s reported data (for windrow exposure time of seven days) showed in increase in percent LSKs of 0.47% for each 10% increase in cylinder speed. The increase
of LSKs at higher PTO speeds during the Runner Study tests show that mechanical damage to harvested peanuts increases at increasing combine rotational speeds. Similar to the results for Tailings Losses, PTO speed settings and improper aggression adjustments (left unchanged throughout each study) could have resulted in unnecessary increases in LSKs. Since the cleaning and conveying air adjustments and aggression settings were not manipulated, to account for increases and decreases in PTO speed, LSKs may have increased more than what a producer would normally see. Producers must use caution running equipment too slow in order to prevent overloading/plugging, which in turn would be costly in equipment repairs.

![Graphs showing LSKs as a function of PTO speed across all loading ranges for the Virginia Study (a), Runner Study (wet) (b), and Runner Study (dry) (c).]

Figure 3. Summarized LSKs as a function of PTO speed across all loading ranges for the Virginia Study (a), Runner Study (wet) (b), and Runner Study (dry) (c).
**Foreign Material (FM)**

Overall, there were no notable trends nor significant differences in FM as a function of PTO speed. For the *Virginia Study* there was a decreasing trend as PTO speed increased across all loadings, but with no statistical significance in any loading range. Both the *Runner Study (wet)* and *Runner Study (dry)* studies showed that there were increasing trends as a function of increasing PTO speed, but also with no significance at any loading range. It is worth noting that FM could increase/decrease due to if the combine’s PTO speed is too fast or the aggression settings are too aggressive. Additionally, if the peanut vines are too tough, they can wrap on the picking/threshing cylinders in the combine, resulting in shelling of the crop inside the combine. This would then produce in an increase in LSKs, but not necessarily more FM since the trash/hulls would be blown out with the tailings.

**Loan Rate & Value**

Overall, peanut loan rate was found to be related to PTO speed throughout. It was seen across all studies that when LSKs & FM increased, there was a decrease in peanut loan rate. For the *Virginia Study* (Figure 4a), while there were no significant differences over the loading ranges tested, loan rate showed an increasing trend across the *Low & Medium Loading Ranges* as PTO speeds increased. The opposite response was seen in both the *Runner Study (wet)* and *Runner Study (dry)* tests (Figure 4b & Figure 4c). The *Runner Study* tests showed that as PTO speed increased, peanut loan rate decreased. The decreased loan rate was due to increasing LSKs and FM found in the grade/quality sample collected for each plot. The increasing loan rate seen in the *Virginia Study* was
thought to have occurred at the higher PTO speeds since the cleaning air fan was able to
blow lower grade material out of the rear with the tailings, making the grade appear better
than it was. The moisture conditions of the Virginia Study may have also contributed.
However, the Runner Study tests’ decreasing loan rate could have been attributed to
reaching proper loading of the combine at the lower PTO speeds. More testing needs to
be conducted to understand these effects.

Peanut value per unit area was affected negatively by increasing PTO speed
throughout all studies. The Virginia Study showed a $59 ha⁻¹ ($24 ac⁻¹) loss in profit per
each 10% increase in PTO speed and the Runner Study (wet) showed a $68 ha⁻¹ ($28 ac⁻¹)
loss in profit per each 10% increase in PTO speed (Figure 5a & Figure 5b). These values
show the combined effects of tailings losses and loan rate on overall peanut value based
on a 2.2 tonne ha⁻¹ (2.0 ton ac⁻¹) theoretical peanut yield.
Figure 4. Summarized loan rate as a function of PTO speed across all loading ranges for the Virginia Study (a), Runner Study (wet) (b), and Runner Study (dry) (c).

Figure 5. Summarized value effects of tailings losses as a function of PTO speed across all loading ranges for the Virginia Study (a) and Runner Study (wet) (b).
References


http://nationalpeanutboard.org/peanut-info/history-peanuts-peanut-butter.htm


CHAPTER 3. YIELD LOSS AND QUALITY EFFECTS OF PEANUT COMBINE GROUND SPEED AND HEADER SPEED SETTINGS

Abstract

A research project was conducted to understand and quantify yield losses and grade/quality associated with peanut combine speed settings. On a peanut harvester, there are two main avenues for potential of peanut losses: losses as associated with the header (where vines enter) and losses associated with the cleanout (where the tailings exit). Variables tested in this study included: PTO speed, ground speed, and header speed. These variables were the only items that were changed throughout this study; other important operational settings, such as threshing aggression and cleaning air adjustments, were set to normal operational settings. Results from ground speed and header speed settings are highlighted in this study.

The study was conducted in Barnwell County, S.C. on commonly grown varieties for regional producers, using a virginia variety (Bailey) in 2018 and a runner variety (FloRun 311) in 2019. Tests were conducted on 4-row wide, 3.86 m (12.67 ft), non-irrigated plots that were 19.20 m (63 ft) in length. Treatments were evaluated using measurements of material throughput, tailings/header losses, grade/quality, loan rate value, and yield. Tailings losses decreased by 44 kg ha\(^{-1}\) for each 1 km hr\(^{-1}\) increase in ground speed (63 lb ac\(^{-1}\) per each 1 mi hr\(^{-1}\) increase in speed) for the 2018 virginia variety testing and decreased by 18 kg ha\(^{-1}\) for each 1 km hr\(^{-1}\) increase in ground speed (26 lb ac\(^{-1}\) per each 1 mi hr\(^{-1}\) increase in speed) for the 2019 runner variety testing. Header losses showed a decline of 22 kg ha\(^{-1}\) (25 lb ac\(^{-1}\)) for every 15% increase in header speed for the
2018 virginia variety testing. Header losses were determined to be insignificant for both research years in comparison to tailings losses, though header losses are reported for this study. Knowledge of yield and grade/quality effects of combine settings will assist producers in making economic decisions for peanut combine operation.

**Introduction**

Peanut production has always been a labor-intensive process where crop yield and grade/quality can be adversely affected as a function of harvesting systems, environmental conditions, and machine settings. There have been several improvements to the machinery used for peanut harvest since its first mechanization. Presently, a producer of peanuts has two main machines at hand to harvest their crop: a digger (digger-shaker-inverter) and a combine (picker or harvester). Both the digger and the combine introduce opportunity for affecting recovered yield and grade/quality.

**The Peanut Harvest Process**

To completely understand the process that peanuts undergo, a more detailed illustration into the process of peanut harvesting will be discussed. First, a producer must establish the proper time to dig the crop from the ground. Wright & Porter reported in 1991 that peanut yields and grade/quality were significantly affected by improper digging date (Wright & Porter, 1991). Proper digging time is important to maximizing yield recovery, at the time of digging, and it is also key to improving the grade of the peanuts, where higher grades equate to higher values. Additional evidence from Mozingo et al. found that not only does proper digging time matter, but in harsh environmental conditions during crucial developmental periods, i.e. pegging and flowering, grade, yield,
and value in peanuts were adversely affected (Mozingo et al., 1991). After a producer
determines that the crop is ready to be harvested, a digger is used to lift the pods from
beneath the ground surface. During this process of digging, the peanuts are raised from
the ground, shaken of dirt that may be adhered to the crop, and flipped upside down
(inverted) to expose the crop to the sun for drying.

A research publication produced by the University of Georgia titled *Peanut Digger and Combining Efficiency*, stated that usually after two to three days after
digging, peanuts can be combined with minor mechanical damage; windrowed peanuts
have reached a moisture content of 18 to 24 percent (Bader & Sumner, 2012). After
drying the crop to the desired moisture content, the producer harvests the peanuts with a
peanut combine. There are different techniques in how peanut combines separate the crop
from their vines, conventional or rotary, but the overall process is essentially the same.
The combine completes all of the following throughout the harvest process: lifts the crop
into the machine with what is known as a header, picks the pods from the vines, separates
pods from remaining vine and trash material, and conveys the pods to a holding reservoir
(basket) on the combine. From there, the peanuts are unloaded on to trailers or wagons
and carried to a buying point to be sold into the market.

**Combine Settings**

Peanut combines are either pull-type or self-propelled. For both the pull-type and
self-propelled combines, there is one person (operator) who changes combine settings
based on experience, vine conditions, and observations. Settings are generally adjusted to
maximize yield recovery and grade/quality while also maintaining a reasonable harvest
timeliness. According to Bader and Sumner, “An improperly set combine can result in reduced peanut yield and a product with excessive pod damage, loose-shelled kernels (LSKs) and foreign material (FM)” (Bader & Sumner, 2012). Some of the settings can be changed in an on-the-go fashion from inside the cab, while others must be done while the combine is stationary. The five main settings that can be changed on-the-go include: PTO speed (combine speed), ground speed, header speed, header height, and elevator fan air volume (for machines using pneumatic conveyance for delivery to the basket). These five settings are critical to an operation’s efficiency and all of which affect profitability; they affect yield recovery, crop grade/quality, and the time to harvest the crop from the field. There are also several combine settings that must be changed while the combine is stationary: aggression of the picking cylinders, cleaning air volume, retention board position, and tail board position.

These settings can vary by machine model, (Amadas Industries, 2010 & KMC, 2015) and could have just as much effect on harvest efficiency as those that can be changed on-the-go. These combine settings are often set at the beginning of a harvest season and are usually left unchanged throughout the harvest season, unless vine or crop conditions change significantly.

If someone were to ask peanut farmers how to setup their combines, their answers would likely differ as a result of: personal preference/experience and perhaps the lack of scientific studies investigating optimum settings. While a great deal of academic research has highlighted digger-related yield losses as a function of operation and settings (Bader & Sumner, 2012; Kirk, et al., 2014; Mozingo et al., 1991; Roberson & Jordan, 2014;
Warner, et al., 2014; Warner A., 2015; Wright & Porter, 1991), less has been reported on losses and grade/quality as a function of combine operation and settings (Washington DC, US Patent No. 4,142,348, 1979; Washington DC, US Patent No. 4,188,772, 1980; Wright F., 1968). The only recent publications (within the past 10 years) found addressing combine settings, were industry operator manual recommendations and an extension publication by the University of Georgia (Bader & Sumner, 2012). The lack of research suggests an opportunity for benefiting the peanut industry through scientific research of yield recovery and grade/quality as a function of combine settings. The potential for grade/quality effects can occur throughout the peanut combine and the potential for losses are at two main locations: the header (where vines and peanuts enter the combine) and cleanout (where tailings/trash exit the combine). These two areas have varying opportunities for yield loss and effects as combine harvest settings are changed.

Though published research for peanut combines proved to be limited, there are several research studies conducted on grain/conventional combines regarding harvest efficiencies (Andrews, S. et al., 1993; Mesquita, C. et al., 2006; & Paulsen, M. et al., 2014). One study by Mesquita, C. et al. in 2006 looked at how harvest efficiency in soybeans was controlled by operational and crop characteristics and found an optimal ground speed and cylinder speed setting for reducing losses (Mesquita, C. et al., 2006). Another research study using conventional combines, though in rice harvesting, by Andrews et al. in 1993 looked at the effects of feed rate, combine speed, and concave settings and found that all three played a role in rice harvest efficiency (Andrews, S. et
al., 1993). As seen in the research found for grain combines, ground and combine speeds are critical to reducing yield losses.

With regards to effects of PTO speed and ground speed on combine efficiency, the most recent research was a study reported by F. Wright in 1968, about half a century ago. Wright investigated the effects of combine cylinder speed and feed rate on peanut damage and combining efficiencies. For a given set of crop conditions, feed rate was found to be directly proportional to ground speed. This study looked at how peanut quality was affected by combine PTO speed and the flow rate of material through the combine, but this study did not look at yield losses specifically related to the header and tailings. Wright found that at lower PTO speeds, there were less losses and LSKs as compared to the higher PTO speeds he tested (Wright F., 1968). It is important to note that Wright changed only the cylinder speed of the 1966 Roanoke 2-row combine used. He did this by varying sprocket sizes to increase and decrease cylinder speeds; -27%, normal, +27% cylinder speeds. Wright held PTO speed, ground speed, and all other variables constant throughout the study. The cleaning fan was decreased in “dry” conditions in order to account for moisture.

With regards to header speed, Amadas Industries (Suffolk, Va.) recommends in their manuals to “set header speed so that [the] header picks up the windrow completely as the combine travels down the field” (Amadas Industries, 2015). Kelly Manufacturing Company (KMC) (Tifton, Ga.) recommends adjusting (matching) the pickup speed to ground speed (KMC, 2015). The publication from the University of Georgia recommends adjusting the header speed so that it would “match the forward speed [ground speed]”
Both the KMC and University of Georgia recommendations are similar, due to similar variety of peanuts being harvested. These recommendations are likely based on years of experience and observation, although none appear to be supported by scientific research.

There have been several systems that used a ground-driven speed system as a gauge for pickup speed. For example, Jordan and Mitchell developed a “hydraulic speed control system for the pickup reel of a peanut combine,” in which they used a gauge wheel driven by one of the tires of the harvester to match the pickup speed to ground speed (Washington DC, US Patent No. 4,188,772, 1980). The technology for these systems were never widely adopted.

Besides research conducted in 1968 by F. Wright, the lack of current research on the effects of peanut combine settings prompted this study to characterize yield losses and grade/quality effects as functions of some of the settings that can be adjusted on-the-go. Specific objectives of this study were to complete the following for both virginia and runner type peanuts: (1) quantify tailings losses, material throughput, grade/quality, and peanut loan rate value as a function of ground speed and (2) quantify header losses as a function of header speed.

**Methods and Materials**

Peanut varieties that were used for testing in the 2018 and 2019 crop years were Bailey, a virginia type peanut, and FloRun 311, a runner type peanut. The tests from 2018 and 2019 will be referred to as the *Virginia Study* and the *Runner Study*, respectively. Peanuts were planted on 97 cm (38 in) row spacing and were managed in accordance
with Clemson Extension recommendations. Traffic rows were excluded from the tests to avoid the effects of compaction, traffic rows being the four rows adjacent to tire tracks for the sprayer used throughout the growing season. The fields that were used for the study, ‘C4’ and ‘G3B’, were located at the Edisto Research and Education Center, Edisto REC, in Barnwell County, S.C. Field ‘C4’ was used for the Virginia Study and field ‘G3B’ was used for the Runner Study. Both of the fields used for this research project consisted predominately of Barnwell loamy sand (Soil Survey Staff, 2019). Weather data was collected using a Davis Vantage Pro 2 weather station (Davis Instruments Corporation, Hayward, CA) located at the EREC. The tractor that was used for these studies was a John Deere 7920 model and the combine was an Amadas 2108 4-row model. The combine used for the testing was a ‘conventional’ threshing harvester, which is the most commonly used combine trashing method for S.C. producers.

Weather present in 2018 from the end of October to the end of November was not well-suited for field drying of peanuts, since after digging peanuts one should generally expect suitable drying within one week (Bader & Sumner, 2012). This drying period is dictated by weather conditions present after digging. Digging of the peanuts for the Virginia Study was conducted on 3 November 2018 and harvest of these peanuts was not until 28-30 November 2018, 25-27 days after digging. This vast time difference was due to receiving rainfall of approximately 9.88 cm (3.89 in) and an average mean temperature of 11°C (52ºF) while the peanuts were on top of the ground, 3 November to 28 November. With the increased time that the peanuts were on top of the ground, losses as a function of field drying time and exposure to weather were potential, but were not
directly assessed for this research, since all treatments were exposed to the same conditions.

For the *Runner Study*, the peanuts were dug on 4 November 2019 and harvested on two separate occasions—a wet harvest and a dry harvest. Having two different harvest times enabled the study to reflect results for different vine and crop moisture conditions. The first harvest period, the *Runner Study (wet)* harvest, was 7 and 8 November 2019, 3 to 4 days after digging. During this time period, rainfall was approximately 1.55 cm (0.61 in) and temperature averaged 15°C (59ºF). The second harvest, the *Runner Study (dry)* harvest, was 22 November 2019, 18 days after digging. During this time period, rainfall was approximately 5.54 cm (2.18 in) and temperature averaged 10°C (50ºF).

Digging losses were not a part of this research, though to keep consistency, all peanut rows were dug in the same direction within a given replication. For all test plots, combine travel direction matched the digger travel direction to mitigate any potential effects of combining opposite of digging direction. Currently there is no absolute data proving the effects of harvesting peanuts in an opposite direction of digging. Peanuts were dug with a KMC 2-row digger at a ground speed of 4.0 km hr⁻¹ (2.5 mi hr⁻¹).

