Soybean Yield Loss Calculator Report 2022

By The Bureau for Food and Agricultural Policy (BFAP)
for
The Oilseed Advisory Committee (OAC)

May 2022

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Acknowledgement

The study was undertaken in collaboration with a study group of farmers in various production regions in South Africa. **Thank you for your invaluable support and collaboration in this process.**

Disclaimer:

Contents

1. Background

Following the successful roll-out of the Soybean Yield Loss Calculator App in 2021, the OAC proposed to conduct a repeat of this analysis during the 2022 season. During 2021, pre-harvest yield losses (due to shattering pods or fallen pods) ranged between 0 – 38kg/ha, while total harvest losses (excluding the pre-harvest loss) ranged between 45kg/ha and 358kg/ha. During the 2022 season, BFAP collaborated with the Afgri pilot initiative, where soybeans were purposefully harvested at a higher moisture content (with the aim of minimising harvest losses due to pod shattering, for example) and then to further dry the soybean grains up to specification at respective silos (Dundee and Afrikaskop). Therefore, this study aims to build on the findings from the 2021 study by examining the impact of moisture content on harvest losses more closely.

The OAC appointed BFAP to roll-out the app during the 2022 soybean harvest season with a dedicated group of farmers. This app is designed to capture georeferenced data into a database which can be used for reporting and feedback purposes. The results of the 2022 harvest season are presented in the sections below.

2. Methodology

BFAP developed and applied the methodology as is described below. The app was designed to capture farmer and harvester details on a variety of metrics that inform soybean yield losses. The type of harvester head (conventional, flexi or flex-draper[1]) was of particular interest for soybeans since the difference in technology influences the height at which plants are cut off, which is one potential source of harvest losses. Furthermore, field details such as cultivar, planting date, moisture content (at which the soybeans were being harvested), plant population and row width were also captured.

Figure 1: Sampling methodology

Sampling methodology:
A sample was taken by placing a hoop with approximately 0.5m^2 surface area in the specified location (before the harvester, behind the harvester and behind the harvester table. Please see explanation below for the selection criteria) followed by collecting all soybeans and pods in the hoop. The sample is then recorded in the app as either number of soybeans (see Equation 1) with an average weight per soybean (e.g. 0.17g per bean depending on the cultivar) or total weight of the sample in grams (see Equation 2). The app then calculated the resulting estimated harvest losses in kg/ha and R/ha. For consistency, this study only used the total weight of the samples, not the counted beans. This is further discussed in Section **Error! Reference source not found.**.

Equation 1: Number of beans

$$Y_{estimated\ loss\ (\frac{kg}{ha})} = \frac{\boldsymbol{X_{number\ of\ beans}}\ (\#) \times X_{avg\ bean\ weight\ (g)}}{1000} \times \frac{1}{X_{Area\ of\ hoop\ (ha)}}$$

[1] The flexi header follows the terrain of the ground and adjusts its height accordingly, while the conventional header is fixed. The draper header has a belt while the conventional and flexi header have an auger that carries the crop to the feeder house. A flex-draper header has both the flexi and draper header functionalities.

Equation 2: Weight of sample

$$Y_{estimated\ loss\ (\frac{kg}{ha})} = \frac{X_{total\ sample\ weight\ (g)}}{1000} \times \frac{1}{X_{Area\ of\ hoop\ (ha)}}$$

Various types of observations were taken per sample in order to determine at which stage during the harvesting process losses occur.

1. **Pre-harvest observation**: In order to determine how much loss has occurred at the pre-harvest phase as a result of shattering. Samples were taken at random locations in the un-harvested field.
2. **Harvesting observation**: Total harvest losses were estimated by taking two samples after the combine has passed. One sample was taken in the centre where the combine has passed and one to a side (either left or right; away from the wheel tracks). The average between the two samples was calculated and used to estimate the total harvest loss. This was done to account for differences in losses between where the chaff from the spreader fell and where it didn't.
3. **Table observation**: Where farmers were willing to pause the harvesting process, the combine was stopped mid-pass and reversed for a few meters in order to take two samples where only the combine header has yet passed (one in the centre of the combine and one to the side). The reason for this sampling approach was to assess and quantify yield losses at the combine header whereas the harvesting sample accounts for machine losses (for instance, as a result of varying drum speeds).

3. Results

BFAP visited 3 farmers during their respective soybean harvesting activities (see locations in Figure 2) and collected a total of 28 useable samples in 4 fields.
Pre-harvest yield losses (due to shattering pods or fallen pods) were 0kg/ha throughout the measurements taken, while total harvest losses (excluding the pre-harvest loss) ranged between 30kg/ha and 468kg/ha.
The 2022 soybean season was characterised as a challenging season with respect to the timing and the sheer amount of rainfall. High levels of rainfall throughout the main parts of the growing season were positive for yield performance, with soybeans performing particularly well in some waterlogged areas, however continued rainfall events during the harvesting season prevented farmers from entering fields and therefore slowed down the harvesting progress and forced farmers to harvest dry soybeans in some cases.
Another record harvest of 1.93 million tonnes was estimated by the Crop Estimates Committee (CEC) in their 4^{th} summer crop production forecast. According to the CEC, area under production for the 2021/22 season is estimated at an all-time high of 925 300 hectares with a projected average yield of 2.08t/ha.

It is important to note that the report draws on a study group sample with particular research outcomes in mind and is not representative of the industry at large. The objective of this study was to compare yield losses from the previous measurements during the 2021/2022 season with particular focus on determining the impact of harvesting soybeans at higher moisture content. The findings of this study have the potential to inform more specific areas of future research to reduce yield losses. Of course, the study will need to be scaled to gain additional insights into the drivers of yield loss. In this report, interpretations made regarding the correlation between harvest loss and yield, moisture content and cultivation practices are limited to the study sample. Thus, the study outcomes cannot be regarded as the industry norm and additional data, trials and research would be required to contribute to this topic.

