Soybean Yield Loss Calculator App

Report by

The Bureau for Food and Agricultural Policy (BFAP)

for

Oilseed Advisory Committee (OAC)

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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.

Contents

1. Background

Following the successful roll-out of the Canola Yield Loss Calculator App in 2020, the OAC has proposed to conduct a similar analysis to quantify soybean yield losses. For canola, significant yield losses up to 350 kg/ha were measured, implying a monetary loss of up to R2,219.54/ha based on an average canola price of R6,341.53. Therefore, measuring and quantifying harvest losses for soybeans is the first step towards understanding the drivers of yield losses which creates the opportunity to identify and implement appropriate interventions to prevent monetary losses, especially during the harvesting process.

The OAC has appointed BFAP to roll-out a similar app for the 2021 soybean harvest season with a dedicated group of farmers or app-users. This app is designed to capture georeferenced data into a database which can be used for reporting and feedback purposes. The results of the 2021 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 2.1: 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

[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.

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 5.

Equation 1: Number of beans

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

Equation 2: Weight of sample

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

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. For example, 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 difference in losses between where the chaff from the spreader fell.
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 (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

During the 2021 harvesting season, additional hoops were handed out to farmers who were interested to continue collecting additional samples throughout the harvesting process. In the future, if farmers were interested in collecting their own samples based on the aforementioned methodology and were to access such an app through app stores, it is proposed that a data input field be made available where farmers can enter their hoop or sampling device surface area.

Figure 2.2: Soybean harvest in Mpumalanga

3. Results

BFAP visited a total of 10 farmers during their respective soybean harvesting activities (see locations in Figure 3.1) and collected a total of 54 useable samples in 11 fields. Three farmers were willing to collect additional samples to include more fields. These farmers got registered/subscribed on the app. However, due to busy harvesting schedules, unfortunately no additional samples could be collected.

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. The 2021 soybean season was characterised as a wet season in later plant stages, with some sclerotinia problems. However, a record harvest of 1.918 million tonnes was estimated by the Crop Estimates Committee (CEC) in their 5th summer crop production forecast. According to CEC, area under production for the 2020/21 season is estimated at 827 100 hectares with a projected average yield of 2.32t/ha.