**Experimental design**

The combine settings that are most commonly altered during the peanut harvest, and the ones tested here, included three of the five settings that can be changed on-the-go: PTO speed, ground speed, and header speed. Elevator air volume, header height, and the settings normally not set on-the-go, stated in previous section, were set to normal peanut producer and machinery manufacturer specifications for the harvested crop conditions.
Plots for the virginia and runner studies were set up similarly, as randomized block designs with five replications, the *Virginia Study* including 25 treatments (Table 22) and the *Runner Study* including a wet harvest with 15 treatments (Table 23) and a dry harvest with 15 treatments (Table 24). The data was collected, normalized, and analyzed using JMP statistical software by SAS. A one-way ANOVA and means comparison test, student’s t-test, were performed at the 95% confidence level for each study to assess statistical differences and trends within the data collected.

Table 22. Combine setting treatments tested in *Virginia Study*.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>PTO Speed, %&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Ground Speed, km hr&lt;sup&gt;−1&lt;/sup&gt; (mi hr&lt;sup&gt;−1&lt;/sup&gt;)</th>
<th>Header Speed, %&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Treatment</th>
<th>PTO Speed, %&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Ground Speed, km hr&lt;sup&gt;−1&lt;/sup&gt; (mi hr&lt;sup&gt;−1&lt;/sup&gt;)</th>
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<td>1.8 (1.1)</td>
<td>115</td>
</tr>
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<td>85</td>
<td>15</td>
<td>100</td>
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</tr>
<tr>
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<td>100</td>
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</tr>
<tr>
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<td>115</td>
<td>17</td>
<td>100</td>
<td>2.3 (1.4)</td>
<td>85</td>
</tr>
<tr>
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<td>130</td>
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<td>100</td>
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<td>85</td>
<td>20</td>
<td>100</td>
<td>2.3 (1.4)</td>
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<td>100</td>
<td>21</td>
<td>90</td>
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</tr>
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<td>115</td>
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<td>1.3 (0.8)</td>
<td>100</td>
</tr>
<tr>
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<td>1.3 (0.8)</td>
<td>130</td>
<td>23</td>
<td>90</td>
<td>1.8 (1.1)</td>
<td>100</td>
</tr>
<tr>
<td>11</td>
<td>100</td>
<td>1.8 (1.1)</td>
<td>70</td>
<td>24</td>
<td>110</td>
<td>1.8 (1.1)</td>
<td>100</td>
</tr>
<tr>
<td>12</td>
<td>100</td>
<td>1.8 (1.1)</td>
<td>85</td>
<td>25</td>
<td>110</td>
<td>2.3 (1.4)</td>
<td>100</td>
</tr>
<tr>
<td>13</td>
<td>100</td>
<td>1.8 (1.1)</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>PTO speed is expressed as a percentage of manufacturer design speed

<sup>b</sup>Header speed is expressed as a percentage of ground speed, measured at 7.0 cm from tip of header tooth
Table 23. Combine setting treatments tested in *Runner Study* (wet) harvest.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>PTO Speed, %&lt;sup&gt;[a]&lt;/sup&gt;</th>
<th>Ground Speed, km hr&lt;sup&gt;-1&lt;/sup&gt; (mi hr&lt;sup&gt;-1&lt;/sup&gt;)</th>
<th>Header Speed, %&lt;sup&gt;[b]&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>90</td>
<td>1.2 (0.75)</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>90</td>
<td>1.6 (1.0)</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>90</td>
<td>2.0 (1.25)</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>90</td>
<td>2.4 (1.5)</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>100</td>
<td>1.2 (0.75)</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>100</td>
<td>1.6 (1.0)</td>
<td>100</td>
</tr>
<tr>
<td>7</td>
<td>100</td>
<td>2.0 (1.25)</td>
<td>100</td>
</tr>
<tr>
<td>8</td>
<td>100</td>
<td>2.4 (1.5)</td>
<td>100</td>
</tr>
</tbody>
</table>

<sup>[a]</sup> PTO speed is expressed as a percentage of manufacturer design speed

<sup>[b]</sup> Header speed is expressed as a percentage of ground speed, measured at 7.0 cm from tip of header tooth

Table 24. Combine setting treatments tested in *Runner Study* (dry) harvest.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>PTO Speed, %&lt;sup&gt;[a]&lt;/sup&gt;</th>
<th>Ground Speed, km hr&lt;sup&gt;-1&lt;/sup&gt; (mi hr&lt;sup&gt;-1&lt;/sup&gt;)</th>
<th>Header Speed, %&lt;sup&gt;[b]&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>90</td>
<td>1.6 (1.0)</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>90</td>
<td>2.4 (1.5)</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>90</td>
<td>3.2 (2.0)</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>90</td>
<td>4.0 (2.5)</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>100</td>
<td>1.6 (1.0)</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>100</td>
<td>2.4 (1.5)</td>
<td>100</td>
</tr>
<tr>
<td>7</td>
<td>100</td>
<td>3.2 (2.0)</td>
<td>100</td>
</tr>
<tr>
<td>8</td>
<td>100</td>
<td>4.0 (2.5)</td>
<td>100</td>
</tr>
</tbody>
</table>

<sup>[a]</sup> PTO speed is expressed as a percentage of manufacturer design speed

<sup>[b]</sup> Header speed is expressed as a percentage of ground speed, measured at 7.0 cm from tip of header tooth

The ground speeds tested were determined at the beginning of each harvest date and were assigned based on the crop moisture conditions present on the given harvest dates, setting the upper ground speed near machine capacity. Ground speeds used in the *Virginia Study* were lower than typical speeds as a result of wet peanut vines, though, as discussed, they had been on top of the ground for a long period of time, not being dry.
enough for normal combining ground speeds. In the Runner Study, since there were two harvest dates, there were two separate ground speed ranges used.

Plot width for both studies was set at four rows (two windrows), 3.86 m (12.67 ft), to match the combine width and the plot length was set at 19.2 m (63 ft) in order to maximize steady-state combine loading conditions while minimizing loading and unloading conditions. Yield data was collected with a pre-production prototype peanut yield monitoring platform jointly developed by Clemson University and Amadas Industries. The first and last 3.65 m (12 ft) of yield monitor data from each plot was deleted to reduce effects of combine loading and unloading. From previous research with the combine used in these studies, mass flow sensor response data suggested that combine loading and unloading both occur within about 10 seconds of steady state loading conditions, reflecting ramp up and ramp down to steady state. At the range of ground speeds used in these studies, the plot length implemented ensured that the combine was at steady state loading for more than half of the plot length for all plots (i.e., ~40 ft).

**Header loss collection**

Methodology was developed to distinguish header losses from above ground digging losses. To effectively capture and quantify combine header losses, a tarp was installed for each plot that header losses were being analyzed. This plot tarp system included a single 1.22 m long by 3.66 m wide (4 ft by 12 ft) canvas tarp that was pinned underneath the four rows (two windrows) of each plot. This was achieved by having several people involved to minimize losses. To install the tarps, two individuals standing
about 1 m (3 ft) apart from one another, picked up a single section of windrow while another person reached under the windrow and placed the tarp. Once this was done for a single windrow (two rows of peanuts), the process was repeated for the next adjacent windrow in the plot. An image of how header losses were collected is shown in Figure 6.

![Image of tarp placement](image.png)

**Figure 6. Tarp placement beneath one plot center (two windrows) for collection and quantification of peanut header losses.**

Grommets were installed on each tarp so that it could be pinned to the ground, reducing the likelihood of the combine to grab the tarp and entangle it in the header and combine. Since the operator would have to stop the combine mid-plot if this occurred, it would void all data from the plot, effectively removing its results from the study. After a handful of deleted plots where the tarp was picked up by the header, it became evident that adding a layer of soil over the leading edge of the tarp solved all tarp entanglement issues that were experienced early in this study. To gather the header losses from the tarps, the plot first needed to be harvested. Following plot harvest, the combine was shut down and losses were collected from the tarp, bagged up for storage, dried for a minimum of 10 days at 75°C (167°F), and weights were taken to determine dry weight header losses of each plot. The ASABE standard, S410.2, for drying peanuts was not followed due to the capabilities of the dryers present at the EREC, a modified drying
schedule was adopted to account for the higher temperatures required by the standard (ASABE Standards, 2010).

It is worth noting here that the tarp did not collect any tailings or tailings losses because of separate tailings collection, described below.

**Tailings loss collection**

To effectively capture and quantify combine tailing losses, a tailings collection trailer was developed. This trailer was made to attach to the combine’s axle and travel with the combine, supported at the rear by a pair of casters. The trailer system included a containment bin that held all tailings from each 19.2 m (63 ft) long plot. There was a tarp attached to the trailer positioned directly on top of the containment chamber so that when harvesting of each plot was completed, unloading of the trailer was simplified. An image of the tailings collection trailer is shown in Figure 7a. After the plot was harvested, the combine was shut down and the total tailings (including any peanut losses) were weighed. Subsequently, the peanut losses and vine material in the tailings were separated using a stationary peanut combine (Henan Xuanhua Import & Export Trading Company, Ltd., China) (Figure 7b). After running through the stationary combine, the separated peanuts (tailings losses) were collected, bagged up for storage, dried for a minimum of 10 days at 75°C (167°F), and weights were taken to determine losses of each plot. The ASABE standard, S410.2, for drying peanuts was not followed due to the capabilities of the dryers present at the EREC, a modified drying schedule was adopted to account for the higher temperatures required by the standard (ASABE Standards, 2010).
Figure 7. Tailings collection trailer system as the combine travelled across the header loss collection tarp (a) and stationary peanut combine operation for separation of peanut losses from vine material in tailings (b).

Vine moisture measurement

A 0.5 kg (1 lb) vine moisture sample was taken from each of the plots at the time of separation of the peanuts using the stationary peanut combine. This sample was bagged up in a sealed plastic bag, weighed within four hours of harvest, dried for a minimum of 10 days at 75°C (167°F), and weighed again to determine the vine moisture content of each plot. Similar drying method as tailings losses performed.

Grade/quality sampling

A 0.9 kg (2 lb) grade/quality sample was collected from the combine during harvest at the center of each plot. This sample was collected by holding a fishing bait net in the path of the peanuts entering the basket. Once the bait net was full, the sample was bagged up for dry storage and grade/quality was determined for each of the samples. The USDA standards for grading virginia and runner type peanuts were used (USDA, 2019).
Yield data collection

As previously stated, peanut yield data was collected with a pre-production prototype peanut yield monitoring platform jointly developed by Clemson University, Amadas Industries, and John Deere. The peanut yield monitor used a John Deere microwave sensor, used in John Deere’s cotton yield monitoring system. The microwave sensor response related to mass flow moving across the sensing field. The accuracy of this platform has not been demonstrated for plot trials. The stability of a calibration is also not known across a wide range of combine operational parameters. For these reasons, the yield data using this system was reported here to demonstrate relative yield averages across treatments, but not for comparison between treatments.

Implications of Observed Effects

While an operator would normally adjust settings on the combine (e.g. threshing aggression, pneumatic separation velocity, and pneumatic conveying velocity) to address some of the effects measured and discussed here, those settings remained constant throughout the study so that only the parameters that were changed were PTO, ground, and header speeds. It is important to note that though the other settings remained constant, volumetric output of the fans and air velocities changed based on the ratio of changes in PTO speed. More research is needed to determine the effects of changing the other adjustments on a peanut combine, relative to the observed effects discussed here.

Header Losses

Header losses are produced when whole pod peanuts are separated from peanut vines prematurely before they enter the combine to be thrashed. This premature release of
peanuts is known to cause potential yield losses that are currently unrecoverable for the
grower. This reduction in yield creates a decrease in the amount of recovered yield from a
field, resulting in a total value reduction of buying point payout for farmer stock peanuts.
Not having a proper header speed has been reported to cause the whole pod peanuts to
fall off of the peanut vines before they enter the combine (Amadas, 2010). To determine
the yield effects that header speed had on peanut combining, several header speeds were
defined for testing relative to ground speed.

*Tailings Losses*

Tailings losses are produced when whole pod peanuts are moved through the
combine and out of the rear of the combine, resulting in a yield loss. This reduction in
yield creates a decrease in the amount of recovered yield from a field, resulting in a total
value reduction of buying point payout for the crop to a producer. Increased threshing
aggression and pneumatic separating velocities could cause the whole pod peanuts to
move through the combine at a faster rate and blown out the rear of the combine due to
the cleaning air fan blowing faster. Alternatively, lesser threshing aggression could also
result in increased tailings losses from clumps of vine material being discharged, from
which pods had not yet been separated.

*Loose Shelled Kernels (LSKs)*

Loose shelled kernels (LSKs) are defined on pages 73-76 of Clemson’s *Peanut
Production Guide* as “kernels and parts of kernels which are free from the hull in a load
of farmers’ stock peanuts” (Anco & Thomas, 2020). When PTO speed increases,
threshing aggression and pneumatic conveying velocities increase proportionality, which
may increase the number of LSKs found in the basket. Increased LSKs would result in a total value reduction of buying point payout for the crop to a producer, due to not receiving the premium amount per kilogram (pound) for Sound Mature Kernels (SMKs); the value for LSKs is approximately $0.15 kg⁻¹ ($0.07 lb⁻¹) or $127 tonne⁻¹ ($140 ton⁻¹). It is reported that for each percent increase of LSKs in a grade/quality sample, there is a $2.0 tonne⁻¹ ($2.2 ton⁻¹) loss in value of the stock peanuts.

*Foreign Material (FM)*

Foreign material (FM) is defined as any “dirt, sticks, rocks, trash & raisins” in a peanut grade sample (FSA, 2018 & FSA, 2019). In general, FM and LSKs are directly proportional since with an increase in LSKs there is inherently an increase in loose hulls, which contribute to FM. Increased FM would result in a reduction of buying point payout for the crop to the producer, resulting in a steep loss. The deduction value of FM is approximately $1 per percent of FM per ton after a value of 4% FM per ton. This deduction is used to find the ‘total discount value’ of peanuts. The ‘total discount value is the sum of the Sound Splits (SS), Damaged Kernels (DK), and the Foreign Material (FM) on a per tonne (ton) basis. All of which deduct final value per tonne (ton) from the total loan rate value of the peanuts.

*Material Throughput*

The rate of material throughput in a peanut combine is determined by ground speed and total dug biomass (vine, leaf, root, and pod) per unit field area. Throughput can be calculated as biomass per unit area multiplied by field area covered per unit time, which is equal to the product of ground speed and header width. Movement of vine
material and whole pods within the combine are dictated by several factors, which relate to retention of material within the combine. Rate of introducing material to the combine (as dictated by ground speed), threshing aggression, and pneumatic processes in a combine are the two main avenues for material movement and can be altered by an operator. Lower ground speeds are related to lower loading/throughput on the combine. Not properly loading a combine has shown to increase yield losses and increase grade/quality effects of the peanuts, causing a loss in profit for the peanut producer.

Yield Data

Peanut yield data was collected with a pre-production prototype peanut yield monitoring platform jointly developed by Clemson University, Amadas Industries, and John Deere. Like all yield monitoring systems, this peanut yield monitoring system performs well in demonstrating relative yield changes across a large area of interest, but its accuracy and performance is unknown across plot sized areas of interest, 3.86 m by 19.20 m (12.67 ft by 63 ft). Furthermore, the stability of a given calibration is unknown when implemented across a wide range of operational parameters, such as those performed in this study. For these reasons, average yield data across treatments was presented for each loading range analysis but yield monitor-indicated yield was not used as a basis for comparison between treatments for both the Virginia Study and Runner Study.

Loan Rate & Value

While yield and peanut value on a per area basis proved to be a highly variable source for data comparisons, peanut loan rate was used to compare ground and header
speed settings across each loading range for both the Virginia Study and Runner Study. Loan rate was calculated based on the grade/quality of the peanuts. The USDA standards for grading virginia and runner type peanuts were used, as previously stated in the Material and Methods, for the peanut grading process (USDA, 2019). Loan rate was determined on a value per weight rate, $ tonne\(^{-1}\) ($ ton\(^{-1}\)). Loan rate was calculated as the difference of the ‘total kernel value’ and the ‘total discount value.’ The ‘total kernel value’ is the sum of the Sound Mature Kernels (SMK), Other Kernels (OK), Extra-Large Kernels (ELK), and Loose Shelled Kernels (LSKs) on a per tonne (ton) basis. The ‘total discount value’ is the sum of the Sound Splits (SS), Damaged Kernels (DK), and the Foreign Material (FM) on a per tonne (ton) basis. Further definitions and value calculations/deductions for SMK, OK, ELK, LSK, SS, DK, and FM are provided by the USDA Farm Service Agency (FSA, 2018 & FSA, 2019). Using loan rate shows the effects of grade/quality due to changes in PTO speed settings and is independent of yield.