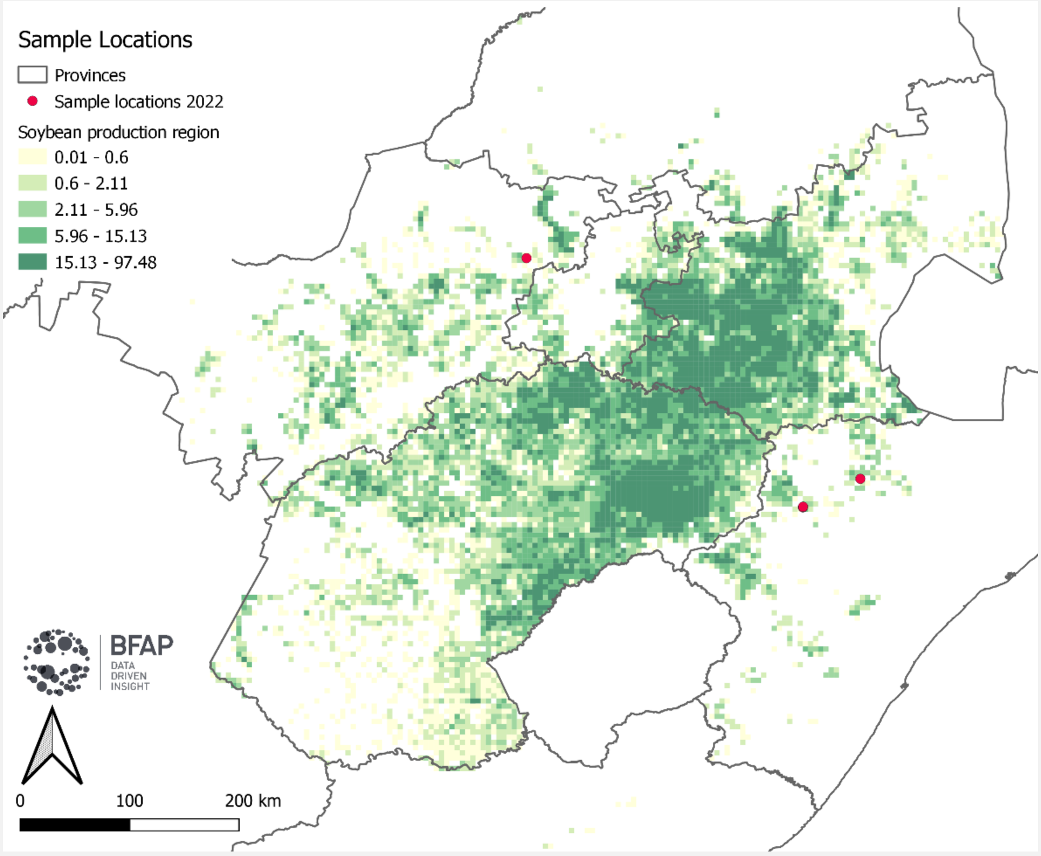

Figure 2: Mapped soybean yield loss

3.1. Yield analysis

It was expected that as yield increases, the loss would also increase, as there is more to be lost per area. However, Figure 3 states otherwise and shows that the percentage yield loss actually decreases. The bars in Figure 3 illustrate the quantity of yield loss recorded (in kg/ha) while the notes on the bars report on the estimated R/ha loss based on an average annual soybean price of R9 151.00/ton for 2022.

This “inverse correlation” supports the hypothesis that other factors are driving yield losses. Some of these potential factors are discussed in the following sections.

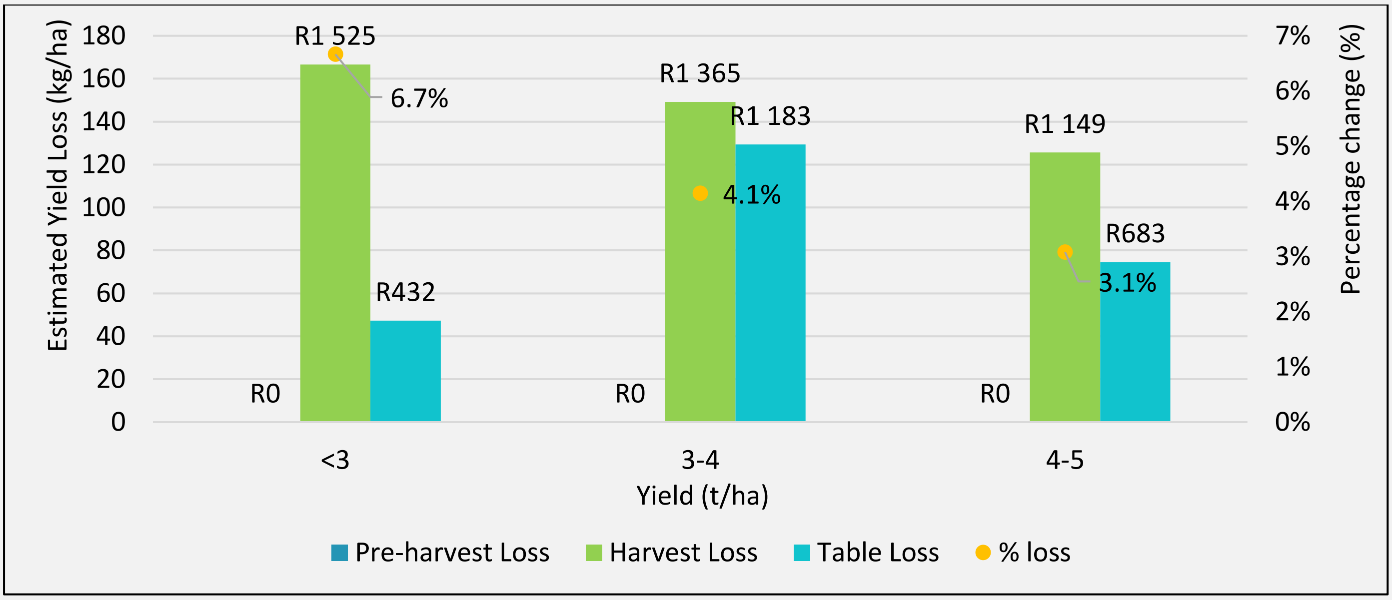

Figure 3: Average soybean yield losses at various yield levels

Figure 4 Shows that the total harvest losses per yield category are highly similar between the two years' recordings. As a percentage of total yield, harvest losses were almost identical to those of last year. The biggest observed difference is the table losses, which are significantly higher in the 2022 measurements.