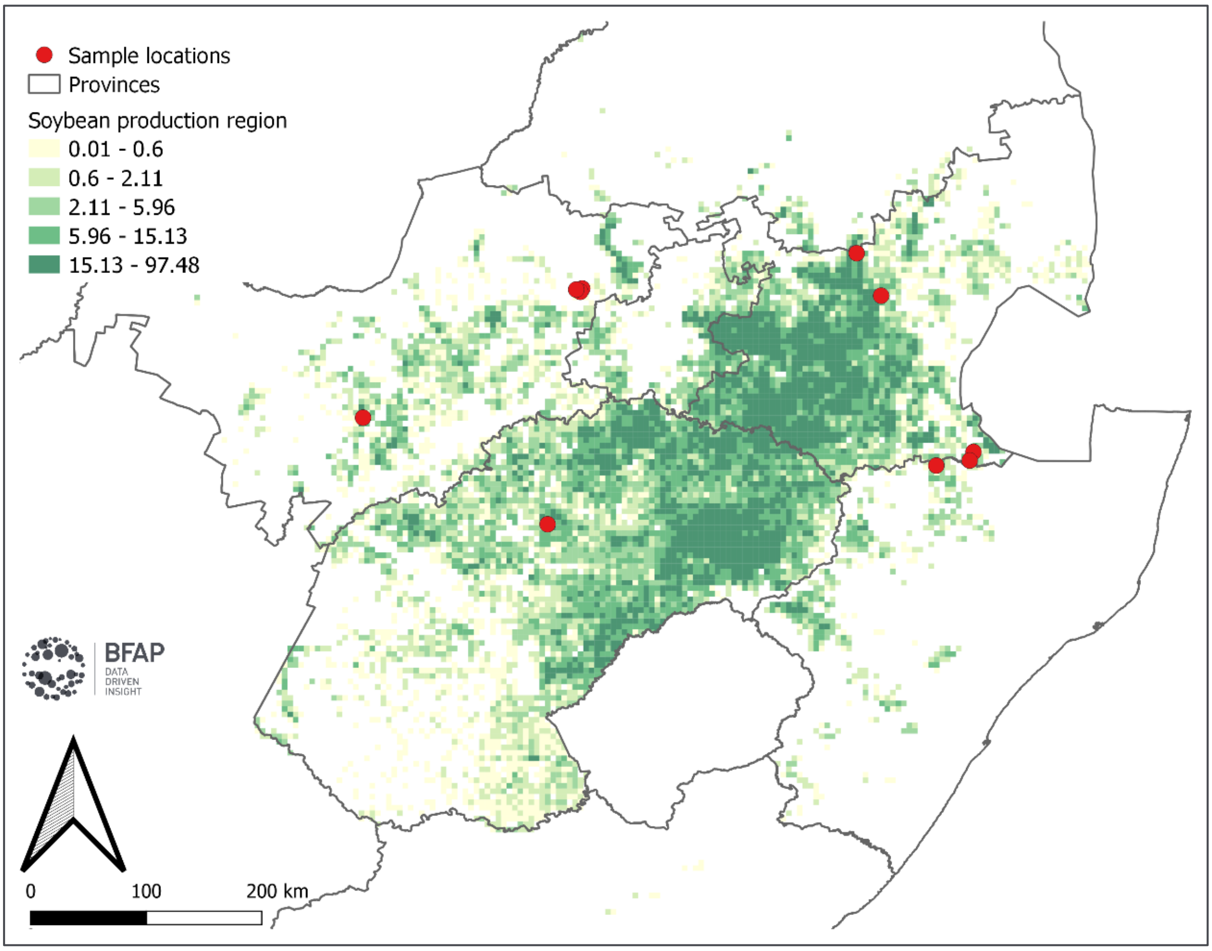

Figure 3.1: Mapped soybean yield loss

It is important to note that the report draws on a study group sample and is not representative of the industry at large . The objective of this study was to introduce the methodology to quantify soybean yield losses through a pilot study. The initial findings of this study have the potential to inform specific areas of future research to reduce yield losses. Of course, the study will need to be scaled to gain additional insights of the drivers of yield loss. In this report, interpretations made regarding the correlation between harvest loss and yield, moisture content, equipment, cultivation practices and regions 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.

3.1. Regional benchmark

Figure 3.2 illustrates the average total harvest yield loss, pre-harvest yield loss and table loss per region, measured in kilogram per hectare and Rand per hectare. It also illustrates the percentage loss of the harvested yield. North West had the highest total loss (217kg/ha or R1 659/ha) and highest percentage loss of the recorded yield (6.5%), with Free State shortly behind (6.1%). More samples per region need to be taken to develop a useable regional benchmark.

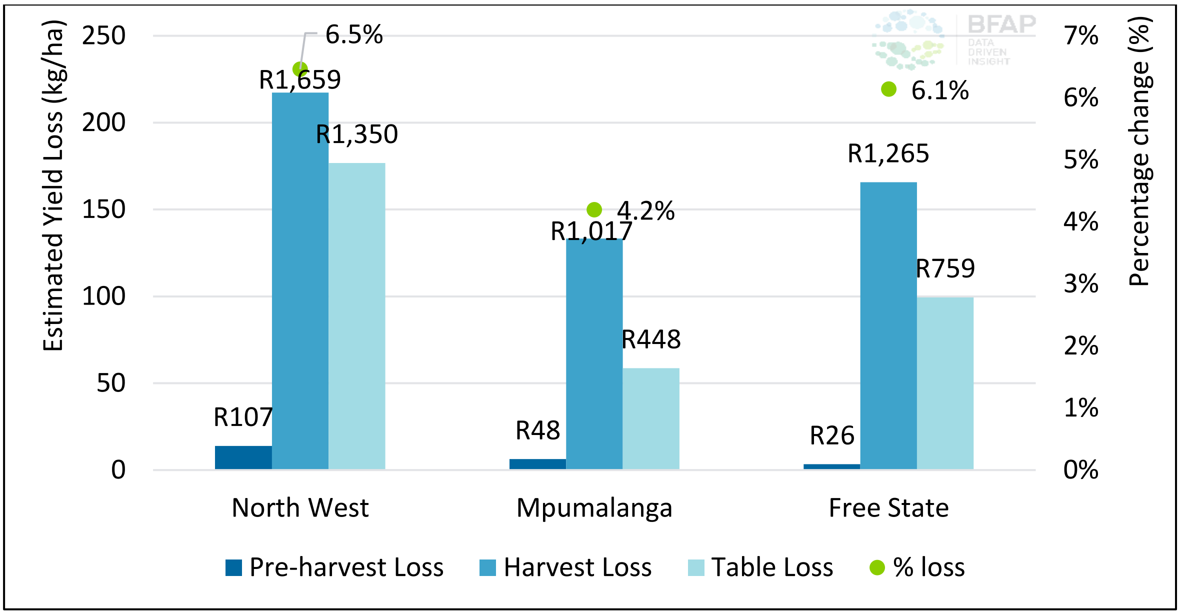

Figure 3.2: Regional benchmark for soybean yield losses during the 2021 season

3.2. 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 3.3 states otherwise and shows that the percentage yield loss actually decreases. This supports the hypothesis that there exist other factors in driving yield losses. Some of these factors are discussed in the following sections.