Peanut value per unit area was projected for each of the treatments by assuming a base yield of 2.2 tonne ha\(^{-1}\) (2.0 ton ac\(^{-1}\)), deducting tailings losses, and applying observed loan rate. These projections suggest the cumulative effects of tailings losses, quality, and loan rate, rather than looking at them independently of one another.

**Results and Discussion**

In 2018 and 2019, research was conducted on virginia and runner type peanuts to determine the effects of ground speed and header speed on several factors that affect the yield losses, grade/quality, and loan rate value of peanuts. The effects of ground speed were split into five different categories: material throughput, tailings losses, % LSKs,
% FM, and loan rate. For the effects of header speed, header losses were the only variable analyzed.

Ground speed settings for harvest conditions will either speed up or slow down the harvest process, either increasing or decreasing field capacity. According to several publications, typical ground speeds for peanut harvest range from 2.4-4.0 km hr\(^{-1}\) (1.5-2.5 mi hr\(^{-1}\)); these ground speeds are based on operator experience and industry recommendations (Amadas, 2015 & Amadas, 2010; KMC, 2015; Clemson, 2020). Ground speeds for harvest are determined by several factors, which include but are not limited to: vine load on the combine, vine moisture of peanut plants, observation of loose shelled kernels (LSKs) in the basket, and observation of whole peanut pods that are either still attached to or detached from the vines and are ejected at the rear of the combine with the tailings (Amadas, 2015; Amadas, 2010; KMC, 2015; Clemson, 2020).

Header speed settings for harvest conditions will either increase or decrease the speed of the vine pickup feed rate to the combine. The header speed is determined usually by the flow rate of material entering the combine in relation to the combine’s forward travel speed. The feed rate of peanuts is an important factor to keep in mind because this is the time that the peanuts enter the combine, which could create losses if not properly set. Header speed for this test was defined as the velocity of the header pickup springs at a distance of 7.0 cm (2.8 in) from the tip of the header pickup spring. According to Amadas Industries recommendation, “Set the header speed so the header picks up the windrow completely as the combine travels down the field. If the header is too slow, it will push the vines along before picking them up, possibly causing peanuts to fall off of
the vines. If operated too fast, the windrow will pull apart before entering the combine and loss could occur” (Amadas Industries, 2010). The AMADAS recommendation was kept in mind, due to the use of their 2108 model for this study.

In 2018, research was conducted on virginia type peanuts, the Virginia Study, and only one harvest timing was performed. Harvesting of the Virginia Study was conducted 25-27 days after digging, as a result of weather-related conditions preventing in field harvest at any earlier time. This vast time delay after digging may have caused weather-related losses and grade/quality effects, but those losses were not determined since they were not a part of this research. At the time of harvest in 2018, the average vine moisture content was approximately 32% wet basis. The treatments that were used in the Virginia Study were developed several weeks before the harvest date. The range of harvest speeds tested could have possibly been increased for this test, although this was difficult to predict prior to testing, given the weather conditions at the time.

In 2019, research was conducted on runner type peanuts, the Runner Study, where two harvest timings were performed: Runner Study (wet) and Runner Study (dry). Dividing the Runner Study into two separate harvest timings allowed better understanding of the effects that vine moisture played in the harvesting process. Both Runner Study tests were dug at the same time, but they were harvested on different dates, to simulate the differing effects vine moisture had on combining. The Runner Study (wet) test was harvested 3-4 days after digging, a time at which many of the vines were still green; vine moisture content of 49% wet basis. The Runner Study (dry) test was harvested 18 days after digging, at which there were some vines that still showed signs of
green biomass, but the majority of the vines did not show signs of green biomass. The time between digging and harvesting for the Runner Study (dry) test had periods of rain and on the day of harvest, there was a light fog/mist that did not lift until the next day, vine moisture content of 47% wet basis. This light fog/mist may have caused vine moisture content to be higher than what one would have expected for the period over which the peanuts were inverted, however, there was no prior basis for vine moisture content in the literature for comparison. The data collected from the Runner Study tests specifically test combine adjustments, but also show how harvest conditions play a role in a successful and efficient harvest.

Effect of Ground Speed: Virginia Study

In 2018, research was conducted on virginia type peanuts, for the purposes of this paper it will be known as the Virginia Study, to determine the effects of ground speed on several factors: including material throughput, tailings losses, grade/quality, yield, and peanut loan rate. To better understand the effects of ground speed, the Virginia Study was split into three different PTO speed groupings: Low PTO Speed, Design PTO Speed, and High PTO Speed. These three categories were determined by dividing all the tested PTO speeds into separate groups based on the PTO speeds that were tested: 90%, 100%, and 110% PTO speed. Dividing them into these groups was hypothesized to be the best way to understand the collected data across differing PTO speeds. A collective analysis was not conducted due to the low sample sizes for some of the PTO speeds tested. The treatments that were used and analyzed for the Virginia Study were from Table 22
The Low PTO Speed grouping consisted of all data for the 90% PTO speed, treatments 21-23. The Design PTO Speed grouping consisted of all data for the 100% PTO speed, treatments 1-20. The High PTO Speed Range grouping consisted of all data for the 110% PTO speed, treatments 24 and 25. Material throughput, tailings losses, grade/quality, and loan rate value effects as a function of ground speed are presented in Table 25 through Table 30, with one table for each PTO speed grouping. Differences may have been more detectable if the sample sizes of each of the ground speeds were larger, but the findings presented reflects the collected data for the Virginia Study.

Low PTO Speed

The treatments that were used and analyzed for the Low PTO Speed grouping were treatments 21-23 from Table 22. These treatments had the lowest PTO speed setting of 90% design rotational speed, had a ground speed range of 0.8-1.8 km hr\(^{-1}\) (0.5- 1.1 mi hr\(^{-1}\)), and a constant header speed, as related to ground speed, of 100%. The average throughput for this range was approximately 6,772 kg ha\(^{-1}\) (14,930 lb ac\(^{-1}\)). Results showing the effects of PTO speed for the Virginia Study, Low PTO Speed are provided in Table 25.
Material Throughput

Material throughput was significantly affected by ground speed settings as shown in Table 25 ($F_{2,9}=11.4376, p=0.0062$). There were significant differences between the lowest ground speed setting, 0.8 km hr$^{-1}$ (0.5 mi hr$^{-1}$), and the upper ground speed settings tested, 1.3 and 1.8 km hr$^{-1}$ (0.8 and 1.1 mi hr$^{-1}$). These data show, as expected, that at a higher ground speed, an increased amount of peanut material, both vine material and pods, passed through the combine, whether exiting as tailings or entering the basket as whole pod peanuts to be sold. The relationship between material throughput and ground speed was approximately linear ($R^2=0.99$); for every 1 km hr$^{-1}$ increase in ground speed, there was an increase of 4,815 kg hr$^{-1}$ in material throughput (17,085 lb hr$^{-1}$ per each 1 mi hr$^{-1}$ increase in speed).

Tailings Losses

Tailings losses were not significantly affected by combine ground speed settings as shown in Table 25 ($F_{2,9}=1.0307, p<0.4052$). There were no significant differences between the ground speeds tested, though in varying field conditions the results could be expected to show a similar trend.

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Table 25. Measured effects of ground speed for Virginia Study, Low PTO Speed (90% PTO speed). Uses treatments 21 through 23 from Table 22. Means with different letters are significantly different (student’s t test, $p < 0.05$).

<table>
<thead>
<tr>
<th>Ground Speed [a] km hr$^{-1}$ (mi hr$^{-1}$)</th>
<th>Material Throughput kg hr$^{-1}$ (lb hr$^{-1}$)</th>
<th>Tailings Losses kg ha$^{-1}$ (lb ac$^{-1}$)</th>
<th>LSK %</th>
<th>FM %</th>
<th>Loan Rate $/tonne$ ($/ton$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>Mean</td>
<td>SE [b]</td>
<td>Mean</td>
<td>SE</td>
<td>Mean</td>
</tr>
<tr>
<td>-----------------</td>
<td>------</td>
<td>-------</td>
<td>------</td>
<td>----</td>
<td>-----</td>
</tr>
<tr>
<td>0.8 (0.5)</td>
<td>3</td>
<td>4,338</td>
<td>(9,564) b</td>
<td>1,620</td>
<td>68</td>
</tr>
<tr>
<td>1.3 (0.8)</td>
<td>3</td>
<td>6,991</td>
<td>(15,413) a</td>
<td>1,620</td>
<td>53</td>
</tr>
<tr>
<td>1.8 (1.1)</td>
<td>4</td>
<td>8,988</td>
<td>(19,814) a</td>
<td>1,403</td>
<td>51</td>
</tr>
</tbody>
</table>

[a] Ground speed expressed as a rate at which the peanut combine covers a specified area.
[b] SE = standard error
have proved significant. These data showed an inversely proportional relationship between tailings losses and ground speed. Tailings losses were lowest at the higher ground speeds, where there appeared to be an asymptotic trend seen at the 1.3 and 1.8 km hr\(^{-1}\) (0.8 and 1.1 mi hr\(^{-1}\)) ground speeds. This could suggest that there was an upper ground speed for minimization of tailings losses and that at higher ground speeds the combine was reaching its loading potential. The relationship between tailings losses and ground speed was approximately linear (\(R^2=0.85\)); for every 1 km hr\(^{-1}\) increase in ground speed, there was a decrease of 18 kg ha\(^{-1}\) in tailings losses (26 lb ac\(^{-1}\) per each 1 mi hr\(^{-1}\) increase in speed).

**Loose Shelled Kernels (LSKs)**

The percentage of LSKs were not significantly affected by ground speed as shown in Table 25 (\(F_{2,9}=0.5175, p=0.6172\)). The relationship between mean LSKs and ground speed was shown to not be linear (\(R^2=0.01\)), rather, these data may suggest that LSKs were minimized at a medium ground speed, 1.3 km hr\(^{-1}\) (0.8 mi hr\(^{-1}\)). However, more testing would need to be done to investigate this suggestion, due to the lack of significance.

**Foreign Material (FM)**

The percentage of FM was not significantly affected by ground speed as shown in Table 25 (\(F_{2,9}=0.8702, p=0.4597\)). Similar to the trend in LSKs for the Low PTO Speed, the relationship between ground speed and FM was not linear (\(R^2=0.42\)) and minimization of FM occurred at the medium ground speed, 1.3 km hr\(^{-1}\) (0.8 mi hr\(^{-1}\)). Often, and in this case, FM and LSKs are affected similarly since with an increase in
LSKs there is that same increase in FM. There was a positive linear relationship between the two \((R^2=0.50)\). Again, more testing would need to be done to prove that this relationship may hold true, due to the lack of significance.

**Loan Rate & Value**

The loan rate was not significantly affected by ground speed as shown in Table 25 \((F_{2,9}=0.9813, p=0.4210)\). Though there were no significant differences, these data showed that peanut loan rate increased as a function of ground speed, overall. This increase may be due to achieving proper combine loading thresholds that allow the combine to run at its designed capacity, though the relationship between loan rate and ground speed was not linear \((R^2=0.49)\). There was a visible relationship with loan rate as a function of %LSKs and % FM. Increased loan rate proved to be associated with fewer LSKs and FM.

Peanut value per unit area was not significantly affected by ground speed settings as shown in Table 26 \((F_{2,9}=1.2488, p=0.3437)\). Value increased as ground speed increased throughout this test.

Table 26. Measured effects of ground speed on value per unit area for the Virginia Study.

*Low PTO Speed* (90% PTO speed). Means with different letters are significantly different (student’s t test, \(p < 0.05\)).

| Ground Speed \(|a|\) \(\text{km hr}^{-1}\) (\(\text{mi hr}^{-1}\)) | \(n\) | Value \(\text{S ha}^{-1}\) (\(\text{S ac}^{-1}\)) | Mean | SE \(|b|\) |
|---|---|---|---|---|
| \(0.8\) (0.5) | 3 | \(1,731\) (701) \(a\) | 11 |
| \(1.3\) (0.8) | 3 | \(1,791\) (725) \(a\) | 11 |
| \(1.8\) (1.1) | 4 | \(1,776\) (719) \(a\) | 10 |

\(|a|\) Ground speed expressed as a rate at which the peanut combine covers a specified area.

\(|b|\) SE = standard error
Design PTO Speed

The treatments that were used and analyzed for the Design PTO Speed grouping were treatments 1-20 from Table 22. These treatments included the design PTO speed setting of 100%, ground speeds of 0.8-2.3 km hr\(^{-1}\) (0.5-1.4 mi hr\(^{-1}\)), and header speeds of 70-130% as related to ground speed. The average throughput for this range was approximately 5,292 kg hr\(^{-1}\) (16,662 lb hr\(^{-1}\)). Results showing the effects of PTO speed for the Virginia Study, Design PTO Speed are provided in Table 27.

Table 27. Measured effects of ground speed for Virginia Study, Design PTO Speed (100% PTO speed). Uses treatments 1 through 20 from Table 22. Means with different letters are significantly different (student’s t test, p < 0.05).

<table>
<thead>
<tr>
<th>Ground Speed ((\text{km hr}^{-1})) ((\text{mi hr}^{-1}))</th>
<th>Material Throughput ((\text{kg hr}^{-1})) ((\text{lb hr}^{-1}))</th>
<th>Tailings Losses ((\text{kg ha}^{-2})) ((\text{lb ac}^{-1}))</th>
<th>LSK %</th>
<th>FM %</th>
<th>Loan Rate ((\text{t}^{-1})) ((\text{ton}^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8 (0.5)</td>
<td>18</td>
<td>3,790 (8,355) d</td>
<td>1,058</td>
<td>186 (166) a</td>
<td>8.0</td>
</tr>
<tr>
<td>1.3 (0.8)</td>
<td>19</td>
<td>6,271 (13,824) c</td>
<td>1,007</td>
<td>155 (138) b</td>
<td>7.8</td>
</tr>
<tr>
<td>1.8 (1.1)</td>
<td>16</td>
<td>8,661 (19,094) b</td>
<td>1,119</td>
<td>124 (111) c</td>
<td>8.5</td>
</tr>
<tr>
<td>2.3 (1.4)</td>
<td>14</td>
<td>11,510 (25,374) a</td>
<td>1,191</td>
<td>126 (113) c</td>
<td>9.1</td>
</tr>
</tbody>
</table>

\(^{(a)}\) Ground speed expressed as a rate at which the peanut combine covers a specified area.

\(^{(b)}\) SE = standard error

Material Throughput

Material throughput was significantly affected by ground speed settings as shown in Table 27 (\(F_{3,71}=42.1523, p<0.0001\)). These data show, as expected, that at a higher ground speed, an increased amount of peanut material, both vine material and pods, passed through the combine, whether exiting as tailings or entering the basket as whole pod peanuts to be sold. The relationship between material throughput and ground speed was approximately linear (\(R^2=0.999\)); for every 1 km hr\(^{-1}\) increase in ground speed, there
was an increase of 5,292 kg hr\(^{-1}\) in material throughput (18,775 lb hr\(^{-1}\) per each 1 mi hr\(^{-1}\) increase in speed).

**Tailings Losses**

Tailings losses were significantly affected by combine ground speed settings as shown in Table 27 ($F_{3,66}=9.8066, p<0.0001$). This relationship between tailings losses and ground speed was similar to the relationship seen in the *Virginia Study, Low PTO Speed* test presented in Table 25, though the results of this test were significantly different across most ground speeds tested. The relationship between tailings losses and ground speed was approximately linear ($R^2=0.87$); for every 1 km hr\(^{-1}\) increase in ground speed, there was a decrease of 44 kg ha\(^{-1}\) in tailings losses (63 lb ac\(^{-1}\) per each 1 mi hr\(^{-1}\) increase in speed).