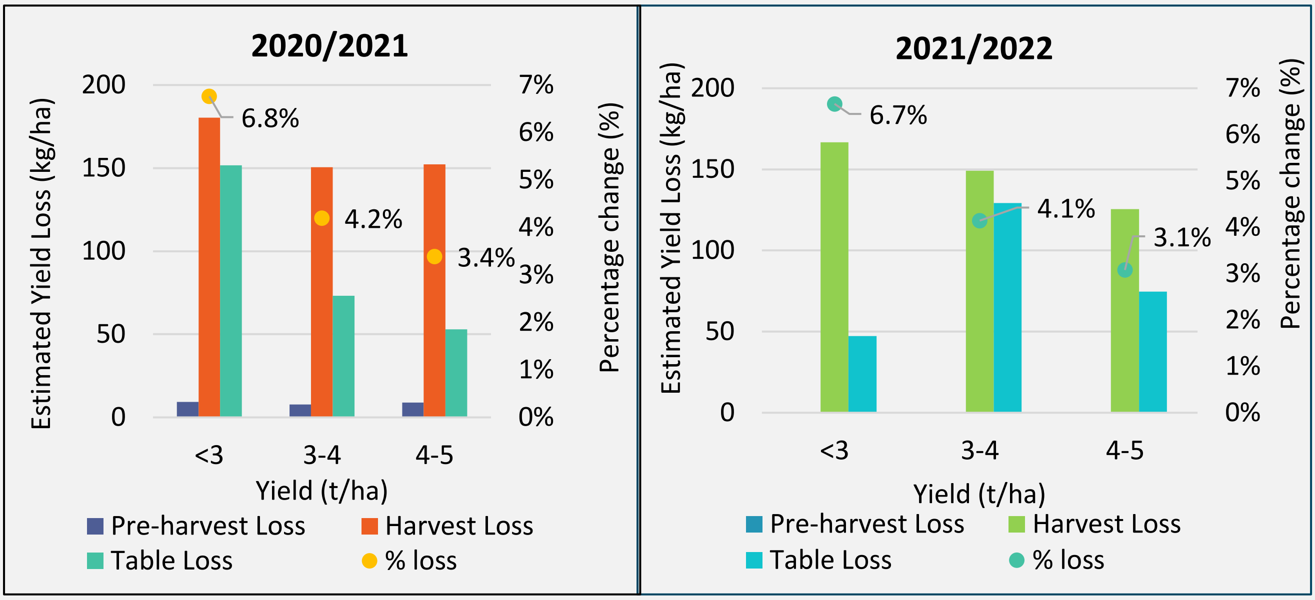

Figure 4: Comparing 2020/2021 and 2021/2022 harvest losses with respect to yield

3.2. Moisture content analysis

Average yield losses were analysed for various levels of moisture content at harvesting. Contrary to expectations, harvesting yield losses generally increased as moisture levels increase. Figure 5 shows pre-harvest losses at 0kg/ha for all moisture levels, while the total harvest losses as well as table losses were estimated to be almost double in higher moisture content observations (higher than 12%) than in the 10-12% moisture content observations.

Figure 6 shows all samples in a scatterplot; a marginal positive relationship between moisture content and total harvest losses is observed. On the other hand, an inverse trend is observed for table losses (Figure 7). From this study, the conclusions regarding harvesting at higher moisture content levels is unclear. The challenging weather circumstances might have had confounding impacts on the yield loss measurements.