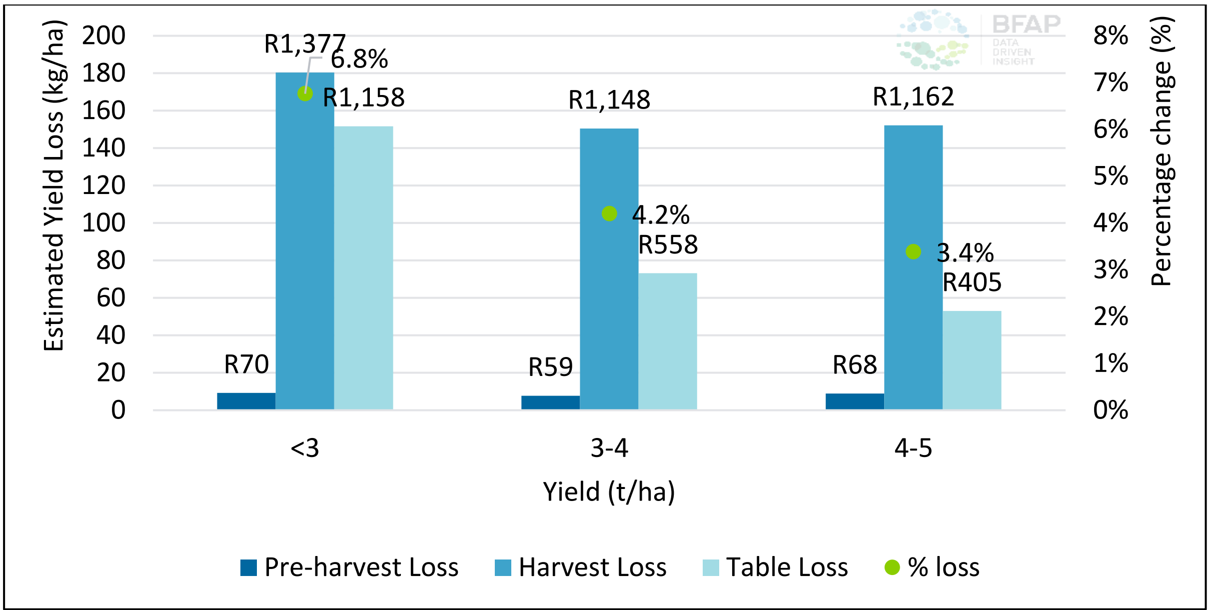

Figure 3.3: Average soybean yield losses at various yield levels

**N/A – no such sample was taken*

3.3. Moisture content analysis

Average yield losses were analysed for various levels of moisture content (at harvesting). As expected, harvesting yield losses have decreased as moisture levels increase. Furthermore, pre-harvest losses were recorded as zero at a moisture level above 12%. *Figure 3.5* shows all samples in a scatterplot; a marginal inverse relationship between moisture content and harvest losses is observed. A similar trend is observed at pre-harvest due to shattering (Figure 3.6). Thus, from the pilot study results, it is argued that as moisture levels increase, losses will decrease.