**Loose Shelled Kernels (LSKs)**

The percentage of LSKs were significantly affected by combine ground speed settings as seen in Table 27 ($F_{3,66}=7.0770, p=0.0004$). This decrease of LSKs at higher ground speeds may indicate that combine harvest efficiency increases as a function of material throughput. The increase of material causes vines and peanuts to move effectively through the combine, as intended. The relationship between LSKs and ground speed was shown to be linear ($R^2=0.96$); for every 1 km hr\(^{-1}\) increase in ground speed, there was a decrease of 2.87% in percent LSKs (4.6% per each 1 mi hr\(^{-1}\) increase in speed). This study was not able to demonstrate a ground speed above which LSKs began to increase.
Foreign Material (FM)

The percentage of FM was significantly affected by combine ground speed settings as demonstrated in Table 27 ($F_{3,66}=3.0927$, $p=0.0332$). There were only significant differences between the lowest ground speed, 0.8 km hr$^{-1}$ (0.5 mi hr$^{-1}$), in comparison to the rest of the ground speeds tested, 1.3-2.3 km hr$^{-1}$ (0.8-1.4 mi hr$^{-1}$). The relationship between FM and ground speed was approximately linear FM ($R^2=0.81$); for every 1 km hr$^{-1}$ increase in ground speed, there was a decrease of 0.63% in FM (1.02% per each 1 mi hr$^{-1}$ increase in speed). Often, and in this case, FM and LSKs are affected similarly since with an increase in LSKs there is that same increase in FM. There was a strong positive linear relationship between the two ($R^2=0.94$). This relationship was also seen in the Virginia Study, Low PTO Speed grouping.

Loan Rate & Value

Mean peanut loan rate was not significantly affected by ground speeds in Table 27 ($F_{3,66}=1.0356$, $p=0.3830$). Though there were no significant differences, these data showed that peanut loan rate increased as a function of ground speed. The relationship between loan rate and ground speed was linear ($R^2=0.77$); for every 1 km hr$^{-1}$ increase in ground speed, there was an increase of $11.19$ tonne$^{-1}$ in loan rate value ($12.33$ ton$^{-1}$ decrease per each 1 mi hr$^{-1}$ increase in speed). There was also a visible relationship with loan rate as a function of %LSKs and % FM. Increased loan rate proved to be associated with fewer LSKs and FM. Though these relationships occurred, that peanut loan rate remained relatively constant across the speed range tests.
A one-way ANOVA suggested that the value of peanuts per unit area was not significantly affected by ground speed settings as shown in Table 28 ($F_{3,66}=2.0147$, $p=0.1209$), although a mean’s comparison showed significant differences. The relationship between value per unit area and ground speed was approximately linear ($R^2=0.88$), equating to roughly a $52 \text{ ha}^{-1}$ increase in value for every 1 km hr$^{-1}$ increase in ground speed ($34 \text{ ac}^{-1}$ decrease per each 1 mi hr$^{-1}$ increase in speed).

Table 28. Measured effects of ground speed on value per unit area for the Virginia Study.

<table>
<thead>
<tr>
<th>Ground Speed $^{[a]}$ km hr$^{-1}$ (mi hr$^{-1}$)</th>
<th>n</th>
<th>Value $^b$ $\text{ha}^{-1}$ ($\text{ac}^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8 (0.5)</td>
<td>18</td>
<td>1,673 (677) b</td>
</tr>
<tr>
<td>1.3 (0.8)</td>
<td>19</td>
<td>1,726 (698) ab</td>
</tr>
<tr>
<td>1.8 (1.1)</td>
<td>16</td>
<td>1,728 (699) ab</td>
</tr>
<tr>
<td>2.3 (1.4)</td>
<td>14</td>
<td>1,756 (711) a</td>
</tr>
</tbody>
</table>

$^{[a]}$ Ground speed expressed as a rate at which the peanut combine covers a specified area.

$^{[b]}$ SE = standard error

**High PTO Speed**

The treatments that were used and analyzed for the High PTO Speed grouping were treatments 24 and 25 from Table 22. These treatments included the highest PTO speed setting of 110%, had a ground speed range of 1.8 and 2.3 km hr$^{-1}$ (1.1 and 1.4 mi hr$^{-1}$), and a constant header speed, as related to ground speed, of 100%. The average throughput for this range was approximately 11,613 kg hr$^{-1}$ (25,602 lb hr$^{-1}$). Results showing the effects of PTO speed for the Virginia Study, High PTO Speed test are provided in Table 29.
Table 29. Measured effects of ground speed for *Virginia Study, High PTO Speed* (110% PTO speed). Uses treatments 24 and 25 from Table 22. Means with different letters are significantly different (student’s t test, p < 0.05).

<table>
<thead>
<tr>
<th>Ground Speed[^a] km hr⁻¹ (mi hr⁻¹)</th>
<th>Material Throughput kg hr⁻¹ (lb hr⁻¹)</th>
<th>Tailings Losses kg ha⁻¹ (lb ac⁻¹)</th>
<th>LSK %</th>
<th>FM %</th>
<th>Loan Rate $ ton⁻¹ ($ ton⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.8 (1.1) 3</td>
<td>10,049 (22,155) b</td>
<td>373 (333) a</td>
<td>41</td>
<td>3.58 a</td>
<td>0.54 2.89 a 0.43 332 (366) a 5</td>
</tr>
<tr>
<td>2.3 (1.4) 3</td>
<td>13,176 (29,048) a</td>
<td>367 (327) a</td>
<td>41</td>
<td>3.90 a</td>
<td>0.54 2.16 a 0.43 328 (361) a 5</td>
</tr>
</tbody>
</table>

[^a] Ground speed expressed as a rate at which the peanut combine covers a specified area.

[^b] SE = standard error

**Material Throughput**

Material throughput was significantly affected by ground speed settings found in Table 29 (F₁,₅=9.1981, p=0.0387). These data show, as expected, that at a higher ground speed, an increased amount of peanut material, both vine material and pods, passed through the combine, whether exiting as tailings or entering the basket as whole pod peanuts to be sold. This relationship between material throughput and ground speed was similar to the relationship seen in both the *Virginia Study, Low PTO Speed* and *Design PTO Speed* tests, Table 25 and Table 27.

**Tailings Losses**

Tailings losses were not significantly affected by combine ground speeds as shown in Table 29 (F₁,₅=0.0103, p=0.9239). Though the differences were far from significant, these data show that at a lower ground speed, an increased amount of yield losses were found in the tailings that exited the combine. This relationship between mean tailings losses and ground speed was similar to the relationship seen in both the *Virginia Study, Low PTO Speed* and *Design PTO Speed* tests, Table 25 and Table 27.
**Loose Shelled Kernels (LSKs)**

The percentage of LSKs was not significantly affected by ground speed seen in Table 29 ($F_{1,5}=0.1797$, $p=0.6935$). There were no significant differences between the ground speeds tested, but there was an increasing trend of percent LSKs as ground speed increased. This is unlike the data observed in the previous speed tests, Table 25 and Table 27. This increase of LSKs at higher ground speeds may indicate that combine harvest efficiency decreases as a function of material throughput at the higher PTO speed of 110%.

**Foreign Material (FM)**

The percentage of FM was not significantly affected by ground speed as shown in Table 29 ($F_{1,5}=1.4672$, $p=0.2924$). There was a downward trend similar to the data in both the Virginia Study, Low PTO Speed and the Design PTO Speed tests. In general, FM and LSKs are affected similarly since with an increase in LSKs there is that same increase in FM; this was not the case.

**Loan Rate & Value**

The loan rate was not significantly affected by ground speed as shown in Table 29 ($F_{1,5}=0.5292$, $p=0.5072$). There was slight relationship with loan rate as a function of %LSKs. Increased loan rate proved to be associated with fewer LSKs, though this relationship occurred, peanut loan rate remained relatively constant across the speed range tests. Overall the value of peanuts per unit area was not significantly affected by ground speed settings as shown in Table 30 ($F_{1,5}=0.1452$, $p=0.7225$).
Table 30. Measured effects of ground speed on value per unit area for the Virginia Study.

High PTO Speed (110% PTO speed). Means with different letters are significantly different (student’s t test, p < 0.05).

<table>
<thead>
<tr>
<th>Ground Speed [a] km hr⁻¹ (mi hr⁻¹)</th>
<th>n</th>
<th>Value $ ha⁻¹ ($ ac⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>1.8 (1.1)</td>
<td>3</td>
<td>1,658 (671) a</td>
</tr>
<tr>
<td>2.3 (1.4)</td>
<td>3</td>
<td>1,638 (663) a</td>
</tr>
</tbody>
</table>

[a] Ground speed expressed as a rate at which the peanut combine covers a specified area.
[b] SE = standard error

**Effect of Ground Speed: Runner Study (wet)**

In 2019, research was conducted on runner type peanuts with relatively wet (green) vine conditions, for the purposes of this paper it will be known as Runner Study (wet), to determine the effects of ground speed on several factors: including material throughput, tailings losses, grade/quality, yield, and peanut loan rate. To better understand the effects of ground speed, the Runner Study (wet) test was split into four different PTO speed groupings: All PTO Speeds, Low PTO Speed, Design PTO Speed, and High PTO Speed. These four categories were determined by dividing the tested PTO speeds into separate groups based on the PTO speeds that were tested: 90%, 100%, 110%, and a collective of all PTO speeds. Dividing them into these groups was hypothesized to be the best way to understand the collected data across differing ground speeds. The treatments that were used and analyzed for the Runner Study (wet) were from Table 23.

The All PTO Speeds grouping consisted of all the data for all the PTO speeds tested, treatments 1-12. The Low PTO Speed grouping consisted of all data for the 90% PTO speed, treatments 1-4. The Design PTO Speed grouping consisted of all data for the 100% PTO speed, treatments 5-8. The High PTO Speed grouping consisted of all data for
the 110% PTO speed, treatments 9-12. Material throughput, tailings loss, grade/quality, and value effects as a function of ground speed are presented in Table 31 through Table 38, with one table for each PTO speed grouping.

**All PTO Speeds**

The treatments that were used and analyzed for the *All PTO Speeds* grouping were treatments 1-12 from Table 23. These treatments consisted of the ground speed range of 1.2-2.4 km hr⁻¹ (0.75-1.5 mi hr⁻¹), had a PTO speed range of 90-110%, and had a consistent header speed, as related to ground speed, of 100%. The average throughput for this range was approximately 5,560 kg hr⁻¹ (12,259 lb hr⁻¹). Average yield for this PTO speed setting was found to be approximately 3,055 kg ha⁻¹ (2,726 lb ac⁻¹) with an estimated acreage value of $1,105 ha⁻¹ ($447 ac⁻¹). Results showing the effects of PTO speed for the *Runner Study (wet)*, *All PTO Speeds* test are provided in Table 31.

Table 31. Measured effects of ground speed for the *Runner Study (wet)*, *All PTO Speeds* (90-110% PTO speeds). Uses treatments 1 through 12 from Table 23. Means with different letters are significantly different (student’s t test, p < 0.05).

<table>
<thead>
<tr>
<th>Ground Speed [a] km hr⁻¹</th>
<th>n [b]</th>
<th>Material Throughput kg hr⁻¹ (lb hr⁻¹)</th>
<th>Tailings Losses kg ha⁻¹ (lb ac⁻¹)</th>
<th>LSK %</th>
<th>FM %</th>
<th>Loan Rate $ ton⁻¹ ($ ton⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2 (0.75)</td>
<td>15</td>
<td>3,619 (7,980) d</td>
<td>124 (110) a</td>
<td>8.02 a</td>
<td>0.94</td>
<td>9.72 a 0.82</td>
</tr>
<tr>
<td>1.6 (1.0)</td>
<td>15</td>
<td>5,010 (11,045) c</td>
<td>124 (111) a</td>
<td>6.17 a</td>
<td>0.94</td>
<td>7.75 a 0.82</td>
</tr>
<tr>
<td>2.0 (1.25)</td>
<td>15</td>
<td>6,046 (13,329) b</td>
<td>113 (101) a</td>
<td>6.30 a</td>
<td>0.94</td>
<td>9.08 a 0.82</td>
</tr>
<tr>
<td>2.4 (1.5)</td>
<td>15</td>
<td>7,566 (16,680) a</td>
<td>103 (92) a</td>
<td>6.99 a</td>
<td>0.94</td>
<td>9.18 a 0.82</td>
</tr>
</tbody>
</table>

[a] Ground speed expressed as a rate at which the peanut combine covers a specified area.

[b] Sample size less due to continuous collection of yield data when other data was not collected; n=14 for 2.0 km hr⁻¹.

[c] SE = standard error
**Material Throughput**

Material throughput was significantly affected by ground speed settings seen in Table 31 (F_{3,58}=141.3113, p<0.0001). These data show, as expected, that at a higher ground speed, an increased amount of peanut material, both vine material and pods, passed through the combine, whether exiting as tailings or entering the basket as whole pod peanuts to be sold. The relationship between mean material throughput and ground speed was approximately linear (R^2=0.995); for every 1 km hr^{-1} increase in ground speed, there was an increase of 3,200 kg hr^{-1} in material throughput (11,354 lb hr^{-1} per each 1 mi hr^{-1} increase in speed). This finding was present in all of the *Virginia Study* groupings.

**Tailings Losses**

Tailings losses were not significantly affected by combine ground speed settings seen in Table 31 (F_{3,58}=0.3469, p=0.7915). The data did suggest a decreasing trend in tailings losses as a function of ground speed. The relationship between mean tailings losses and ground speed was approximately linear (R^2=0.89); for every 1 km hr^{-1} increase in ground speed, there was a decrease of 18 kg ha^{-1} in tailings losses (26 lb ac^{-1} per each 1 mi hr^{-1} increase in speed). Findings from the *Virginia Study, Low PTO Speed* grouping showed the exact same findings, Table 25.

**Loose Shelled Kernels (LSKs)**

The percentage of LSKs were not significantly affected by ground speed, as shown in Table 31 (F_{3,59}=0.8131, p=0.4920). Though not significant nor linear (R^2=0.20), these data show that at medium ground speeds, 1.6-2.0 km hr^{-1} (1.0-1.25 mi hr^{-1}), a
decreased amount of LSKs were found in the basket of the combine. This trend was also seen in the Virginia Study, Low PTO Speed test, which may suggest that this trend is meaningful, despite the lack of significance. Overall, an argument may be had that these ground speeds had the optimum ground speed for the decreased LSKs, but more testing would need to be done to prove that theory, due to the lack of significance.

*Foreign Material (FM)*

The percentage of FM was not significantly affected by ground speed, as shown in Table 31 ($F_{3,59}=1.0342, p=0.3846$). Often, and in this case, FM and LSKs are affected similarly, with the lowest amount of FM at the 1.6 km hr$^{-1}$ (1.0 mi hr$^{-1}$) ground speed, since with an increase in LSKs there is that same increase in FM. There was a positive linear relationship ($R^2=0.62$); this trend was also seen in the Virginia Study, Low PTO Speed grouping, which suggests that it may be meaningful, despite lack of significance. Even at the lowest average of FM in this study, a deduction of $3.6$ tonne$^{-1}$ ($4.0$ ton$^{-1}$) would be taken from the load of farmer stock peanuts.

*Loan Rate & Value*

Peanut loan rate was not significantly affected by PTO speed settings, as shown in Table 31 ($F_{3,59}=0.7741, p=0.5134$). The relationship between loan rate and ground speed was not linear ($R^2=0.21$). There was a negative relationship with loan rate as a function of % LSKs ($R^2=0.55$) and a strong negative relationship between loan rate and %FM. Increased loan rate proved to be associated with fewer LSKs and FM. Overall, peanut loan rate increased slightly as a function of ground speed. Value of peanuts per unit area
not significantly affected by ground speed settings as shown in Table 32 ($F_{3,58}=0.6897$, $p=0.5622$).

Table 32. Measured effects of ground speed on value per unit area for the Runner Study (wet).

All PTO Speeds (90-110% PTO speed). Means with different letters are significantly different (student’s t test, $p < 0.05$).

<table>
<thead>
<tr>
<th>Ground Speed (b) km hr$^{-1}$ (mi hr$^{-1}$)</th>
<th>n</th>
<th>Value $\text{ha}^{-1}$ ($$ \text{ac}^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2 (0.75)</td>
<td>15</td>
<td>1,457 (590) a</td>
</tr>
<tr>
<td>1.6 (1.0)</td>
<td>15</td>
<td>1,507 (610) a</td>
</tr>
<tr>
<td>2.0 (1.25)</td>
<td>14</td>
<td>1,489 (603) a</td>
</tr>
<tr>
<td>2.4 (1.5)</td>
<td>15</td>
<td>1,502 (608) a</td>
</tr>
</tbody>
</table>

(a) Ground speed expressed as a rate at which the peanut combine covers a specified area.