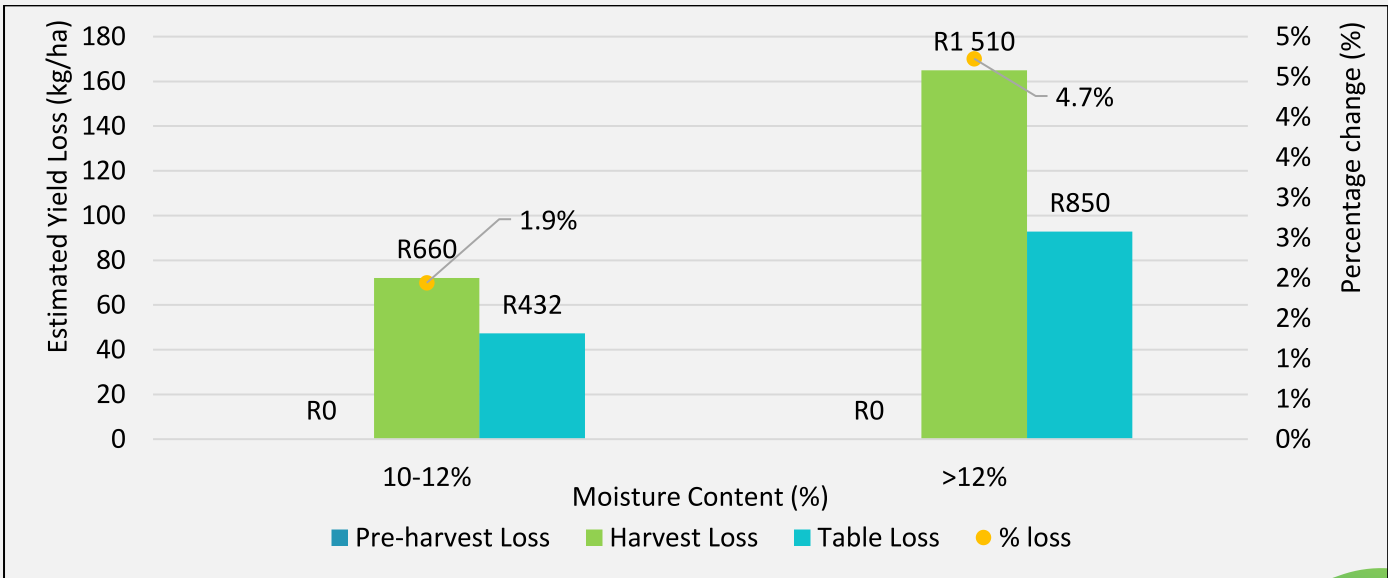

Figure 5: Average soybean yield losses at various moisture content levels

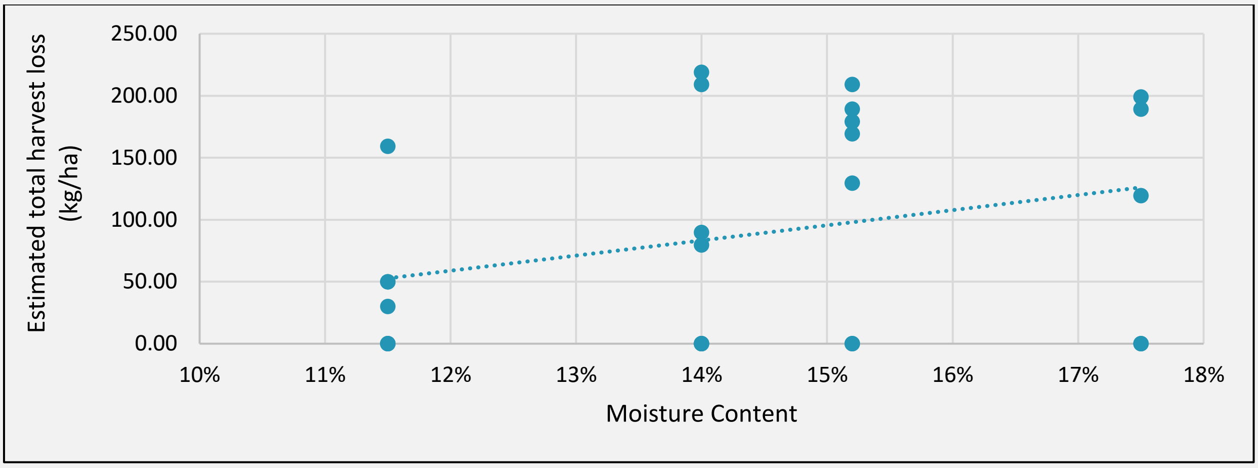

Figure 6: Estimated total soybean harvest yield loss vs. moisture content

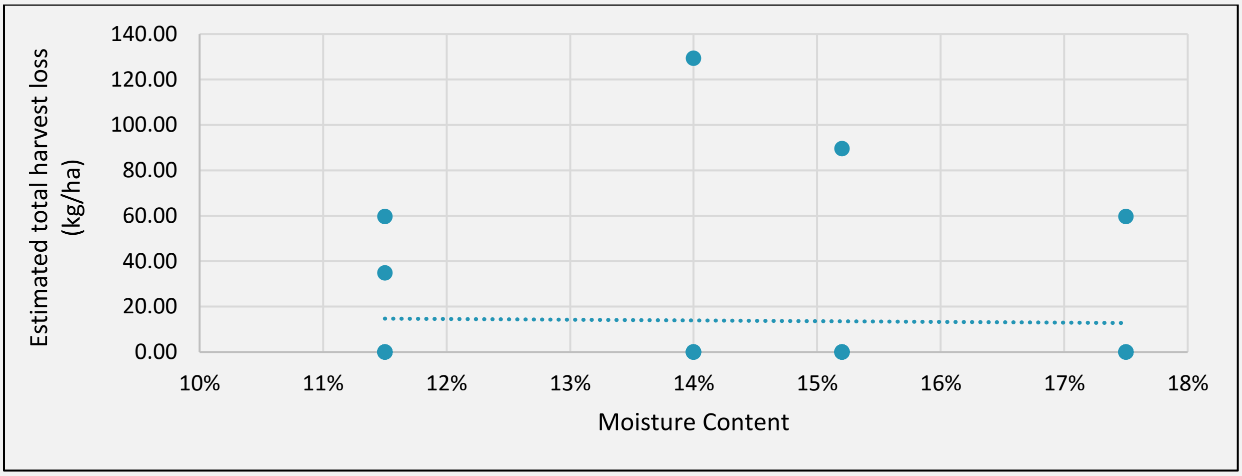

Figure 7: Estimated table soybean yield loss vs. moisture content

Figure 8 illustrates a comparison between the 2021 and 2022 results and, even though yield losses seem to be inversely correlated with respect to moisture content in the 2022 data, the magnitudes are very comparable with the bigger 2021 dataset. In fact, the 10-12% moisture level observations have recorded significantly lower losses than in 2021 with the “higher than 12%” moisture losses being quite comparable to the respective 2021 results.

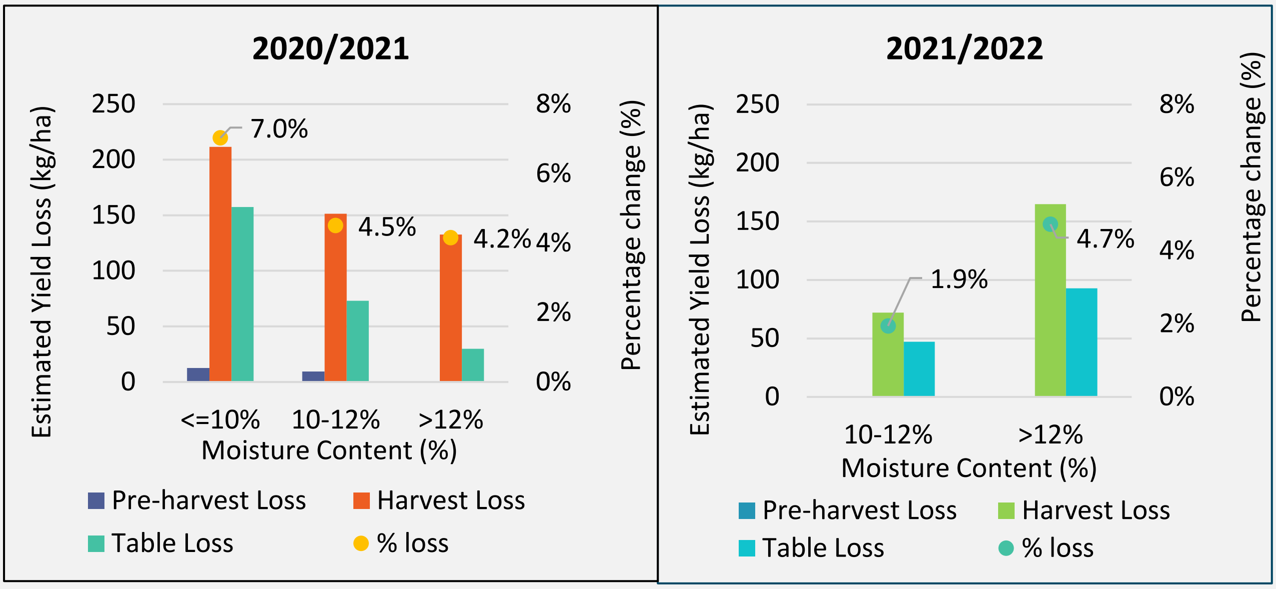

Figure 8: Comparison of 2020/2021 and 2021/2022 recordings with respect to moisture content

3.3. Equipment analysis

All harvest loss measurements taken in the 2021/2022 season were harvested with a Flexi head and therefore the analysis based on type of harvester header was not repeated, as was done in 2020/2021. The harvest losses at various harvester speeds and drum speeds, irrespective of header type, are evaluated in the analysis below.

Figure 9 and Figure 10 illustrate how the loss increases as the speed of the harvester and drum increases. From the samples taken in 2022, harvest losses as a percentage of yields decreased as harvester speed increased, while the lowest harvest losses were observed at lowest drum speed and losses remained similar at drum speeds of above 500 rotations per minute.
The comparative analysis in Figure 10 shows the 2021 results next to the 2022 results. And while varying ranges of harvester speeds were used during data analysis, the combined data does not agree on whether higher harvester speeds are preferable (highest losses recorded in 2021 at high speeds while lowest losses recorded in 2022). It is clear however, that losses were overall lower as a percentage of yield in 2022.