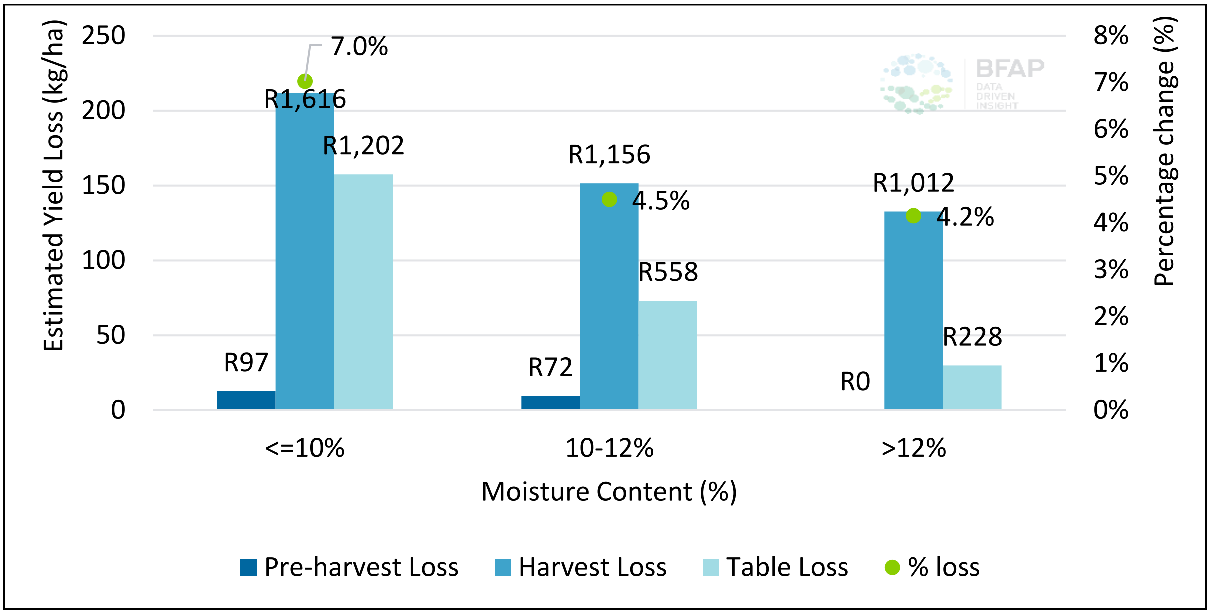

Figure 3.4: Average soybean yield losses at various moisture content levels

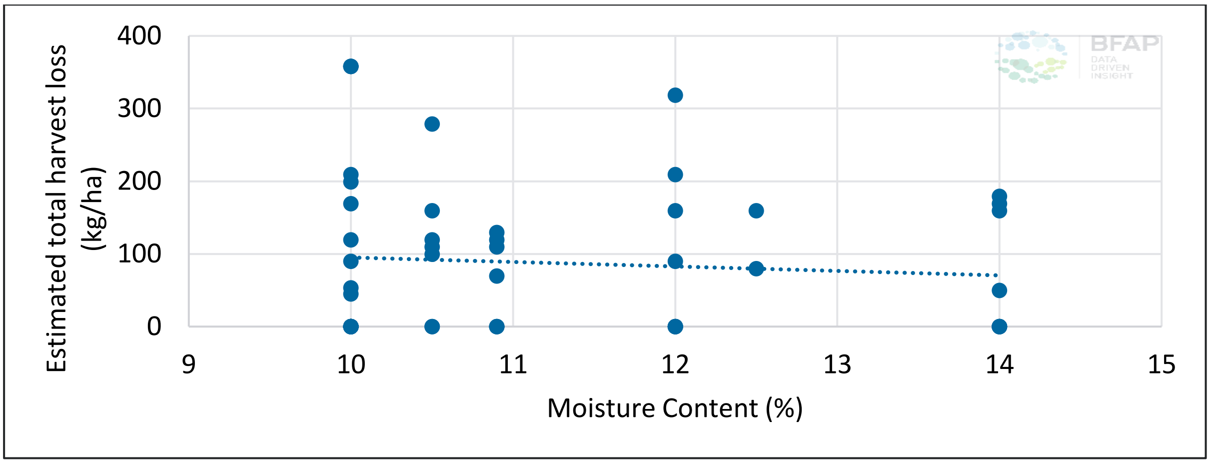

Figure 3.5: *Estimated total soybean harvest yield loss vs. moisture content*

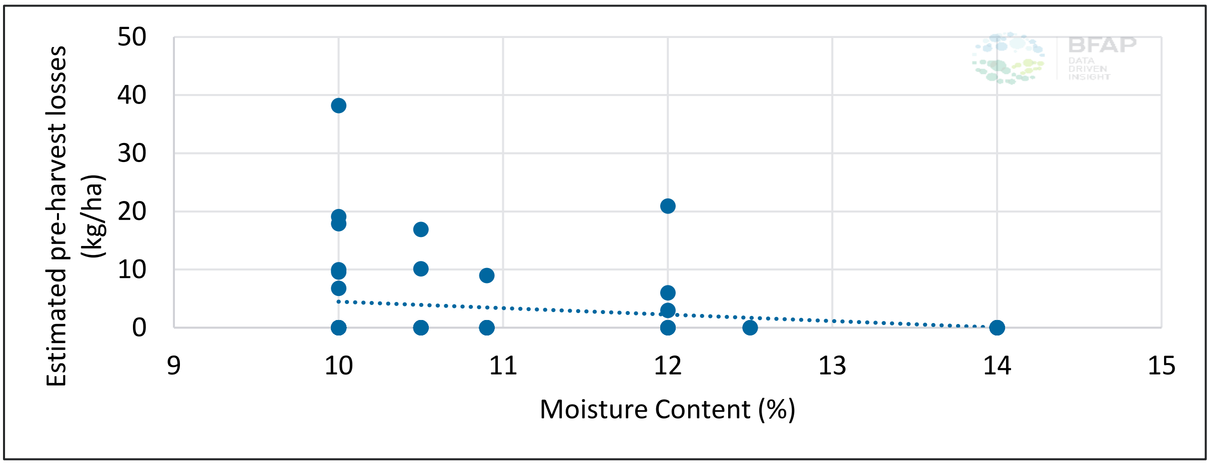

Figure 3.6 Estimated pre-harvest soybean yield loss vs. moisture content

3.3. Equipment analysis

While designing the methodology, it was anticipated that the type of combine header technology used would play a role in yield loss measurements. Figure 3.7 indicates that the highest yield loss was observed with the use of conventional combine headers with losses averaging 270 kg/ha. For flexi headers, harvest losses were on average 142kg/ha lower compared to conventional headers. Using an average farm gate soybean price of R7 633 per ton, a 142kg/ha loss will translate into a monetary loss of R1 084 per hectare (refer to Section 0). This can be attributed to the observation that conventional headers are limited in adjusting the cutting height from the ground relative to flexi headers.