(b) SE = standard error

**Low PTO Speed**

The treatments that were used and analyzed for the Low PTO Speed grouping were treatments 1-4 from Table 23. These treatments had the lowest PTO speed setting of 90% design rotational speed, had a ground speed range of 1.2-2.4 km hr$^{-1}$ (0.75-1.5 mi hr$^{-1}$), and a constant header speed, as related to ground speed, of 100%. The average throughput for this range was approximately 5,469 kg ha$^{-1}$ (12,057 lb ac$^{-1}$). Average yield for this PTO speed setting was found to be approximately 2,962 kg ha$^{-1}$ (2,643 lb ac$^{-1}$) with an estimated acreage value of $1,076 ha$^{-1}$ ($435 \text{ac}^{-1}$). Results showing the effects of PTO speed for the Runner Study (wet), Low PTO Speed test are provided in Table 33.
Table 33. Measured effects of ground speed for the Runner Study (wet), Low PTO Speed (90 PTO speed). Uses treatments 1 through 4 from Table 23. Means with different letters are significantly different (student’s t test, p < 0.05).

<table>
<thead>
<tr>
<th>Ground Speed [a] km hr⁻¹ (mi hr⁻¹)</th>
<th>n</th>
<th>Material Throughput kg hr⁻¹ (lb hr⁻¹)</th>
<th>Tailings Losses kg ha⁻¹ (lb ac⁻¹)</th>
<th>LSK %</th>
<th>FM %</th>
<th>Loan Rate $ ton⁻¹ ($ ton⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2 (0.75)</td>
<td>5</td>
<td>3,361 (7,410) d</td>
<td>486</td>
<td>73 (65) a</td>
<td>12</td>
<td>4.71 a</td>
</tr>
<tr>
<td>1.6 (1.0)</td>
<td>5</td>
<td>4,920 (10,846) c</td>
<td>486</td>
<td>66 (59) a</td>
<td>12</td>
<td>4.43 a</td>
</tr>
<tr>
<td>2.0 (1.25)</td>
<td>5</td>
<td>6,029 (13,293) b</td>
<td>486</td>
<td>53 (47) a</td>
<td>12</td>
<td>4.05 a</td>
</tr>
<tr>
<td>2.4 (1.5)</td>
<td>5</td>
<td>7,566 (16,680) a</td>
<td>486</td>
<td>66 (59) a</td>
<td>12</td>
<td>5.54 a</td>
</tr>
</tbody>
</table>

[a] Ground speed expressed as a rate at which the peanut combine covers a specified area.
[b] SE = standard error

Material Throughput

Material throughput was significantly affected by ground speed settings, as shown in Table 33 (F₃,₁₉=65.0035, p<0.0001). These data show, as expected, that at a higher ground speed, an increased amount of peanut material, both vine material and pods, passed through the combine, whether exiting as tailings or entering the basket as whole pod peanuts to be sold. The relationship between mean material throughput and ground speed was approximately linear (R²=0.996); for every 1 km hr⁻¹ increase in ground speed, there was an increase of 3,411 kg hr⁻¹ in material throughput (12,103 lb hr⁻¹ per each 1 mi hr⁻¹ increase in speed).

Tailings Losses

Tailings losses were not significantly affected by combine ground speed settings, as shown in Table 33 (F₃,₁₉=0.3613, p=0.7818). This data did show that at lower ground speeds there was an increased amount of yield losses. The relationship between mean tailings losses and ground speed was not linear (R²=0.26), but parabolic in shape (R²=0.75). A trend like this was observed in the Virginia Study for both the Low and
Design PTO Speed (Table 25 and Table 27). This could show that there was an optimum combine ground speed for minimization of tailings losses at higher ground speeds for 90% PTO speed, Low PTO Speed.

Loose Shelled Kernels (LSKs)

The percentage of LSKs were not significantly affected by combine ground speed settings, as shown in Table 33 (F3,19=0.4549, p=0.7175). The data did show that at a ground speed of 2.0 km hr⁻¹ (1.25 mi hr⁻¹) there was a decreased amount of LSKs. The relationship between mean LSKs and ground speed was shown to not be linear (R²=0.19) but was found to be parabolic in shape (R²=0.84). This ‘trend’ was also seen in the Virginia Study, Low PTO Speed test (Table 25) and Runner Study (wet) All PTO Speeds test (Table 31), which suggests this trend is a viable result.

Foreign Material (FM)

The percentage of FM was significantly affected by combine ground speed settings, as shown in Table 33 (F3,19=1.7694, p=0.1935). There were no significant differences at the lowest and highest ground speeds tested. Similar to the trend in LSKs, the relationship between ground speed and FM was not linear (R²=0.0003) and minimization of FM occurred at the medium ground speed, 1.6 km hr⁻¹ (1.0 mi hr⁻¹). FM and LSKs were not affected similarly (R²=0.10). This ‘trend’ was also seen in the Virginia Study, Low PTO Speed test (Table 25) and Runner Study (wet) All PTO Speeds test (Table 31), which could prove that this trend is a viable result. Even at the lowest average of FM in this study, a deduction of $1.8 tonne⁻¹ ($2.0 ton⁻¹) would be taken from the load of stock peanuts.
**Loan Rate & Value**

Peanut loan rate was significantly affected by combine ground speed settings, as shown in Table 33. \( F_{3,19}=1.2357, p=0.3294 \). The relationship between loan rate and ground speed was not substantially linear \( R^2=0.66 \). Overall, peanut loan rate increased as a function of ground speed. Value of peanuts per unit area was not significantly affected by ground speed settings as shown in Table 34 \( F_{3,19}=1.4399, p=0.2682 \).

<table>
<thead>
<tr>
<th>Ground Speed (^{(a)}) km hr(^{-1}) (mi hr(^{-1}))</th>
<th>n</th>
<th>Value $ ha(^{-1}) ($ ac(^{-1}))</th>
<th>Mean</th>
<th>SE (^{(b)})</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2 (0.75)</td>
<td>5</td>
<td>1,485 (601) a</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>1.6 (1.0)</td>
<td>5</td>
<td>1,561 (632) a</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>2.0 (1.25)</td>
<td>5</td>
<td>1,546 (626) a</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>2.4 (1.5)</td>
<td>5</td>
<td>1,569 (635) a</td>
<td>13</td>
<td></td>
</tr>
</tbody>
</table>

\(^{(a)}\) Ground speed expressed as a rate at which the peanut combine covers a specified area.

\(^{(b)}\) SE = standard error

**Design PTO Speed**

The treatments that were used and analyzed for the Design PTO Speed grouping were treatments 5-8 from Table 23. These treatments had the design PTO speed setting of 100% design rotational speed, a ground speed range of 1.2-2.4 km hr\(^{-1}\) (0.75-1.5 mi hr\(^{-1}\)), and a constant header speed, as related to ground speed, of 100%. The average throughput for this range was approximately 5,524 kg hr\(^{-1}\) (12,178 lb hr\(^{-1}\)). Average yield for this PTO speed setting was found to be approximately 3,073 kg ha\(^{-1}\) (2,742 lb ac\(^{-1}\)) with an estimated acreage value of $1,110 ha\(^{-1}\) ($449 ac\(^{-1}\)). Results showing the effects of PTO speed for the Runner Study (wet), Design PTO Speed are provided in Table 35.
Table 35. Measured effects of ground speed for the Runner Study (wet), Design PTO Speed (100% PTO Speed). Uses treatments 5 through 8 from Table 23. Means with different letters are significantly different (student’s t test, p < 0.05).

<table>
<thead>
<tr>
<th>Ground Speed (a) (mi hr(^{-1}))</th>
<th>Material Throughput kg hr(^{-1}) (lb hr(^{-1}))</th>
<th>Tailings Losses kg ha(^{-1}) (lb ac(^{-1}))</th>
<th>LSK %</th>
<th>FM %</th>
<th>Loan Rate $ tonne(^{-1}) ($ ton(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2 (0.75)</td>
<td>3,743 (8,252) d</td>
<td>551</td>
<td>104 (93) a</td>
<td>8</td>
<td>7.66 a 1.43</td>
</tr>
<tr>
<td>1.6 (1.0)</td>
<td>4,856 (10,706) c</td>
<td>551</td>
<td>99 (88) a</td>
<td>8</td>
<td>6.25 a 1.43</td>
</tr>
<tr>
<td>2.0 (1.25)</td>
<td>6,149 (13,557) b</td>
<td>551</td>
<td>88 (79) a</td>
<td>8</td>
<td>6.90 a 1.43</td>
</tr>
<tr>
<td>2.4 (1.5)</td>
<td>7,347 (16,198) a</td>
<td>551</td>
<td>85 (76) a</td>
<td>8</td>
<td>5.56 a 1.43</td>
</tr>
</tbody>
</table>

(a) Ground speed expressed as a rate at which the peanut combine covers a specified area.

(b) SE = standard error

Material Throughput

Material throughput was significantly affected by ground speed settings, as shown in Table 35 ($F_{3,19}=39.1932$, $p<0.0001$). These data show that at a higher ground speed, like all other findings for this comparison across tests, an increased amount of peanut material, both vine material and pods, passed through the combine, whether exiting as tailings or entering the basket as peanuts to be sold. The relationship between mean material throughput and ground speed was approximately linear ($R^2=0.999$); for every 1 km hr\(^{-1}\) increase in ground speed, there was an increase of 3,009 kg hr\(^{-1}\) in material throughput (10,675 lb hr\(^{-1}\) per each 1 mi hr\(^{-1}\) increase in speed).

Tailings Losses

Tailings losses were not significantly affected by combine ground speed settings, as shown in Table 35 ($F_{3,19}=0.9540$, $p=0.4382$). The relationship between tailings losses and ground speed was approximately linear ($R^2=0.96$); for every 1 km hr\(^{-1}\) increase in
ground speed, there was a decrease of 17 kg ha\(^{-1}\) in tailings losses (25 lb ac\(^{-1}\) decrease per each 1 mi hr\(^{-1}\) increase in speed).

\textit{Loose Shelled Kernels (LSKs)}

The percentage of LSKs were not significantly affected by combine ground speed settings, as shown in Table 35 (F\(_{3,19}=0.3963, p=0.7574\)). Though there were no significant differences between the ground speeds tested, though at the highest ground speed tested the least amount of LSKs were found. The relationship between mean LSKs and ground speed was shown to not be substantially linear (R\(^2=0.66\)), but generally decreased as a function of ground speed.

\textit{Foreign Material (FM)}

The percentage of FM was not significantly affected by ground speed, as shown in Table 35 (F\(_{3,19}=0.3019, p=0.8236\)). There did not appear to be a meaningful trend exhibited between FM and ground speed and it is thought that any apparent trend is likely driven by variability present in the samples. Often, and in this case, FM and LSKs are affected similarly since with an increase in LSKs there is that same increase in FM. There was a negative linear relationship between the two (R\(^2=0.58\)).

\textit{Loan Rate & Value}

Peanut loan rate was not significantly affected by combine ground speed settings, as shown in Table 35 (F\(_{3,19}=0.2278, p=0.8756\)). These data show that loan rate was lowest in the middle ground speeds tested, increasing for both the lowest and highest ground speeds; the relationship between loan rate and ground speed was not linear (R\(^2=0.04\)). Value of peanuts per unit area was not significantly affected by ground speed.
settings as shown in Table 36 ($F_{3,19}=0.2289$, $p=0.8749$). Value increased as ground speed increased throughout this test.

Table 36. Measured effects of ground speed on value per unit area for the Runner Study (wet).

Design PTO Speed (100% PTO speed). Means with different letters are significantly different (student’s t test, $p < 0.05$).

<table>
<thead>
<tr>
<th>Ground Speed ($^a$) km hr$^{-1}$ (mi hr$^{-1}$)</th>
<th>n</th>
<th>Value $$ \text{ha}^{-1}$ ($$ \text{ac}^{-1}$)</th>
<th>Mean</th>
<th>SE$^{[b]}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2 (0.75)</td>
<td>5</td>
<td>1,508 (610) a</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>1.6 (1.0)</td>
<td>5</td>
<td>1,474 (597) a</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>2.0 (1.25)</td>
<td>5</td>
<td>1,475 (597) a</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>2.4 (1.5)</td>
<td>5</td>
<td>1,526 (618) a</td>
<td>22</td>
<td></td>
</tr>
</tbody>
</table>

$^{[a]}$ Ground speed expressed as a rate at which the peanut combine covers a specified area.

$^{[b]}$ SE = standard error

**High PTO Speed**

The treatments that were used and analyzed for the High PTO Speed grouping were treatments 9-12 from Table 23. These treatments had the high PTO speed setting of 110% rotational speed, had a ground speed range of 1.2-2.4 km hr$^{-1}$ (0.75-1.5 mi hr$^{-1}$), and a constant header speed, as related to ground speed, of 100%. The average throughput for this range was approximately 5,683 kg hr$^{-1}$ (12,528 lb hr$^{-1}$). Average yield for this PTO speed setting was found to be approximately 3,129 kg ha$^{-1}$ (2,792 lb ac$^{-1}$) with an estimated acreage value of $1,131 \text{ha}^{-1}$ ($458 \text{ac}^{-1}$). Results showing the effects of PTO speed for the Runner Study (wet), High PTO Speed are provided in Table 37.
Material Throughput

Material throughput was significantly affected by ground speed settings, as shown in Table 37 ($F_{3,18}=36.2774$, $p<0.0001$). These data show that at a higher ground speed, like all other findings for this comparison across tests, an increased amount of peanut material, both vine material and pods, passed through the combine, whether exiting as tailings or entering the basket as peanuts to be sold. The relationship between mean material throughput and ground speed was approximately linear ($R^2=0.97$); for every 1 km hr$^{-1}$ increase in ground speed, there was an increase of 3,175 kg hr$^{-1}$ in material throughput (11,264 lb hr$^{-1}$ per each 1 mi hr$^{-1}$ increase in speed).

Tailings Losses

Tailings losses were not significantly affected by combine ground speed settings, as shown in Table 37 ($F_{3,18}=1.6146$, $p=0.2279$). Tailings losses were found to be lowest at the highest ground speed, 2.4 km hr$^{-1}$ (1.5 mi hr$^{-1}$). The relationship between tailings losses and ground speed was found to not be linear ($R^2=0.23$), but parabolic in shape.
(R²=0.89), peaking at a mid-range ground speed. This was similar to the relationships seen in the Virginia Study for both the Low and Design PTO Speed (Table 25 and Table 27) and Runner Study (wet), Low and Design PTO Speed (Table 33 and Table 35). Though the findings of this test were not significant, they could prove to be significant in varying field conditions.

*Loose Shelled Kernels (LSKs)*

The percentage of LSKs were not significantly affected by combine ground speed settings, as shown in Table 37 (F₃,₁₉=1.0626, p=0.3925). The relationship between LSKs and ground speed appeared to be parabolic with least LSKs occurring at medium ground speeds, 1.6-2.0 km hr⁻¹ (1.0-1.25 mi hr⁻¹). This ‘trend’ was also seen in the Virginia Study, Low PTO Speed (Table 25) and Runner Study (wet), All PTO Speeds (Table 31) tests, which could prove that this trend is a viable result. LSKs had an inverse relationship with tailings losses.

*Foreign Material (FM)*

The percentage of FM was significantly affected by ground speed, as shown in Table 37 (F₃,₁₉=1.6896, p=0.2093). The relationship between FM and ground speed was parabolic, within minimum FM occurring at a medium speed. This ‘trend’ was also seen in the Virginia Study, Low PTO Speed (Table 25) and Runner Study (wet) All PTO Speeds (Table 31) tests, which could prove that this trend is a viable result. Often, and in this case, FM and LSKs are affected similarly since with an increase in LSKs there is that same increase in FM. There was a positive linear relationship between the two (R²=0.80).
Even at the lowest average of FM in this study, a deduction of $2.7 tonne\(^{-1}\) ($3.0 ton\(^{-1}\)) would be taken from the load of stock peanuts.