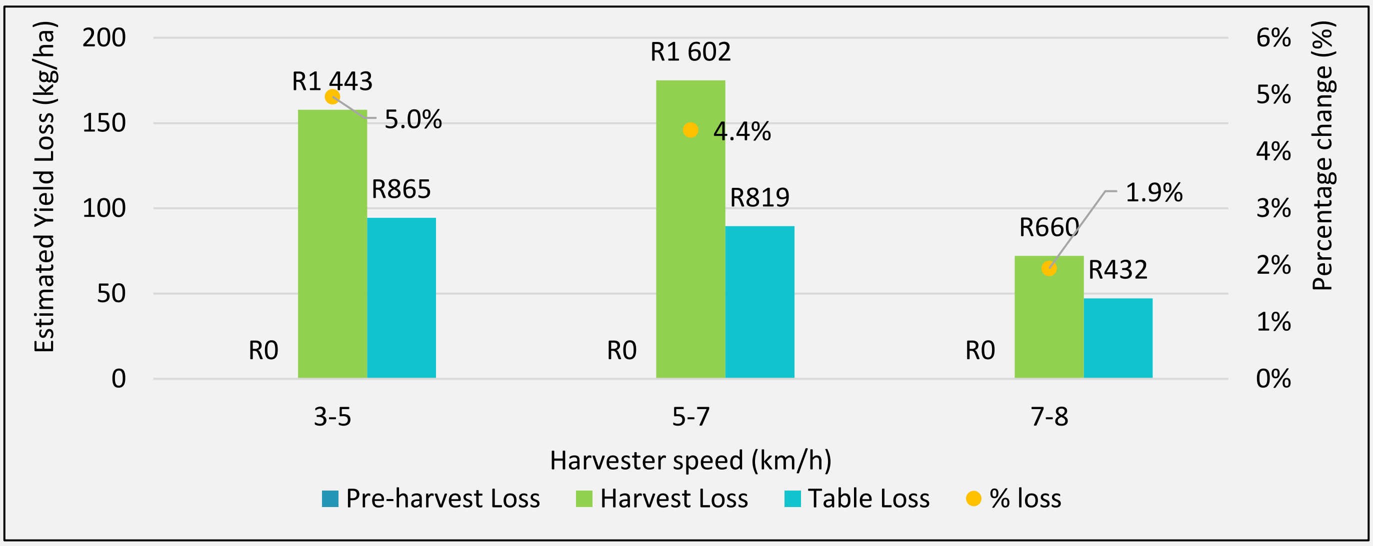

Figure 9: Average yield losses for various speed ranges

The comparative analysis on drum speed in Figure 12 seems to suggest that highest yield losses are recorded at drum speeds between 500 and 600 rotations per minute, with lower losses at either lower or higher drum speeds.