Contrary to what was expected, the total loss of the flex-draper header was not lower compared to the flexi header. However, when the table sample is considered, yield losses of the flex-draper header were lower compared to other technologies, which can be considered as the main indicator between the two equipment types. The flex-draper header reported 45kg per hectare (R343/ha) lower table loss than the flexi header. On average, the loss incurred at the table, accounts for 88% and 58% of the total loss, for a conventional and flexi header respectively, while only 17% of the total loss is accounted by the table of a flex-draper header.

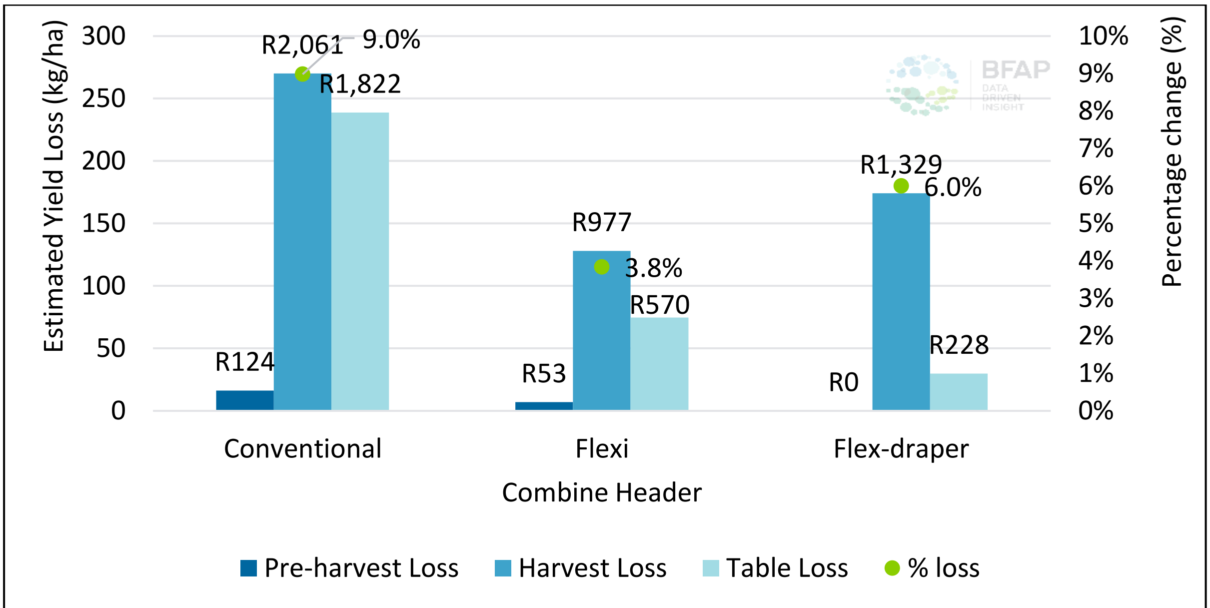

Figure 3.7: Average yield losses per Combine Header type

****Only one field with a flex-draper header was surveyed. The flex-draper header had technical issues on the field, and the reliability of the collected data is uncertain.***