**Loan Rate & Value**

Peanut loan rate was not significantly affected by combine ground speed settings as shown in Table 37 (F\(_{3,19}=1.6042, p=0.2277\)). The relationship between loan rate and ground speed was not linear (R\(^{2}=0.0026\)). There was a negative relationship with loan rate (R\(^{2}=0.59\)) as a function of %LSKs and a strong negative relationship between %FM (R\(^{2}=0.92\)). Increased loan rate proved to be associated with fewer LSKs and FM.

Peanut value per unit area was not significantly affected by ground speed settings as shown in Table 38 (F\(_{3,18}=1.3253, p=0.3032\)). Value per unit area showed a maximum value at the 1.6 km hr\(^{-1}\) (1.0 mi hr\(^{-1}\)) speed with a somewhat parabolic trend (R\(^{2}=0.73\)). This may show that though tailings losses were not the lowest at this speed, loan rate was mostly determined by grade/quality (Table 37).

**Table 38.** Measured effects of ground speed on value per unit area for the Runner Study (wet).

*High PTO Speed (110% PTO speed). Means with different letters are significantly different (student’s t test, p < 0.05).*

<table>
<thead>
<tr>
<th>Ground Speed [^{[a]}] km hr(^{-1}) (mi hr(^{-1}))</th>
<th>n</th>
<th>Value $ ha(^{-1}) ($ ac(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2 (0.75)</td>
<td>5</td>
<td>1,379 (558) a</td>
</tr>
<tr>
<td>1.6 (1.0)</td>
<td>5</td>
<td>1,485 (601) a</td>
</tr>
<tr>
<td>2.0 (1.25)</td>
<td>4</td>
<td>1,436 (581) a</td>
</tr>
<tr>
<td>2.4 (1.5)</td>
<td>5</td>
<td>1,410 (571) a</td>
</tr>
</tbody>
</table>

\[^{[a]}\] Ground speed expressed as a rate at which the peanut combine covers a specified area.

\[^{[b]}\] SE = standard error
Effect of Ground Speed: Runner Study (dry)

In 2019, research was conducted on runner type peanuts with relatively dry vine conditions, for the purposes of this paper it will be known as the Runner Study (dry), to determine the effects of ground speed on several factors: including grade/quality, yield, and peanut loan rate. To better understand the effects of ground speed, the Runner Study (dry) was split into four PTO speed groupings: All PTO Speeds, Low PTO Speed, Design PTO Speed, and High PTO Speed. These four categories were determined by dividing all the tested PTO speeds into separate groups based on the PTO speeds that were tested: 90%, 100%, 110%, and all PTO speeds. Dividing them into these groups proved to be the best way to understand the collected data across differing PTO speeds. Though the average throughput and tailings losses were determined for the Virginia Study and Runner Study (wet) they were not collected for this study due to harvest time constraints and lack of labor for the collection processes.

The treatments that were used and analyzed for the Runner Study (dry) were from Table 24. The All PTO Speeds grouping consisted of all data for the 90%-110% PTO speeds tested, treatments 1-12. The Low PTO Speed grouping consisted of all data for the 90% PTO speed, treatments 1-4. The Design PTO Speed grouping consisted of all data for the 100% PTO speed, treatments 5-8 and 13-15. The High PTO Speed grouping consisted of all data for the 110% PTO, treatments 9-12. LSK, FM, and loan rate value as a function of ground speed are presented in Table 39 through Table 42, with one table for each PTO speed group.
**All PTO Speeds**

The treatments that were used and analyzed for the *All PTO Speeds* grouping were treatments 1-12 from Table 24. These treatments consisted of the ground speed range of, 1.6-4.0 km hr⁻¹ (1.0-2.5 mi hr⁻¹), had a PTO speed setting range of 90-110%, and had a consistent header speed, as related to ground speed, of 100%. Average yield for this PTO speed setting was found to be approximately 3,493 kg ha⁻¹ (3,117 lb ac⁻¹) with an estimated acreage value of $1,327 ha⁻¹ ($537 ac⁻¹) Results showing the effects of PTO speed for the *Runner Study (dry)*, *All PTO Speeds* are provided in Table 39.

Table 39. Measured effects of ground speed for the *Runner Study (dry)*, *All PTO Speeds* (90-110% PTO speeds). Uses treatments 1 through 12 from Table 24. Means with different letters are significantly different (student’s t test, p < 0.05).

<table>
<thead>
<tr>
<th>Ground Speed⁺⁻ km hr⁻¹ (mi hr⁻¹)</th>
<th>n</th>
<th>LSK %</th>
<th>Mean</th>
<th>SE⁺⁻</th>
<th>FM %</th>
<th>Mean</th>
<th>SE</th>
<th>Loan Rate $ tonne⁻¹ ($ ton⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.6 (1.0)</td>
<td>15</td>
<td>16.11 a</td>
<td>1.73</td>
<td>1.73</td>
<td>8.35 ab</td>
<td>0.97</td>
<td>269 (296) a</td>
<td>7</td>
</tr>
<tr>
<td>2.4 (1.5)</td>
<td>15</td>
<td>14.32 a</td>
<td>1.73</td>
<td>1.73</td>
<td>7.60 b</td>
<td>0.97</td>
<td>272 (300) a</td>
<td>7</td>
</tr>
<tr>
<td>3.2 (2.0)</td>
<td>15</td>
<td>14.70 a</td>
<td>1.73</td>
<td>1.73</td>
<td>10.58 a</td>
<td>0.97</td>
<td>262 (289) a</td>
<td>7</td>
</tr>
<tr>
<td>4.0 (2.5)</td>
<td>15</td>
<td>11.43 a</td>
<td>1.73</td>
<td>1.73</td>
<td>7.71 b</td>
<td>0.97</td>
<td>278 (306) a</td>
<td>7</td>
</tr>
</tbody>
</table>

⁺⁻ Ground speed expressed as a rate at which the peanut combine covers a specified area.
⁺⁻ SE = standard error

**Loose Shelled Kernels (LSKs)**

The percentage of LSKs were not significantly affected by ground speed, as shown in Table 39 (F₃,₅₉=1.2862, p=0.2880). LSKs did generally decrease as a function of ground speed. The relationship was approximately linear (R²=0.81); for every 1 km hr⁻¹ increase in ground speed, there was a decrease of 1.70% in LSKs (2.73% decrease per each 1 mi hr⁻¹ increase in speed). This overall ‘trend’ was also seen in the
Virginia Study, Low PTO Speed (Table 25) and Runner Study (wet), Design PTO Speed (Table 35) tests.

Foreign Material (FM)

The percentage of FM was significantly affected by ground speed, as shown in Table 39 ($F_{3,59}=2.0468$, $p=0.1177$). For this speed range test, the relationship between LSKs and FM did not occur at all the ground speeds tested. Although the trend was not well-defined, the relationship between FM and ground speed appeared to be parabolic, with the highest FM occurring at a medium ground speed. This study shows the same overall ‘trend’ that was also seen in the Virginia Study, Low PTO Speed (Table 25) and Runner Study (wet), Design PTO Speed (Table 35) tests. Even at the lowest average of FM in this study, a deduction of $3.6\ tonne^{-1}$ ($4.0\ ton^{-1}$) would be taken from the load of stock peanuts.

Loan Rate

Peanut loan rate was not significantly affected by combine ground speed settings Table 39 ($F_{3,59}=0.9755$, $p=0.4108$). The relationship between loan rate and ground speed was not linear ($R^2=0.12$). There was a negative relationship with loan rate as a function of % LSKs ($R^2=0.52$) and a strong negative relationship between loan rate and %FM ($R^2=0.80$). Increased loan rate proved to be associated with fewer LSKs and FM. Overall, peanut loan rate increased slightly as a function of ground speed.

Low PTO Speed

The treatments that were used and analyzed for the Low PTO Speed grouping were treatments 1-4 from Table 24. These treatments had the lowest PTO speed setting of
90% design rotational speed, had a ground speed range of 1.6-4.0 km hr\(^{-1}\) (1.0- 2.5 mi hr\(^{-1}\)), and a constant header speed, as related to ground speed, of 100%.

Average yield for this PTO speed setting was found to be approximately 10,227 kg ha\(^{-1}\) (3,511 lb ac\(^{-1}\)) with an estimated acreage value of $1,473 ha\(^{-1}\) ($596 ac\(^{-1}\)) Results showing the effects of PTO speed for the Runner Study (dry), Low PTO Speed are provided in Table 40.

Table 40. Measured effects of ground speed for Runner Study (dry), Low PTO Speed (90% PTO speed). Uses treatments 1 through 4 from Table 17. Means with different letters are significantly different (student’s t test, \(p < 0.05\)).

<table>
<thead>
<tr>
<th>Ground Speed(^{[a]}) km hr(^{-1}) (mi hr(^{-1}))</th>
<th>n</th>
<th>LSK % Mean</th>
<th>SE</th>
<th>FM % Mean</th>
<th>SE</th>
<th>Loan Rate $ tonne(^{-1}) ($ ton(^{-1})) Mean</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.6 (1.0)</td>
<td>5</td>
<td>13.52 a</td>
<td>2.16</td>
<td>7.37 a</td>
<td>1.99</td>
<td>273 (301) a</td>
<td>14</td>
</tr>
<tr>
<td>2.4 (1.5)</td>
<td>5</td>
<td>10.68 a</td>
<td>2.16</td>
<td>7.04 a</td>
<td>1.99</td>
<td>279 (307) a</td>
<td>14</td>
</tr>
<tr>
<td>3.2 (2.0)</td>
<td>5</td>
<td>10.26 a</td>
<td>2.16</td>
<td>11.33 a</td>
<td>1.99</td>
<td>267 (294) a</td>
<td>14</td>
</tr>
<tr>
<td>4.0 (2.5)</td>
<td>5</td>
<td>9.05 a</td>
<td>2.16</td>
<td>6.99 a</td>
<td>1.99</td>
<td>287 (316) a</td>
<td>14</td>
</tr>
</tbody>
</table>

\(^{[a]}\) Ground speed expressed as a rate at which the peanut combine covers a specified area.

\(^{[b]}\) SE = standard error

**Loose Shelled Kernels (LSKs)**

The percentage of LSKs were not significantly affected by ground speed settings, as shown in Table 40 (\(F_{3,19}=0.7677, p=0.5287\)). At the highest ground speed of 4.0 km hr\(^{-1}\) (2.5 mi hr\(^{-1}\)) there was a decreased amount of LSKs reported. The relationship between LSKs and ground speed was approximately linear (\(R^2=0.89\)); for every 1 km hr\(^{-1}\) increase in ground speed, there was a decrease of 1.72% in LSKs (2.77% per each 1 mi hr\(^{-1}\) increase in speed). Overall, an argument may be had that higher ground speeds are the optimum ground speed for the decreased LSKs, but more testing would need to be done to prove that theory, due to the lack of significance.
**Foreign Material (FM)**

The percentage of FM was not significantly affected by ground speed, as shown in Table 40 ($F_{3,19}=1.1212, p=0.3699$). The relationship between FM and ground speed in this grouping was parabolic, with the highest FM occurring at a medium ground speed. For this speed range test, the relationship between LSKs and FM did not occur. This study showed the same overall ‘trend’ that was also seen in the *Virginia Study, Low PTO Speed* (Table 25), *Runner Study (wet) Design PTO Speed* (Table 35), and *Runner Study (dry) All PTO Speeds* (Table 39) tests, which could prove that this trend is a viable result. Even at the lowest average of FM in this study, a deduction of $2.7 \text{ tonne}^{-1} (\$3.0 \text{ ton}^{-1})$ would be taken from the load of stock peanuts.

**Loan Rate**

Peanut loan rate was not significantly affected by combine ground speed settings, as shown in Table 40 ($F_{3,19}=0.4946, p=0.6911$). These data show that the relationship between loan rate and ground speed was parabolic, with the lowest loan rate occurring at a medium ground speed. Overall, peanut loan rates were relatively constant, other than the value for 3.2 km hr$^{-1}$ (2.0 mi hr$^{-1}$). The relationship between loan rate and ground speed was not linear ($R^2=0.20$). There was a negative relationship with loan rate as a function of %FM ($R^2=0.63$). Increased loan rate proved to be associated with fewer FM. Overall, peanut loan rate increased as a function of ground speed.

**Design PTO Speed**

The treatments that were used and analyzed for the *Design PTO Speed* grouping were treatments 5-8 and 13-15 from Table 24. These treatments had the design PTO
speed setting of 100% design rotational speed, had a ground speed range of
1.6- 4.8 km hr\(^{-1}\) (1.0-3.0 mi hr\(^{-1}\)), and a constant header speed, as related to ground speed,
of 100%. Average yield for this PTO speed setting was found to be approximately
3,367 kg ha\(^{-1}\) (3,004 lb ac\(^{-1}\)) with an estimated acreage value of $1,283 ha\(^{-1}\) ($519 ac\(^{-1}\)).
As the test was executed, the sample size for the 4.8 km hr\(^{-1}\) (3.0 mi hr\(^{-1}\)) treatment was
larger than for the other speeds. Results showing the effects of PTO speed for the *Runner
Study (dry)*, *Design PTO Speed* are provided in Table 41.

**Table 41.** Measured effects of ground speed for *Runner Study (dry)*, *Design PTO Speed* (100% PTO
speed). Uses treatments 5-8 and 13-15 from Table 24. Means with different letters are significantly
different (student’s t test, \(p < 0.05\)).

<table>
<thead>
<tr>
<th>Ground Speed(\text{[a]}) km hr(^{-1}) (mi hr(^{-1}))</th>
<th>n(\text{[b]})</th>
<th>LSK %</th>
<th>FM %</th>
<th>Loan Rate $ tonne(^{-1}) ($ ton(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.6 (1.0)</td>
<td>5</td>
<td>15.92 a</td>
<td>1.76</td>
<td>7.89 a</td>
</tr>
<tr>
<td>2.4 (1.5)</td>
<td>5</td>
<td>14.59 ab</td>
<td>1.76</td>
<td>7.85 a</td>
</tr>
<tr>
<td>3.2 (2.0)</td>
<td>5</td>
<td>12.72 abc</td>
<td>1.76</td>
<td>7.32 a</td>
</tr>
<tr>
<td>4.0 (2.5)</td>
<td>5</td>
<td>10.63 bc</td>
<td>1.76</td>
<td>7.52 a</td>
</tr>
<tr>
<td>4.8 (3.0)</td>
<td>15</td>
<td>9.38 c</td>
<td>1.02</td>
<td>7.73 a</td>
</tr>
</tbody>
</table>

\(\text{[a]}\) Ground speed expressed as a rate at which the peanut combine covers a specified area.

\(\text{[b]}\) Sample size more due to 3 replicate treatments at 100% PTO speed; \(n=15\) for 4.8 km hr\(^{-1}\) (3.0 mi hr\(^{-1}\)).

\(\text{[c]}\) SE = standard error

**Loose Shelled Kernels (LSKs)**

The percentage of LSKs were significantly affected by ground speed settings, as
shown in Table 41 (\(F_{4,34}=3.5857, p=0.0167\)). These data show that the highest ground
speed of 4.8 km hr\(^{-1}\) (3.0 mi hr\(^{-1}\)) there was a decreased amount of LSKs reported. The
relationship was approximately linear for LSKs (\(R^2=0.99\)); for every 1 km hr\(^{-1}\) increase in
ground speed, there was a decrease of 2.12% in LSKs (3.41% per each 1 mi hr⁻¹ increase in speed).

Foreign Material (FM)

The percentage of FM was not significantly affected by ground speed, as shown in Table 41 (F₄,₃₄=0.0572, p=0.9936) For this speed range test, the relationship between LSKs and FM did not occur, overall. This study shows a similar overall ‘trend’ that was seen in the Virginia Study Low PTO Speed (Table 25); Runner Study (wet) All and High PTO Speed (Table 31 and Table 37). Overall, an argument may be had that this ground speed was the optimum ground speed for the decreased FM. Even at the lowest average of FM in this study, a deduction of $2.7 tonne⁻¹ ($3.0 ton⁻¹) would be taken from the load of stock peanuts.

Loan Rate

Peanut loan rate was not significantly affected by combine ground speed settings in Table 41 (F₃,₃₄=0.3862, p=0.8168). The relationship between loan rate and ground speed was approximately linear (R²=0.77); for every 1 km hr⁻¹ increase in ground speed, there was an increase of $2.5 tonne⁻¹ in loan rate value ($2.8 ton⁻¹ decrease per each 1 mi hr⁻¹ increase in speed). There was a strong negative relationship with loan rate as a function of % LSKs (R²=0.76). Increased loan rate proved to be associated with fewer LSKs. Overall, peanut loan rate increased as a function of ground speed.