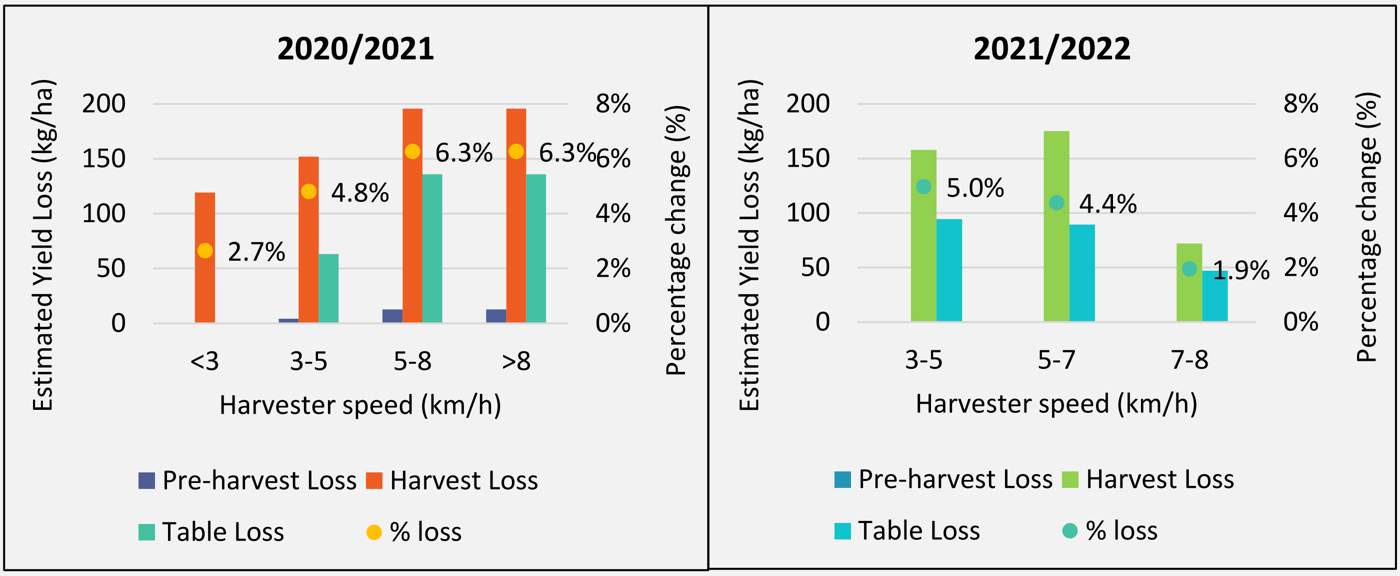

Figure 11: Comparing 2021 with 2022 yield losses for various harvester speeds

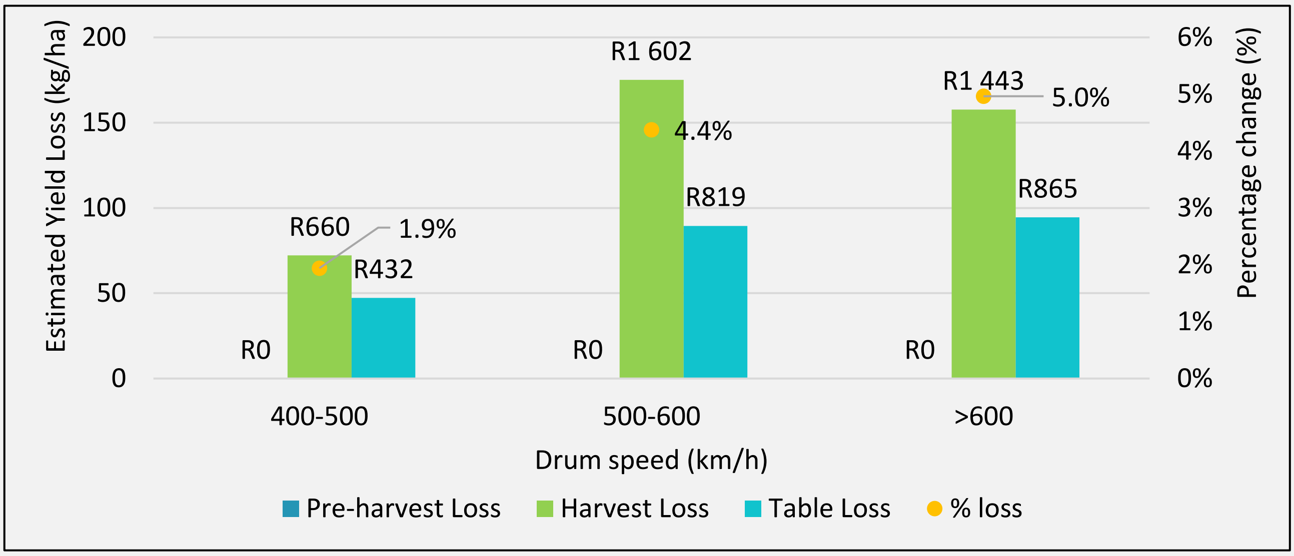

Figure 10: Average yield losses for various drum speed ranges

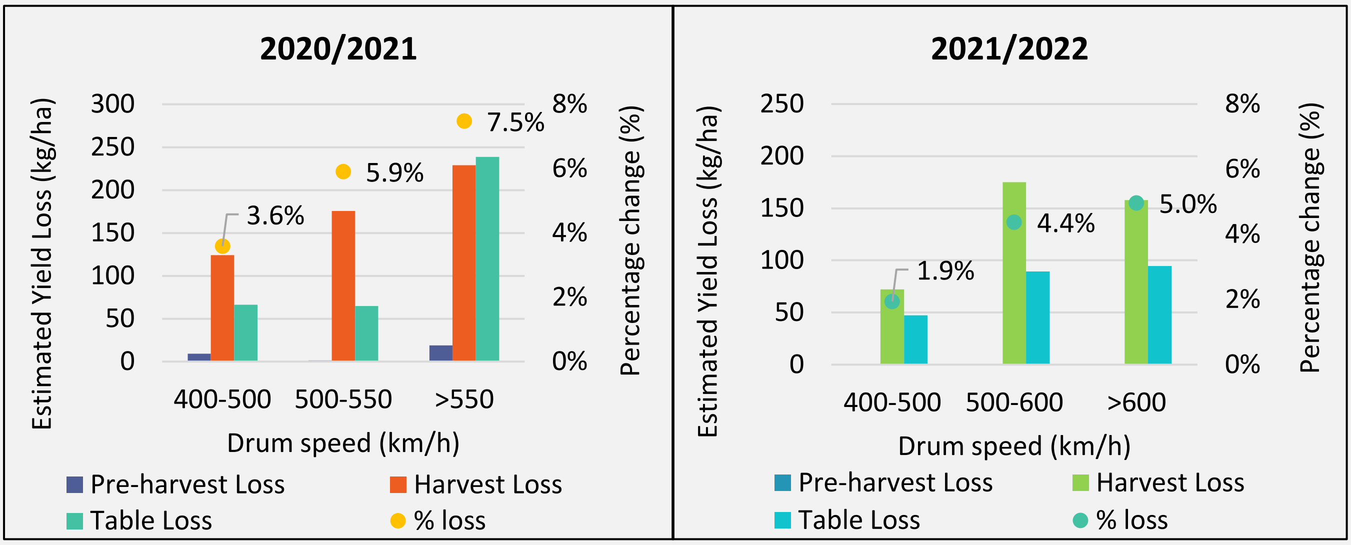

Figure 12: Comparing 2021 with 2022 yield losses for various drum speeds

3.4. Cultivation practice analysis

The fields where samples were drawn in 2022 were all planted at similar planting densities, including row widths, hence the 2022 data was added to the 2021 graphs and highlighted in green.
From the 2021 analysis there seemed to be an optimum planting density range between 200 000 to 400 000 plants per hectare, and the added 2022 samples (in green shadings in Figure 13) seem to support this assertion.

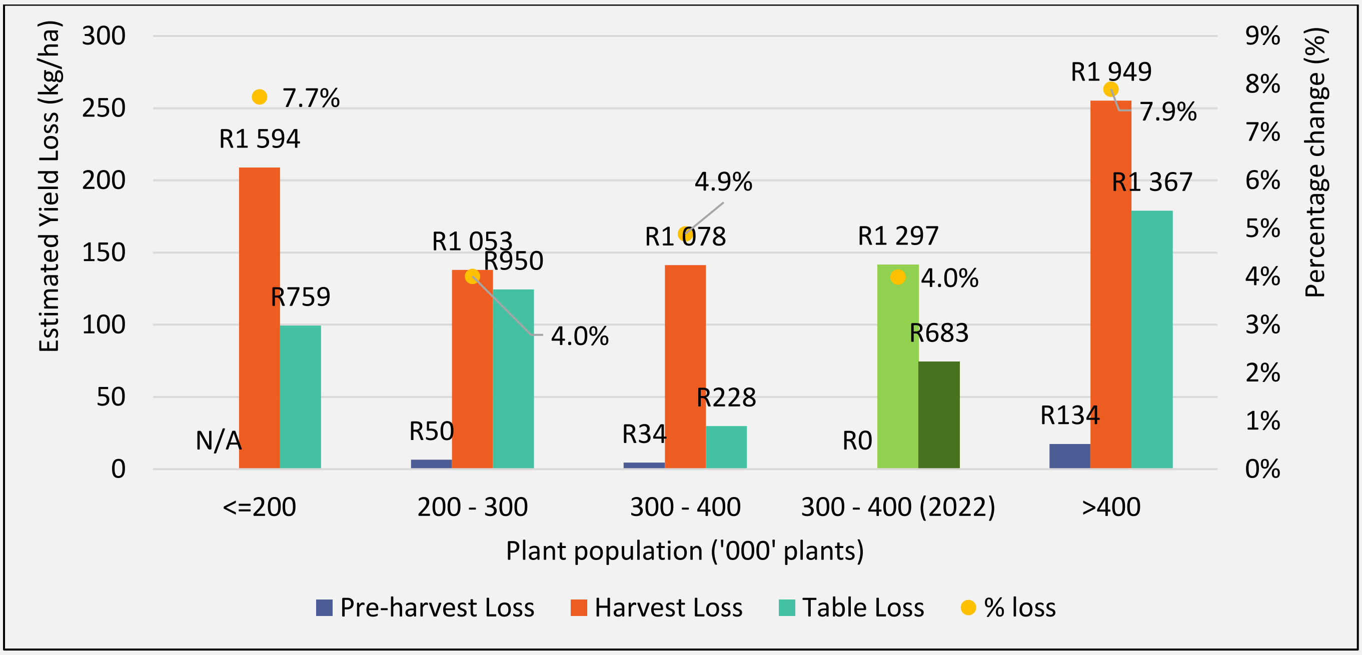

Figure 13: Average yield loss for various plant populations

There seems to be a negative correlation between row width and estimated yield loss. Figure 14 illustrates that the percentage yield loss decreased as the row width increased in 2021, and the 2022 data point at a 760mm row width supports this point. The 2022 yield loss observations were slightly lower than expected given the 2021 results.