Figure 3.7Figure 3.8 and Figure 3.9 illustrate how the loss increases as the speed of the harvester and drum increases. There was a comment from a farmer regarding the trade-off between the speed of the combine and fuel consumption. It is argued that in order to harvest a cleaner sample to avoid deductions/penalties, harvesting speed needs to be reduced which consequently implies higher fuel consumption per hectare.

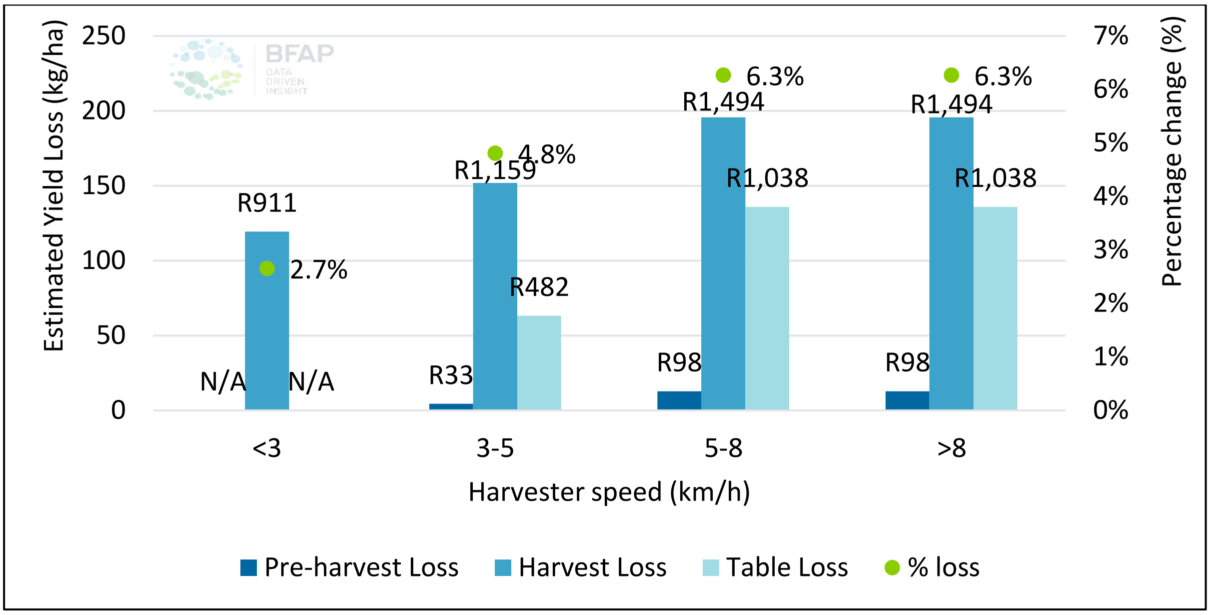

Figure 3.8 Average yield losses for various speed ranges

**N/A – no such sample was taken*

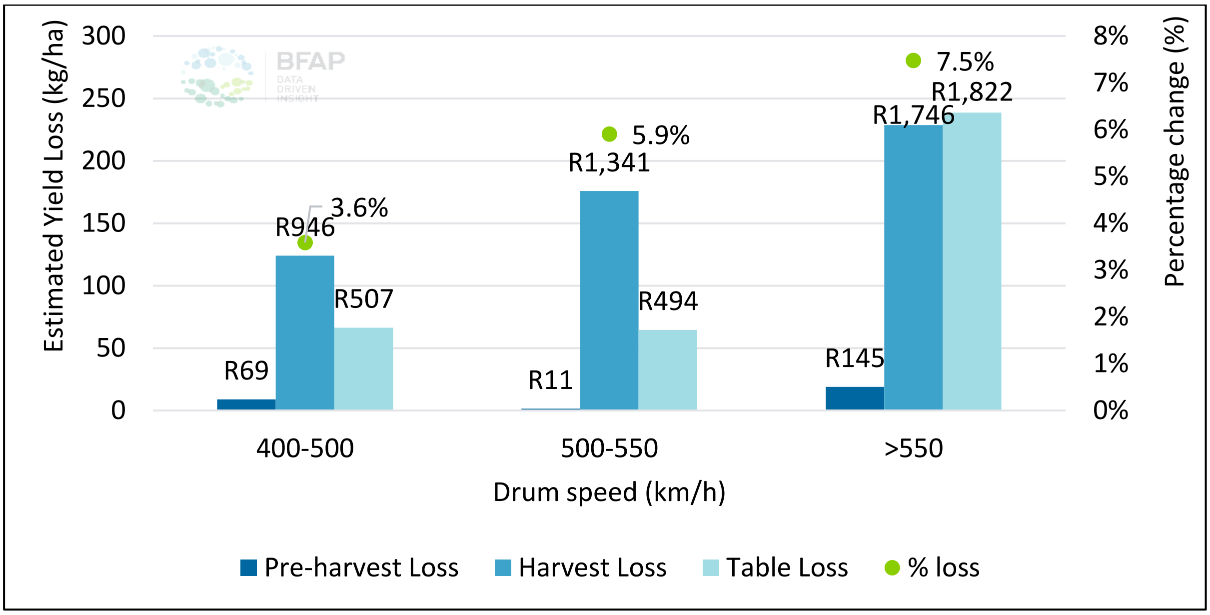

Figure 3.9 Average yield losses for various drum speed ranges

3.4. Cultivation practice analysis

There seems to be an optimum planting density range between 200 000 to 400 000 plants per hectare. The highest loss (255 kg/ha) was observed at a plant population above 400 000 plants per hectare. This is opposite to what was expected, as pods are normally formed higher on plants with a higher planting density, improving overall collection of pods. However, care needs to be taken with this statement, as the samples collected for planting population above 400 000 plants per hectare, were only harvested with a conventional header, which may have contributed to higher losses. More data and samples are required to investigate the relationship between plant population and yield losses.

There is no trend between yield losses occurring at the table sample and planting density, however some evidence suggests there do exists a correlation between pre-harvest losses and plant population.

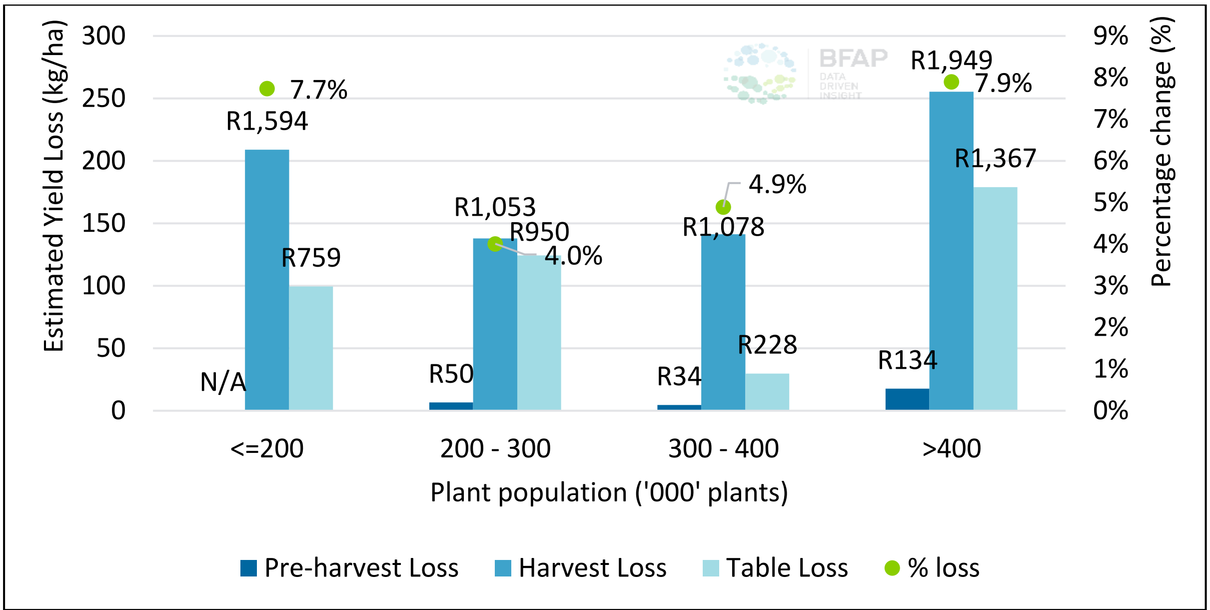

Figure 3.10: Average yield loss for various plant populations

**N/A – no such sample was taken*

There seems to be a negative correlation between row width and estimated yield loss. Figure 3.11 illustrates that the percentage yield loss has decreased as the row width increases.