High PTO Speed

The treatments that were used and analyzed for the High PTO Speed grouping were treatments 9-12 from Table 24. These treatments had the highest PTO speed setting
of 110% rotational speed, had a ground speed range of 1.6-4.0 km hr\(^{-1}\) (1.0-2.5 mi hr\(^{-1}\)),
and a constant header speed, as related to ground speed, of 100%. Average yield for this
PTO speed setting was found to be approximately 2,986 kg ha\(^{-1}\) (2,664 lb ac\(^{-1}\)) with an
estimated acreage value of $1,145 ha\(^{-1}\) ($463 ac\(^{-1}\)). Results showing the effects of PTO
speed for the *Runner Study (dry)*, *High PTO Speed* are provided in Table 42.

Table 42. Measured effects of ground speed for the *Runner Study (dry)*, *High PTO Speed* (110%
PTO speed). Uses treatments 9 through 12 from Table 17. Means with different letters are
significantly different (student’s t test, \(p < 0.05\)).

<table>
<thead>
<tr>
<th>Ground Speed ((\text{km hr}^{-1}))</th>
<th>LSK %</th>
<th>FM %</th>
<th>Loan Rate (\text{S tonne}^{-1}) ((\text{S ton}^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SE</td>
<td>Mean</td>
</tr>
<tr>
<td>1.6 (1.0)</td>
<td>18.89a</td>
<td>3.75</td>
<td>9.80a</td>
</tr>
<tr>
<td>2.4 (1.5)</td>
<td>17.69a</td>
<td>3.75</td>
<td>7.91a</td>
</tr>
<tr>
<td>3.2 (2.0)</td>
<td>21.13a</td>
<td>3.75</td>
<td>13.09a</td>
</tr>
<tr>
<td>4.0 (2.5)</td>
<td>14.6a</td>
<td>3.75</td>
<td>8.61a</td>
</tr>
</tbody>
</table>

\(^{[a]}\) Ground speed expressed as a rate at which the peanut combine covers a specified area.

\(^{[b]}\) SE = standard error

**Loose Shelled Kernels (LSKs)**

The percentage of LSKs were not significantly affected by ground speed, as shown in Table 42 (\(F_{3,19}=0.5266, p=0.6703\)). These data, though not significant, show that at the ground speed of 4.0 km hr\(^{-1}\) (2.5 mi hr\(^{-1}\)) percent LSKs were lowest. The
relationship between mean LSKs and ground speed was shown to not be linear (\(R^2=0.20\))
and there was no apparent relationship between LSK and ground speed. This ‘trend’ was
also seen in the *Virginia Study, Low PTO Speed* (Table 25) and *Runner Study (wet), All*
and *High PTO Speed* (Table 31 and Table 37) tests, which could prove that this trend is a
viable result.
**Foreign Material (FM)**

The percentage of was not significantly affected by ground speed, as shown in Table 42 ($F_{3,19}=1.4396, p=0.2683$). There was no apparent trend in the relationship between FM and ground speed for this grouping. This ‘trend’ was also seen in the *Virginia Study Low PTO Speed* (Table 25) and *Runner Study (wet) All and High PTO Speed* (Table 31 and Table 37) tests. For this speed range test, a positive relationship between LSKs and FM did occur ($R^2=0.63$). Even at the lowest average of FM in this study, a deduction of $3.6$ tonne$^{-1}$ ($4.0$ ton$^{-1}$) would be taken from the load of stock peanuts.

**Loan Rate**

Peanut loan rate was not significantly affected by combine ground speed settings shown in Table 42 ($F_{3,19}=0.9216, p=0.4528$). The relationship between loan rate and ground speed was not linear ($R^2=0.0053$). There was a strong negative relationship with loan rate as a function of % LSKs ($R^2=0.83$) and %FM ($R^2=0.94$). Increased loan rate proved to be associated with fewer LSKs and FM. Overall, peanut loan rate increased slightly as a function of ground speed.

**Effect of Header Speed: Virginia Study**

In 2018, research was conducted on virginia type peanuts, for the purposes of this paper it will be known as the *Virginia Study*, to determine the effects of header speed on several factors: including material throughput, header losses, and peanut loan rate. To better understand the effects of header speed, the *Virginia Study* was split into four different ground speed categories: *All Ground Speeds, Low Ground Speed, Medium*
Ground Speed, and High Ground Speed. These four categories were determined by dividing all the tested ground speeds into separate groups based on the ground speeds that were tested. Dividing them into these groups proved to be the best way to understand the collected data under differing throughput on the combine. The treatments that were used and analyzed for the Virginia Study were from Table 22. The All Ground Speed Range grouping consisted of all data for all the ground speeds tested ranging from 0.8-2.3 km hr\(^{-1}\) (0.5-1.4 mi hr\(^{-1}\)), treatments 1-20. The Low Ground Speed Range grouping consisted of the lowest ground speeds tested ranging from 0.8-1.3 km hr\(^{-1}\) (0.5-0.8 mi hr\(^{-1}\)), treatments 1-10. The Medium Ground Speed Range grouping consisted of the medium ground speeds tested ranging from 1.3-1.8 km hr\(^{-1}\) (0.8-1.1 mi hr\(^{-1}\)), treatments 6-15. The High Ground Speed Range grouping consisted of the highest ground speeds tested ranging from 1.8-2.4 km hr\(^{-1}\) (1.1-1.4 mi hr\(^{-1}\)), treatments 11-20. Results are presented in Table 43 through Table 46, with one table for each ground speed range.

All Ground Speeds Range

The treatments that were used and analyzed for the All Ground Speeds Range were treatments 1-20 from Table 22. These treatments consisted of the ground speed range of 0.8-2.3 km hr\(^{-1}\) (0.5-1.4 mi hr\(^{-1}\)), had a PTO speed of 100%, and had header speeds, as related to ground speed, of 70-130%. The average throughput for this range was approximately 7,190 kg hr\(^{-1}\) (15,852 lb hr\(^{-1}\)). Average yield for this ground speed range was found to be approximately 9,252 kg ha\(^{-1}\) (8,254 lb ac\(^{-1}\)) with an estimated acreage value of $3,831 ha\(^{-1}\) ($1,550 ac\(^{-1}\)). Results showing the effects of header speed for the Virginia Study, All Ground Speeds Range are provided in Table 43.
Table 43. Measured effects of header speed for Virginia Study, All Ground Speeds Range (0.8-2.3 km hr⁻¹). Uses treatments 1 through 20 from Table 22. Means with different letters are significantly different (student’s t test, p < 0.05).

<table>
<thead>
<tr>
<th>Header Speed %</th>
<th>n</th>
<th>Header Losses kg ha⁻¹ (lb ac⁻¹)</th>
<th>SE [b]</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>9</td>
<td>105 (94) a</td>
<td>12.32</td>
</tr>
<tr>
<td>85</td>
<td>12</td>
<td>95 (85) ab</td>
<td>10.67</td>
</tr>
<tr>
<td>100</td>
<td>13</td>
<td>58 (52) c</td>
<td>10.25</td>
</tr>
<tr>
<td>115</td>
<td>17</td>
<td>69 (61) bc</td>
<td>8.96</td>
</tr>
<tr>
<td>130</td>
<td>16</td>
<td>62 (56) c</td>
<td>9.24</td>
</tr>
</tbody>
</table>

[a] Header speed expressed as a percentage of ground speed, measured at 7.0 cm from tip of header teeth.
[b] SE = standard error
[c] Expressed as percentage of recovered yield

Header losses were significantly affected by header speed settings as shown in Table 43 (F₄,₆₆=2.8673, p=0.0303). These data show a generally significant decrease in header losses as header speed increased, with a marginally linear relationship for mean header losses (R²=0.71). This shows that over all the ground speeds tested, matching and ‘leading’ the header speed to ground speed provided the least amount of yield losses, and that the two higher header speeds resulted in numerically higher header losses, but the differences for these three treatments were insignificant. The decrease in header losses at these higher header speeds as they relate to ground speed may be a result of finding the proper feed rate of material at the header in relation to ground speed. Though the findings of this test were not significant, they could prove to be significant in varying field conditions.

Low Ground Speed Range

The treatments that were used and analyzed for the Low Ground Speed Range grouping were treatments 1-10 from Table 22. These treatments consisted of the ground
speed range of 0.8-1.3 km hr\(^{-1}\) (0.5-0.8 mi hr\(^{-1}\)), a PTO speed setting of 100\%, and header speeds, as related to ground speed, of 70-130\%. The average throughput for this range was approximately 4,990 kg hr\(^{-1}\) (11,001 lb hr\(^{-1}\)). Average yield for this ground speed range was found to be approximately 9,009 kg ha\(^{-1}\) (8,037 lb ac\(^{-1}\)) with an estimated acreage value of $3,775 ha\(^{-1}\) ($1,528 ac\(^{-1}\)). Results showing the effects of header speed for the *Virginia Study, Low Ground Speed Range* are provided in Table 44.

Table 44. Measured effects of header speed for the *Virginia Study, Low Ground Speed Range* (0.8-1.3 km hr\(^{-1}\)). Uses treatments 1 through 10 from Table 22. Means with different letters are significantly different (student’s t test, p < 0.05).

<table>
<thead>
<tr>
<th>Header Speed(^{[a]}) %</th>
<th>n</th>
<th>Header Losses kg ha(^{-1}) (lb ac(^{-1}))</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>5</td>
<td>60 (53) ab</td>
<td>13</td>
</tr>
<tr>
<td>85</td>
<td>5</td>
<td>98 (87) a</td>
<td>13</td>
</tr>
<tr>
<td>100</td>
<td>9</td>
<td>52 (46) b</td>
<td>10</td>
</tr>
<tr>
<td>115</td>
<td>9</td>
<td>73 (65) ab</td>
<td>10</td>
</tr>
<tr>
<td>130</td>
<td>9</td>
<td>71 (63) ab</td>
<td>10</td>
</tr>
</tbody>
</table>

\(^{[a]}\) Header speed expressed as a percentage of ground speed, measured at 7.0 cm from tip of header teeth.

\(^{[b]}\) SE = standard error

\(^{[c]}\) Expressed as percentage of recovered yield.

Header losses were significantly affected by header speed settings as shown in Table 44 (F\(_{4,36}=1.6649\), p=0.1824). These data show a minimal amount of header losses at 100% header speed; an increased amount of header losses was measured for all other header speeds, although the increase was only significant for one comparison, the 85% header speed. This trend was observed in the *Virginia Study, All Ground Speeds Range* test (Table 43). The data also shows that increased or ‘leading’ header speed is also not significantly different from matching header speed to ground speed and would also be effective of decreasing yield losses at the header.
Medium Ground Speed Range

The treatments that were used and analyzed for the Medium Ground Speed Range were treatments 6-15 from Table 22. These treatments consisted of the ground speed range of 1.3-1.8 km hr⁻¹ (0.8-1.1 mi hr⁻¹), a PTO speed setting of 100%, and header speeds, as related to ground speed, of 70-130%. The average throughput for this range was approximately 4,990 kg hr⁻¹ (11,001 lb hr⁻¹). Average yield for this ground speed range was found to be approximately 9,915 kg ha⁻¹ (8,400 lb ac⁻¹) with an estimated acreage value of $3,862 ha⁻¹ ($1,563 ac⁻¹). Results showing the effects of header speed for the Virginia Study, Medium Ground Speed Range are provided in Table 45.

Table 45. Measured effects of header speed for the Virginia Study, Medium Ground Speed Range (1.3-1.8 km hr⁻¹). Uses treatments 6 through 15 from Table 22. Means with different letters are significantly different (student’s t test, p < 0.05).

<table>
<thead>
<tr>
<th>Header Speed[a]</th>
<th>n</th>
<th>Header Losses kg ha⁻¹ (lb ac⁻¹)</th>
<th>SE[b]</th>
</tr>
</thead>
<tbody>
<tr>
<td>70 4</td>
<td></td>
<td>98 (88) a</td>
<td>18</td>
</tr>
<tr>
<td>85 7</td>
<td></td>
<td>83 (74) a</td>
<td>14</td>
</tr>
<tr>
<td>100 6</td>
<td></td>
<td>74 (66) a</td>
<td>15</td>
</tr>
<tr>
<td>115 9</td>
<td></td>
<td>74 (66) a</td>
<td>12</td>
</tr>
<tr>
<td>130 9</td>
<td></td>
<td>57 (51) a</td>
<td>12</td>
</tr>
</tbody>
</table>

[a] Header speed expressed as a percentage of ground speed, measured at 7.0 cm from tip of header teeth.
[b] SE = standard error
[c] Expressed as percentage of recovered yield.

Header losses were not significantly affected by header speed settings in Table 45 (F₄,₃₄=0.8973, p=0.4778). These data, though not significant, show a decreasing amount of header losses as header speed increased. This relationship was approximately linear (R²=0.93); for every 15% increase in header speed, there was a decrease of approximately 9 kg ha⁻¹ (8 lb ac⁻¹). The decrease in header losses at these higher header
speeds as they relate to ground speed may be a result of finding the proper feed rate of material at the header in relation to ground speed.

**High Ground Speed Range**

The treatments that were used and analyzed for the *High Ground Speed Range* were treatments 11-20 from Table 22. These treatments consisted of the ground speed range of 1.8-2.3 km hr⁻¹ (1.1-1.4 mi hr⁻¹), a PTO speed setting of 100%, and had header speeds, as related to ground speed, of 70-130%. The average throughput for this range was approximately 9,954 kg hr⁻¹ (21,944 lb hr⁻¹). Average yield for this ground speed range was found to be approximately 9,519 kg ha⁻¹ (8,493 lb ac⁻¹) with an estimated acreage value of $3,892 ha⁻¹ ($1,575 ac⁻¹). Results showing the effects of PTO speed for the *Virginia Study, High Ground Speed Range* are provided in Table 46.

<table>
<thead>
<tr>
<th>Header Speed [%]</th>
<th>n</th>
<th>Header Losses [kg ha⁻¹ (lb ac⁻¹)]</th>
<th>SE [b]</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>4</td>
<td>162 (144) a</td>
<td>19</td>
</tr>
<tr>
<td>85</td>
<td>7</td>
<td>93 (83) b</td>
<td>14</td>
</tr>
<tr>
<td>100</td>
<td>4</td>
<td>73 (65) b</td>
<td>19</td>
</tr>
<tr>
<td>115</td>
<td>8</td>
<td>64 (57) b</td>
<td>13</td>
</tr>
<tr>
<td>130</td>
<td>7</td>
<td>52 (46) b</td>
<td>14</td>
</tr>
</tbody>
</table>

[a] Header speed expressed as a percentage of ground speed, measured at 7.0 cm from tip of header teeth.
[b] SE = standard error
[c] Expressed as percentage of recovered yield.

Header losses were significantly affected by header speed settings as shown in Table 46 (F₄,₂₉=5.0636, p=0.0040). These data show decreasing header losses at increasing header speeds. The relationship for header losses was approximately linear.
(R²=0.82); for every 15% increase in header speed, there was a decrease of approximately 22 kg ha⁻¹ (25 lb ac⁻¹). The decrease in header losses at these higher header speeds as they relate to ground speed may be a result of finding the proper feed rate of material at the header in relation to ground speed. This trend was found for the Medium Ground Speed Range test (Table 45).

**Effect of Header Speed: Runner Study (wet)**

In the Runner Study (wet) test treatments were included to determine the effects of header speed on header losses. The experimental design in the Runner Study placed less focus on header speeds and more focus on other factors, so groupings of ground speed showing effects of header speed were not tested. The treatments that were used and analyzed for the Runner Study (wet) were from Table 23. The test group consisted of a constant ground speed of 2.0 km hr⁻¹ (1.25 mi hr⁻¹), treatments 7, and 13-15. Header speeds ranged from 70-130%. Average yield for this ground speed range was found to be approximately 2,962 kg ha⁻¹ (2,643 lb ac⁻¹) with an estimated acreage value of $1,059 ha⁻¹ ($429 ac⁻¹). Results showing the effects of header speed for the Runner Study (wet) are provided in Table 47.
Table 47. Measured effects of header speed for the Runner Study (wet) (2.0 km hr⁻¹ ground speeds). Uses treatments 7, 13, 14, and 15 from Table 23. Means with different letters are significantly different (student’s t test, p < 0.05).