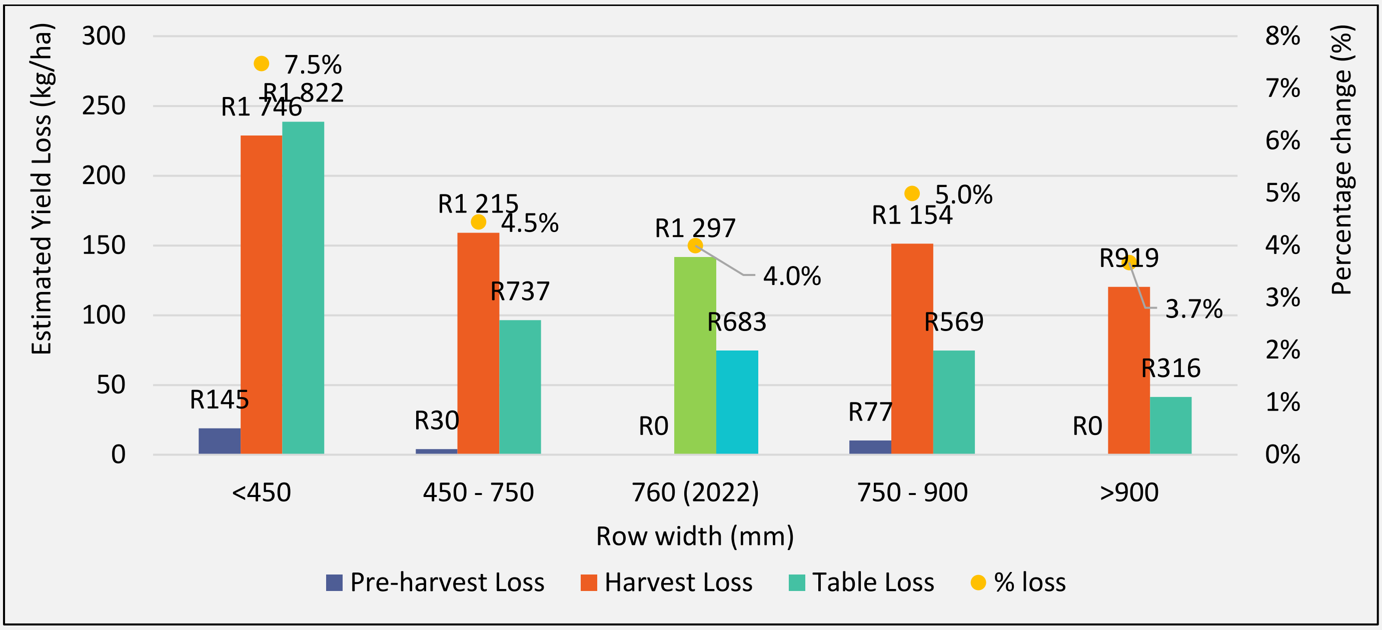

Figure 14: Average yield loss for various row widths

4. Financial impacts

Figure 15 illustrates the effect on gross margins resulting from yield losses for dryland and irrigated production systems. It shows the gross margin impact relative to the baseline (assuming zero losses) as a result of the average loss, which is calculated at 0.16t/ha, and the maximum loss, calculated at 0.47t/ha during the 2022 production season. The baseline gross margin assumes an average farm gate soybean price of R9 151/ton, a dryland yield of 2.08t/ha and irrigated yield of 3.95t/ha. The average yield loss (0.16t/ha) reduces the soybean enterprise profit by R1 472 per hectare, which can increase to a R4 278 per hectare loss when maximum losses (0.47t/ha) are considered.

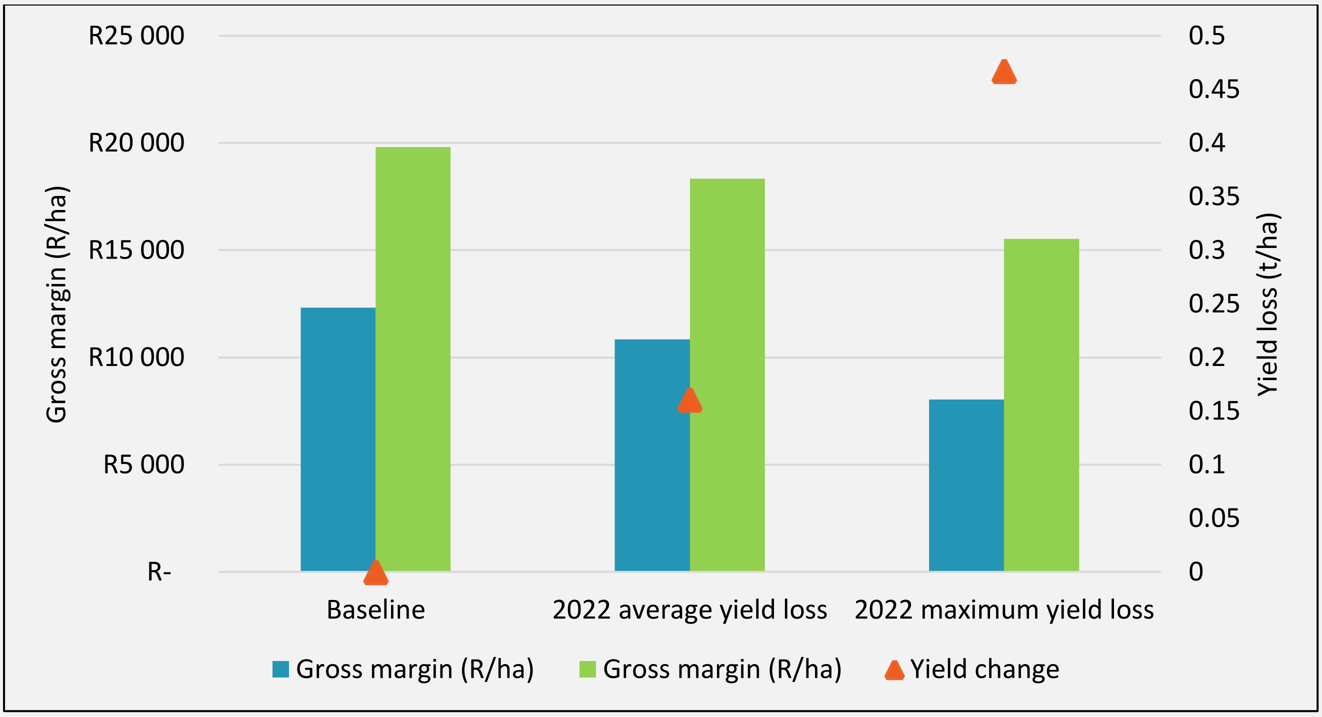

Figure 15 Impact on gross margin (R/ha) per yield loss level

*** The gross margins only consider direct variable costs, i.e they exclude overhead costs.*

Even though the average yield loss in the 2022 production season is lower than in the 2021 season (average: 0.17t/ha), the impact on the gross margin per hectare is higher due to the higher soybean selling price in 2022. Table 1 illustrates the sensitivity analysis of the impact that the yield loss may have on the change in gross margin at different price levels.