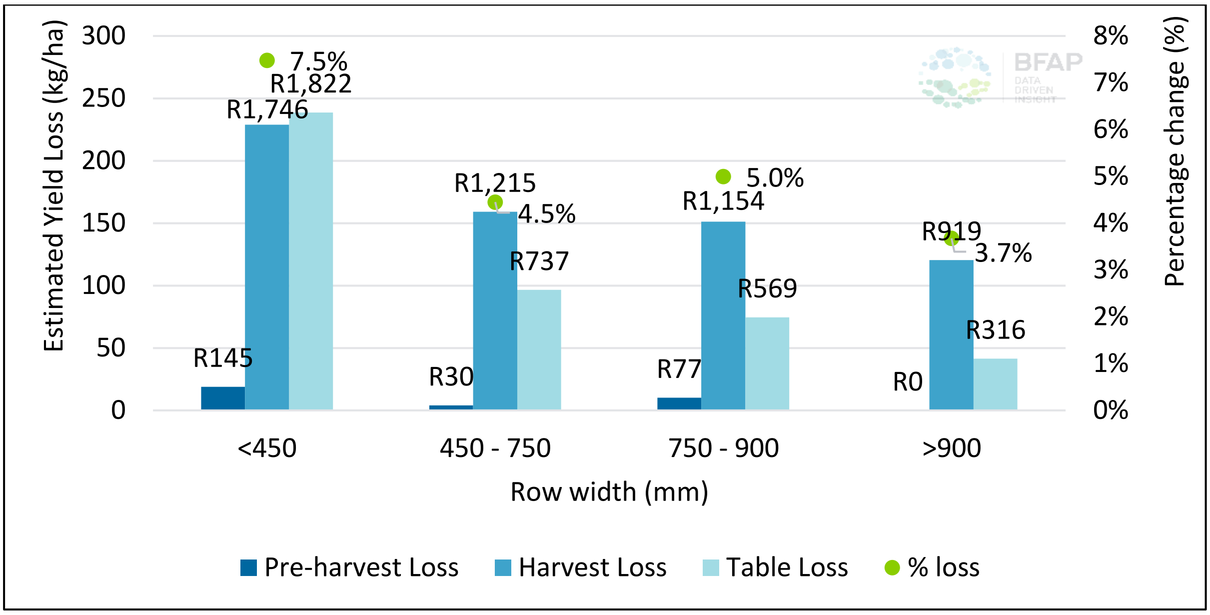

Figure 3.11: Average yield loss for various row widths

4. Financial impacts

Figure 4.1 illustrates the effect on gross margin as a result of 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 0.17t/ha and the maximum loss, calculated at 0.36t/ha during the 2021 production season. The baseline gross margin assumes an average farm gate soybean price of R7 633/ton, a dryland yield of 2.08t/ha and irrigated yield of 3.95t/ha. The average yield loss (0.17t/ha) reduces the soybean enterprise profit with R1 298 per hectare, and can increase to R2 748 per hectare when maximum losses are considered.

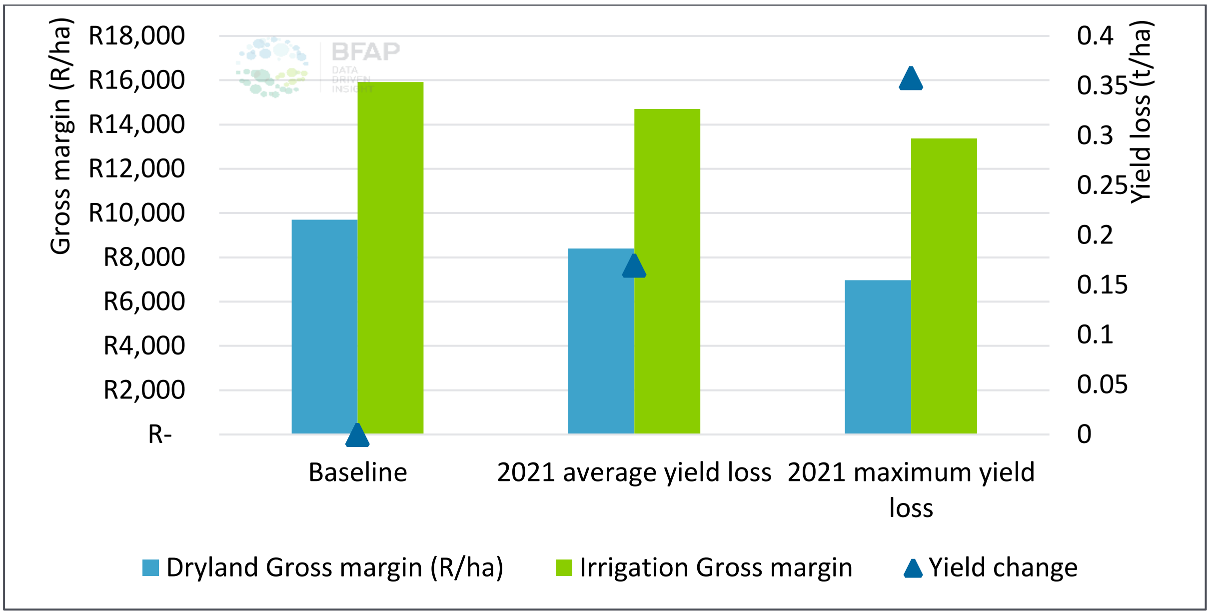

Figure 4.1 Impact on gross margin (R/ha) per yield loss level

*** The gross margins only consider direct variable cost and exclude overhead costs.*

Figure 4.2 shows the impact at farm gross margin 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 R259 522 when the 2021 average yield loss of 0.17t/ha is considered, while the maximum yield loss of 0.36t/ha would entail a total reduction in farm gross margin of R546 675.