<table>
<thead>
<tr>
<th>Header Speedᵃ</th>
<th>n</th>
<th>Header Losses</th>
<th>SEᵇ</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td></td>
<td>kg ha⁻¹ (lb ac⁻¹)</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>3</td>
<td>18 (16) a</td>
<td>6</td>
</tr>
<tr>
<td>100</td>
<td>4</td>
<td>20 (18) a</td>
<td>5</td>
</tr>
<tr>
<td>115</td>
<td>4</td>
<td>13 (12) a</td>
<td>5</td>
</tr>
<tr>
<td>130</td>
<td>4</td>
<td>17 (15) a</td>
<td>5</td>
</tr>
</tbody>
</table>

ᵃ Header speed expressed as a percentage of ground speed, measured at 7.0 cm from tip of header teeth.
ᵇ SE = standard error
ᶜ Expressed as percentage of recovered yield.

Header losses were not significantly affected by header speed settings as shown in Table 47 (F₃,₁₄=0.2589, p=0.8535). Moreover, the magnitude of header losses was so low in all treatments that it would likely be considered to be inconsequential to any peanut grower. There was no apparent trend between header losses and header speed.

**Conclusions**

In this study, the peanut combine operating parameters of ground and header speeds were varied to determine the effect on economic factors of peanut harvest (tailings losses, header losses, grade/quality, and loan rate). The following conclusions can be drawn from the results presented here.

When looking at the conclusions, keep in mind that in the 2018 harvest season, virginia type peanuts were grown, and in the 2019 season, runner type peanuts were grown. While it is expected that magnitudes may be inconsistent across years, machines, and conditions, it was hypothesized that general trends may be similar. The harvest season for the Virginia Study was not as favorable for peanut research as normal years.
Poor drying conditions resulted in a crop for this test that was not harvestable in a timely manner, which also resulted in a reduction in replications for some treatments. The harvest season for the *Runner Study* proved to be more favorable for peanut production. Further research across both runner and virginia peanut varieties should be conducted for comparison to the results here and establish a basis for repeatability. The findings from studies such as this one should promote advancements in peanut harvest technologies and increase peanut production profitability if they can be used to improve combine operator adjustments.

**Effect of Ground Speed**

*Material Throughput*

Overall, material throughput was directly related to ground speed of the combine as would be expected. Both the *Virginia Study* and *Runner Study (wet)* studies showed that material throughput consistently increased as a function of ground speed for all PTO speed groupings and they all had a linear relationship (Figure 8). Findings from the *Virginia Study*, Design PTO Speed grouping (Table 27) showed for every 1 km hr\(^{-1}\) increase in ground speed, there was an increase of 5,292 kg hr\(^{-1}\) in material throughput (18,775 lb hr\(^{-1}\) per each 1 mi hr\(^{-1}\) increase in speed). The speed range of 100% PTO speed is what Amadas Industries recommended for proper and efficient operation of their peanut combine. Findings from the *Runner Study (wet)*, Low PTO Speed grouping (Table 33) showed for every 1 km hr\(^{-1}\) increase in ground speed, there was an increase of 3,411 kg hr\(^{-1}\) in material throughput (12,103 lb hr\(^{-1}\) per each 1 mi hr\(^{-1}\) increase in speed).
Tailings Losses

Overall, tailings losses generally decreased as a function of ground speed for both the Virginia Study and Runner Study (wet) (Figure 9), although most comparisons lacked significant differences. Findings from the Virginia Study, Design PTO Speed grouping (Table 27) showed that for every 1 km hr⁻¹ increase in ground speed, there was a decrease of 44 kg ha⁻¹ in tailings losses (63 lb ac⁻¹ per each 1 mi hr⁻¹ increase in speed). Findings from the Runner Study (wet) showed that the All PTO Speeds and Design PTO Speed groupings (Table 31 and Table 35) showed similar data; for every 1 km hr⁻¹ increase in ground speed, there was a decrease of 18 kg ha⁻¹ in tailings losses (26 lb ac⁻¹ per each 1 mi hr⁻¹ increase in speed). While the treatments presented here do not compare PTO speeds but instead use them as groupings, it is apparent from the data that PTO speed tends to have a larger effect on tailings losses than ground speed and that the least amount of tailings losses generally occur at lower PTO speeds and mid to high ground speeds. Producers must use caution running equipment too slow in order to prevent overloading/plugging, which in turn would be costly in equipment repairs.
Figure 9. Summarized mean tailings losses as a function of ground speed across all PTO speed groupings in Virginia Study (a) and Runner Study (wet) (b).

Loose Shelled Kernels (LSKs)

Overall, for LSKs, the Low PTO Speed setting for all studies demonstrated the least LSKs, overall (Figure 10). These studies showed that LSKs generally decreased as ground speed increased, but there were few PTO speed groupings demonstrating significant differences; exceptions were the Virginia Study, Design PTO Speed grouping (Table 27) and the Runner Study (dry), Design PTO Speed grouping (Table 41). The Virginia Study demonstrated the greatest rate of LSK reduction as a function of ground speed for the Design PTO Speed grouping (Table 27); for every 1 km hr\(^{-1}\) increase in ground speed, there was a decrease of 2.87% in percent LSKs (4.6% per each 1 mi hr\(^{-1}\) increase in speed). For the Runner Study (wet) test, the data suggested that there may be a ground speed at which LSKs are minimized. This ground speed normally ranged from 1.6-2.0 km hr\(^{-1}\) (1.0-1.25 mi hr\(^{-1}\)). While there was a consistent trend, due to the lack of significant differences here more testing should be conducted to determine if this is the case. For the Runner Study (dry) test, the greatest rate of change in LSKs as a function of speed occurred in the Design PTO Speed grouping (Table 41); for every 1 km hr\(^{-1}\)
increase in ground speed, there was a decrease of 2.12% in LSKs (3.41% per each 1 mi hr⁻¹ increase in speed).

The speed range of 100% PTO speed is what Amadas Industries recommended for proper and efficient operation of their peanut combine. The increase of LSKs at slower PTO speeds for the Design PTO Speed Range may indicate that combine harvest efficiency increases as a function of increased ground speed at the 100% PTO speed setting. Increasing of ground speed may cause vines and peanuts to move effectively through the combine, as intended. Lowest overall LSKs were seen at the Low PTO Speed Range.

Figure 10. Summarized LSKs as a function of ground speed across all PTO speed groupings for Virginia Study (a), Runner Study (wet) (b), and Runner Study (dry) (c).
Foreign Material (FM)

Overall, there were no strong and consistent relationships between FM and ground speed in either the Virginia Study or Runner Studies (Figure 11). In general, FM and LSKs are thought to be affected similarly since with an increase in LSKs there is that same increase in FM; in this report, that relationship only held true for the Virginia Study. In the Virginia Study, Design PTO Speed grouping (Table 27), the relationship was approximately linear for FM as a function of ground speed; for every 1 km hr\(^{-1}\) increase in ground speed, there was a decrease of 0.63% in FM (1.02% decrease in FM per each 1 mi hr\(^{-1}\) increase in speed). Findings for the Runner Study (wet) test were not absolutely consistent across PTO speed groupings. In the Runner Study (wet) test, a ground speed of 1.6 km hr\(^{-1}\) (1.0 mi hr\(^{-1}\)) demonstrated the least amount of FM in three out of the four PTO speed groupings tested, with increased FM at both lower and higher ground speeds. In the Runner Study (dry) test, there was a notable increase in amount of FM at the ground speed of 3.2 km hr\(^{-1}\) (2.0 mi hr\(^{-1}\)) in three out of the four groupings, but the data didn’t show any significant differences and our observations and experience do not suggest an explanation for this phenomenon.
Loan Rate & Value

Overall, peanut loan rate was found to be related to ground speed for both the *Virginia Study* (Figure 12a) and *Runner Studies* (Figure 12b & Figure 12c). Loan rate also showed to be related to grade/quality. As LSKs and FM decreased in response to increased ground speed changes, loan rate increased as a result. The increasing loan rate could have been attributed to reaching proper loading of the combine at the higher ground speeds, enabling the peanuts to flow through the combine at the designed rate. More testing needs to be conducted to understand these effects.

Peanut value per unit area was affected positively by increasing ground speed throughout the majority of the studies. The *Virginia Study* showed roughly a $52 \text{ ha}^{-1}$
increase in value for every 1 km hr\(^{-1}\) increase in ground speed ($34$ ac\(^{-1}\) decrease per each 1 mi hr\(^{-1}\) increase in speed) and the Runner Study (wet) showed an increasing trend in value as ground speed increased (Figure 13a & Figure 13b). These values show the combined effects of tailings losses and peanut loan rate on overall value based on a 2.2 tonne ha\(^{-1}\) (2.0 ton ac\(^{-1}\)) theoretical peanut yield.

![Figure 12. Summarized loan rate as a function of ground speed across all PTO speeds for the Virginia Study (a), Runner Study (wet) (b), and Runner Study (dry) (c).](image-url)
Effect of Header Speed

Overall, header losses consistently decreased as header speed increased for the Virginia Study at all ground speed groupings, with no notable trend in the Runner Study (wet) test. In the Virginia Study, the Design and High Ground Speed groupings both showed linear relationships, and the results of the High Ground Speed Range (Table 46) showed a decline of 22 kg ha⁻¹ (25 lb ac⁻¹) header losses for every 15% increase in header speed. For the All and Low Ground Speed groupings, it was found that at a 100% header speed setting, losses were minimized, though not significantly. The Runner Study (wet) test showed that header losses were minimized at the 115% header speed range, although the general header losses here were thought to be inconsequential.
Figure 14. Header losses as a function of header speed across all ground speeds for the Virginia Study test.
References


http://nationalpeanutboard.org/peanut-info/history-peanuts-peanut-butter.htm


CHAPTER 4. CONCLUSION OF THE STUDY

In these studies, the peanut combine operating parameters of PTO speed, ground speed, and header speed were varied to investigate their effects on economic factors of peanut harvest (tailings and header losses, grade/quality, and loan rate or peanut value). The following general conclusions can be drawn from the results presented here.

When evaluating the results and conclusions presented here, it is important to do so with respect to the harvest conditions for each test. While it is expected that magnitudes of effects may be inconsistent across years, machines, and conditions, it is hypothesized that general trends may be similar. The harvest season for the Virginia Study was not as favorable for peanut research as normal years. Poor drying conditions resulted in a crop for this test that was not harvestable in a timely manner, which also resulted in a reduction in replications for some comparisons. The harvest season for the Runner Study proved to be more favorable for peanut production.

For the PTO speed testing, data was collected and evaluated for both the Virginia Study and Runner Studies to determine effects on tailings losses, LSKs, FM, and loan rate due to changes in PTO speeds. These findings are consistent with those from the only known study on this subject (Wright F., 1968), which took place a half a century prior to this study. Overall, in both the Virginia Study and Runner Study (wet), tailings losses consistently increased as a function of PTO speed at all loading ranges and all loading ranges provided significant findings. For each 10% increase in PTO speed, tailings losses increased by 161 kg ha\(^{-1}\) (142 lb ac\(^{-1}\)) in the Virginia Study and tailings losses increased by 76 kg ha\(^{-1}\) (68 lb ac\(^{-1}\)) in the Runner Study (wet). Results in changes in LSKs as a
function of PTO speed from the *Virginia Study* showed no significant differences nor major trends, though both the *Runner Study (wet)* and *Runner Study (dry)* testing showed increasing LSKs as a function of PTO speed and demonstrated significant differences. For each 10% increase in PTO speed, LSKs increased by 1.83% for the *Runner Study (wet)* by 4.47% for the *Runner Study (dry)*. There were inconsistent trends and no significant differences in FM as a function of PTO speed. The *Virginia Study* showed a decreasing trend in FM as PTO speed increased and both the *Runner Study (wet)* and *Runner Study (dry)* studies showed an increasing trend in FM as PTO speed increased, but with no significance across all tests. These studies showed that for the *Virginia Study* loan rate increased as PTO speed increased, thought to have occurred since the cleaning air fan was blowing faster and able to blow lower grade material out of the rear with the tailings, making the grade appear better than it was. Moisture also may have contributed to this finding. However, the *Runner Study* tests showed a decreasing loan rate as PTO speed increased. Peanut value per unit area was affected negatively by tailings losses throughout all studies. The *Virginia Study* showed a $59 ha⁻¹ ($24 ac⁻¹) loss in profit per each 10% increase in PTO speed and the *Runner Study (wet)* showed a $68 ha⁻¹ ($28 ac⁻¹) loss in profit per each 10% increase in PTO speed. This could have been attributed to reaching proper loading of the combine at the lower PTO speeds. Producers must use caution running equipment too slow in order to prevent overloading/plugging, which in turn would be costly in equipment repairs.

For the ground speed testing, data was collected and evaluated for both the *Virginia Study* and *Runner Studies* to determine effects on material throughput, tailings
losses, LSKs, FM, and loan rate due to changes in ground speed. Material throughput was
directly related to the ground speed of the combine for both the Virginia Study and
Runner Study (wet). These studies showed that material throughput consistently increased
as a function of ground speed and all had linear relationships. Tailings losses consistently
decreased as a function of ground speed at all PTO speed groupings for both the Virginia
Study and Runner Study (wet). All PTO speed groupings showed a linear relationship
between tailings losses and ground speed for the Virginia Study, but in the Runner Study
(wet) tests only half of the PTO speed groupings demonstrated a linear relationship. In
the Virginia Study, Design PTO Speed grouping, for every 1 km hr⁻¹ increase in ground
speed, there was a decrease of 44 kg ha⁻¹ in tailings losses (63 lb ac⁻¹ decrease per each
1 mi hr⁻¹ increase in speed). The Runner Study (wet), All PTO Speeds grouping showed
that for every 1 km hr⁻¹ increase in ground speed, there was a decrease of 18 kg ha⁻¹ in
tailings losses (26 lb ac⁻¹ decrease per each 1 mi hr⁻¹ increase in speed). The Low PTO
Speed grouping for all studies generally demonstrated the least amount of LSKs. There
were only significant differences in LSKs as a function of ground speed in the Design
PTO Speed grouping for the Virginia Study and the Runner Study (dry) tests. In both of
these tests, LSKs decreased, fairly consistently, as a function of ground speed. In the
Runner Study (wet) grouping, there was a trend showing a general minimization of LSKs
as a function of ground speed at 1.6-2.0 km hr⁻¹ (1.0-1.25 mi hr⁻¹). This finding may show
a possible optimum ground speed (and therefore throughput) for reduction of LSKs, but
more testing would need to be conducted to confirm. For FM, there was a consistent
reduction in FM as a function of ground speed in the Virginia Study but no consistent
relationship between FM and ground speed in the Runner Studies. Loan rate was found to increase as ground speeds increased. The increasing loan rate could have been attributed to reaching proper loading of the combine at the higher ground speeds, enabling the peanuts to flow through the combine at the designed rate. This trend was seen throughout the Virginia and Runner Studies. Peanut value per unit area was affected positively by tailings losses throughout the majority of the studies. The Virginia Study showed roughly a $52 ha$^{-1}$ increase in value for every 1 km hr$^{-1}$ increase in ground speed ($34$ ac$^{-1}$ decrease per each 1 mi hr$^{-1}$ increase in speed) and the Runner Study (wet) showed an increasing trend in value as ground speed increased.

For the header speed testing, data was collected and evaluated for both the Virginia Study and Runner Study (wet) tests to determine effects on header losses due to changes in header speeds. In the Virginia Study, header losses consistently decreased as a function of header speed. There was a decline of 22 kg ha$^{-1}$ (25 lb ac$^{-1}$) header losses for every 15% increase in header speed. Overall, the Virginia Study showed that matching or leading the header speed to ground speed was the optimal header speed setting range. There was no meaningful trend in header loss as a function of header speed in the Runner Study (wet) test and magnitude of header losses here was consistently at a level likely inconsequential to most peanut producers. The Runner Study (wet) test showed an optimum header speed of 115% in the All Ground Speeds grouping.

Further research across both runner and virginia peanut varieties should be conducted for comparison to the results here and establish a basis for repeatability. Future research that could benefit the work presented in these findings could include and are not
limited to: lower PTO speed settings, higher ground speeds, additional moisture conditions, and changing of aggression and pneumatic conveyance/cleaning settings. The findings from studies such as this one should promote advancements in peanut harvest technologies and increase peanut production profitability if they are applied to improve combine operator adjustments.