Table 1 Soybean yield sensitivity analysis

Soybean yield loss sensitivity analysis (change in gross margin per hectare)							
PRODUCERS	YIELD LOSS (T/HA)						
PRICE	0.00	0.08	0.15	0.23	0.30	0.38	0.45
R8,751	R -	R 656	R 1,313	R 1,969	R 2,625	R 3,282	R 3,938
R8,851	R -	R 664	R 1,328	R 1,991	R 2,655	R 3,319	R 3,983
R8,951	R -	R 671	R 1,343	R 2,014	R 2,685	R 3,357	R 4,028
R9,051	R -	R 679	R 1,358	R 2,036	R 2,715	R 3,394	R 4,073
R9,151	**R -**	**R 686**	**R 1,373**	**R 2,059**	**R 2,745**	**R 3,432**	**R 4,118**
R9,251	R -	R 694	R 1,388	R 2,081	R 2,775	R 3,469	R 4,163
R9,351	R -	R 701	R 1,403	R 2,104	R 2,805	R 3,507	R 4,208
R9,451	R -	R 709	R 1,418	R 2,126	R 2,835	R 3,544	R 4,253
R9,551	R -	R 716	R 1,433	R 2,149	R 2,865	R 3,582	R 4,298

Figure 1616 shows the impact on farm gross margins as a result of yield losses. The figure therefore shows the total potential monetary loss given total area under soybean cultivation (100ha, 200ha and 300ha). Assuming that a farm cultivates 200 hectares of soybeans, total farm gross margin will decrease by R294 498 when the 2022 average yield loss of 0.16t/ha is considered, while the maximum yield loss of 0.47t/ha would entail a total reduction in farm gross margin of R855 651.

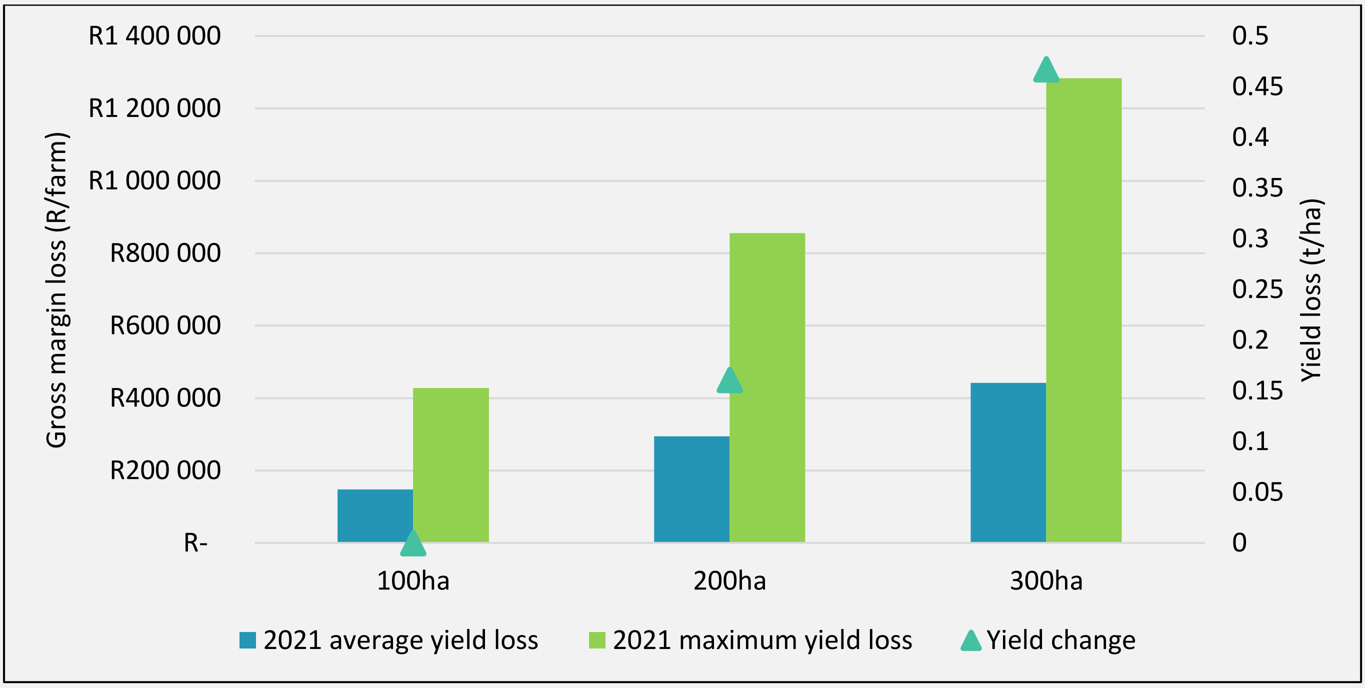

Figure 16: Farm profit loss due to yield loss per farm

5. Other possible areas to research

Further research needs to be done with more data and isolated trials to increase the validity of theseconclusions. Other possible research areas and their effect on the harvest loss include:

- The effect of different cultivars:
    - The size of the bean
    - Different cultivar subcategories (e.g. red or white beans)
- Field typography:
    - Different contours (field slopes)
    - Level of flatness of the field due to cultivation (e.g. no-till vs rolled field)
- Harvest methodology:
    - The financial impact of the speed of the harvester, versus the increase or decrease of the losses (a faster harvesting speed may have lower fuel costs, but higher harvest losses)
    - Investigate possible solutions to facilitate faster harvester speeds. Examples include infrastructure upgrades at silos.

6. Conclusion

In this study samples were drawn from different farms with different cultivars and harvesting equipment. The total harvest yield loss ranged between 30kg/ha and 467kg/ha, table losses ranged between 35kg/ha and 129kg/ha and pre-harvest losses were recorded at 0kg/ha throughout. The financial impact of these losses can be significant, as the maximum loss can reduce the producer's revenue by R4 278.25 per hectare based on an average annual soybean price of R9 151.00/ton in 2022.

Table 2 summarises the correlation between the factors considered and the harvest loss from the recorded data. **In this regard, is important to note that the report draws on study group samples from 2021 and 2022 and cannot be presented as representative of the industry at large. More data, research and isolated trials are required to make any certain conclusions and trends.**

Table 2 The effect of some factors on harvest yield loss

Factor	**Effect on harvest yield loss**
Increase in Yield	Decrease in loss
Increase in Moisture Content	Decrease in loss *(viewed in the context of 2021 data as well)*
Increase in Plant population	Optimum range: 200 000 – 400 000 pants/ha
Increase in Row Width	Decrease in loss

Thank you

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