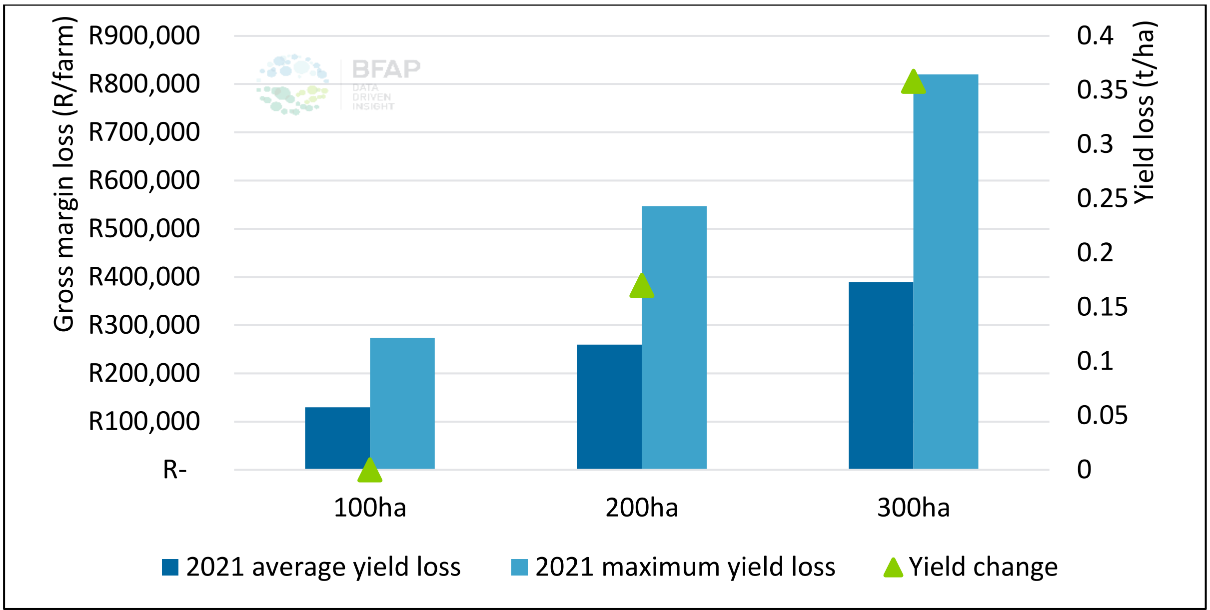

Figure 4.2 Farm profit loss due to yield loss per farm

5. Bean weight vs bean count case study

Additional analyses were done to investigate and illustrate the difference between counting and weighing the beans. When counting the beans, an average bean weight of the utilised cultivar is used to calculate the total weight of the loss, while weighing is simply determined by a scale. This difference resulted in different losses measured in the samples. Figure 5.1 illustrates the range of difference in losses (in kg/ha and R/ha) due to measuring the losses by weighing the beans versus counting the beans. On average, when counting beans, the loss was 31kg/ha (R239/ha) lower than when weighing them. During the trial, the counted beans ranged from 76kg/ha below the weighed beans, and 29kg/ha higher than the weighed beans.

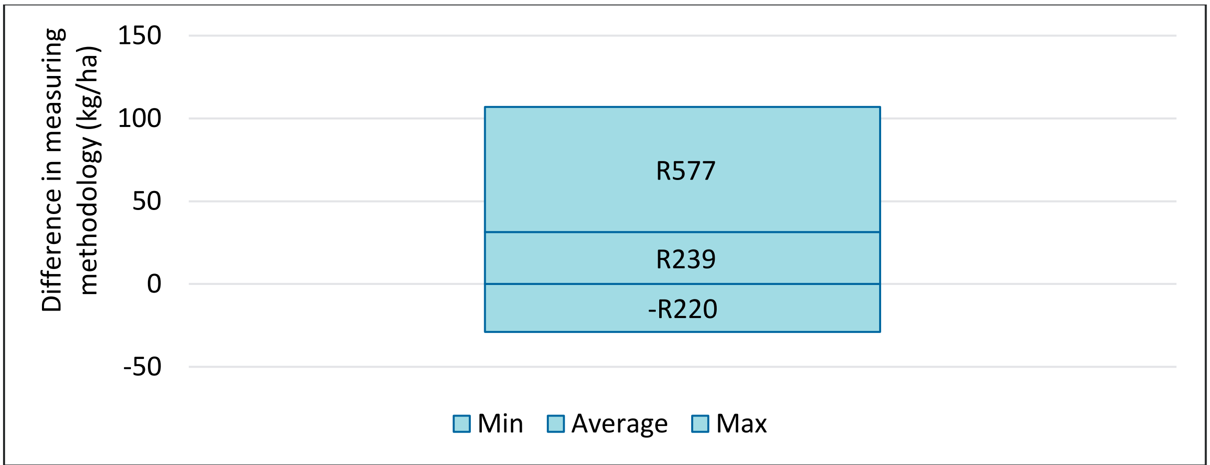

Figure 5.1 Difference in yield losses due to measuring methodology

Both approaches have their advantages and disadvantages. It depends on the:

1. <u>Objective</u>:

Due to the fact that the producer is paid per ton, and not per number of beans, it makes sense to rather weigh the beans when extracting a financial impact of the data. However, when analysing the losses in relation to moisture content (determining the effect of moisture content on losses), it makes sense to rather count the beans, as higher moisture content will result in a larger loss due to heavier bean weight (marginal but significant).

2. <u>Practicality</u>:

Counting the beans accommodates scenarios where access to a scale is not possible, while weighing the beans is much easier and faster.

3. <u>Accuracy:</u>

Soybeans are a natural product which depend on natural conditions. For example, if a soybean plant experiences stress while forming its beans (e.g. drought), it will produce a smaller bean. Thus, the beans may not conform to the average weight (even when taking a cultivar average), and thus multiplying the number of beans by the weight is not always representative.

6. Other possible areas to research

Further research needs to be done with more data and isolated trials to make conclusions. Other possible research areas and trends 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.

7. Conclusion

The study collected samples from different farms with different production practices, cultivars and harvesting equipment. The total harvest yield loss ranged between 45kg/ha and 358kg/ha, and pre-harvest losses from 0 – 38kg/ha. The financial impact of these losses can be very significant, the maximum loss can decrease the producer's revenue by R2 733 per hectare.

Table 1 summarises the correlation between the factors considered and the harvest loss from the recorded data. **It is important to note, that the report draws on a study group sample 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 1 The effect of some factors on harvest yield loss

Factor	**Effect on harvest yield loss**
Increase in Yield	Decrease in loss *(suspicious)*
Increase in Moisture Content	Decrease in loss
Increase in Plant population	Optimum range: 200 000 – 400 000 pants/ha *(suspicious)*
Increase in Row Width	Decrease in loss
Equipment	Total loss: Flexi header performed the best *(suspicious)* Table loss: Draper header performed the best

BFAP

DATA
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