Sesame
Business
Network
Ethiopia

Sesame yields and (post-)harvest losses in Ethiopia:

Evidence from the field

SBN

About the Sesame Business Network Ethiopia

The Sesame Business Network (SBN) is an informal network that is driven by local and other stakeholders to work towards more competitive, sustainable and inclusive sesame value chains. The SBN is currently built around 19 local sesame business clusters in 8 *woredas* in northwest Ethiopia. Actors of these clusters have analysed their situation and formulated clear economic objectives.

The SBN has a three-year support programme (2013-2015) that supports the stakeholders of the sector. Farmer income improvement is the overall goal of SBN. SBN focuses on achieving five major objectives, which together contribute to the overall goal of the SBN and its support programme:

(1) Productivity and quality improvement
(2) Credit cost reduction
(3) Harvest, transport and storage loss reduction
(4) (Post-)harvest value creation
(5) Market linkages and sales

The SBN support programme is managed by the SBN team, a team of 20 coaches and facilitators who are located in Gondar, Metema and Humera in northwest Ethiopia. The programme is coordinated by this SBN team, together with the Centre for Development Innovation of Wageningen University and Research Centre (CDI), the Netherlands. The SBN support programme is funded by the Netherlands Government and works in partnership with the 2-SCALE programme.

SBN works in close cooperation with the Ethiopian public and private sector involved in the sesame sector and collaborates with other relevant development projects and programmes.

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Sesame yields and (post-)harvest losses in Ethiopia: Evidence from the field

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With support of SBN stakeholders and team

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Executive summary

Sesame is an increasingly important cash crop to the Ethiopian economy and the sesame agri-business sector has substantial potential for further improvement. Two of the key objectives of the SBN support programme are: (i) improving sesame yields, productivity and quality, and (ii) reducing harvest, transport and storage losses. In order to get reliable data for designing interventions and practical options to contribute to these strategies, the SBN support programme has conducted two action-oriented studies among farmers in the Tigray and Amhara region of northwest Ethiopia.

In the sesame production and marketing season of 2013, a *yield study* was conducted through a survey and other methods with 93 farmers, as to gather data on farmers' sesame yields and production practices. In addition, a study on *harvest, transport, and storage losses* has been undertaken to identify sources and quantities of sesame losses, and to come up with interventions to reduce these losses.

Results of the yield study show that the average yield in 2013 has been 449.88 kg / ha. Higher yields in Amhara (490.42 kg/ha) as compared to Tigray (419.42 kg/ha) were observed. This can be explained by insufficient rainfall in Tigray in the 2013 season. There are no significant differences between yields of micro, small, intermediate and investor farmers in both regions. With regards to farming practices, farmers in Tigray significantly plough their land more often, use more fertilizers and weed more times as compared to Amhara farmers.

Existing research and previous years' results on demonstration plots show that the application of improved production technologies can lead to yields of 800 kg per hectare. With 2013 yields being about 450 kg per hectare, a massive yield gap exists. Based on the outcomes of this study, the SBN support programme, together with its partners, has in 2014 started to scale out locally adapted and improved sesame production technologies across 8 *woredas* (districts) and 92 *kebeles* (villages) in northwest Ethiopia.

Results of the (post-)harvest losses study reveal that the total loss of sesame as measured during the different handling stages is 55.56 kg per hectare. With a land coverage of 500,000 hectare of sesame in 2013, this means a loss of 277,800 quintals of sesame (27,780 metric tons). Using the average productivity of 4.5 quintals of sesame yields per hectare (as measured in the yield study), it means that 12.67 percent of sesame is lost. Most sesame is lost during the drying of *hilla*s (5.54%), followed by pre-harvest plant shattering (3.25%), *hilla* transport to threshing sites (1.85%) and re-bagging at market centres (1.12%).

The sesame losses represent a massive monetary loss. The annual economic loss of sesame in northwest Ethiopia (500,000 ha with productivity of 4.5 quintals/ha and selling price of 4000 ETB / quintal) exceeds 1 billion ETB, which is more than 40 million euro, and 50 million dollar! Even when selling prices of sesame would be lower than 4000 ETB in years to come, it would represents significant economic losses.

We have come up with a number of practical recommendations to improve farmers yields and to reduce their (post-)harvest losses. Already in the 2014 sesame production season, a guide with improved sesame production practices, called *"20 Important Steps to Double Yields and Improve Quality of Sesame"*, has been developed and distributed to farmers and other actors.

Farmers have been coached on these improved practices through field demonstrations and ongoing monitoring. Farmers also trace their yields and production practices through a logbook at some 1000 sites (Farmer Training Centres and farmers' plots) with close monitoring of agronomists and development agents of w*oreda* Offices of Agriculture and the SBN team. This data will be analysed for the 2014-2015 season. In this way, important information will be available for comprehensive insights in farmer practices and sesame yields and quality in northwest Ethiopia.

Finally, the guide *"20 Important Steps to Double Yields and Improve Quality of Sesame"* also includes practical ways to reduce (post-)harvest losses at field, transport and storage levels. In the coming years, the recommended interventions will be further developed, tested, rolled out and evaluated, as to achieve our targets of 50% average yield improvement and 30% reduction of harvest, transport and storage losses.

Sesame Business Network
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1. Introduction

Sesame is an increasingly important crop to the Ethiopian economy, and in the last decade, Ethiopia has increased its production by ten-fold. Nevertheless, the Ethiopian sesame sector has substantial potential for improvement, for example on improving productivity and quality of sesame for accessing higher value markets.

The Sesame Business Network (SBN) has a three-year support programme (2013-2015) with the aim to develop more competitive, sustainable and inclusive sesame value chains. One of the key strategies of the SBN support programme is *production cost-price reduction*, which is to be achieved by:

1) Sesame yield and quality improvement
2) Credit cost reduction
3) Harvest, transport and storage loss reduction

This report contributes to the first and third objective by presenting results of two action-oriented studies that have focused on sesame yields and productivity, and on harvest, transport and storage losses (hereafter called (post-)harvest losses).

The first study has focused on *objective 1): sesame productivity and quality improvement* by measuring farmers' sesame yields and productivity. The farmers in the sesame business clusters perceive the huge yield gap, and a target of 50% yield improvement has been set (compared to the SBN 2013 baseline level). As a result, the study is designed to collect data on sesame productivity that triangulates 2013 SBN baseline data, and that can be used for monitoring the 50% yield improvement target. In addition, the study aims to identify practical options for farmers to improve their yields and productivity.

The second study has focused on *objective 3): (post-)harvest losses reduction*. SBN aims to reduce losses by 30% by the end of 2015, set against the 2013 baseline level. It is estimated that there are significant losses of sesame during harvesting, storage and transport, yet field evidence is lacking to substantiate this. SBN has therefore conducted a study to identify sources of losses and to quantify the losses at different handling stages in the sesame value chain. In addition, the study aims to adequate, practical and affordable measures to reduce the losses.

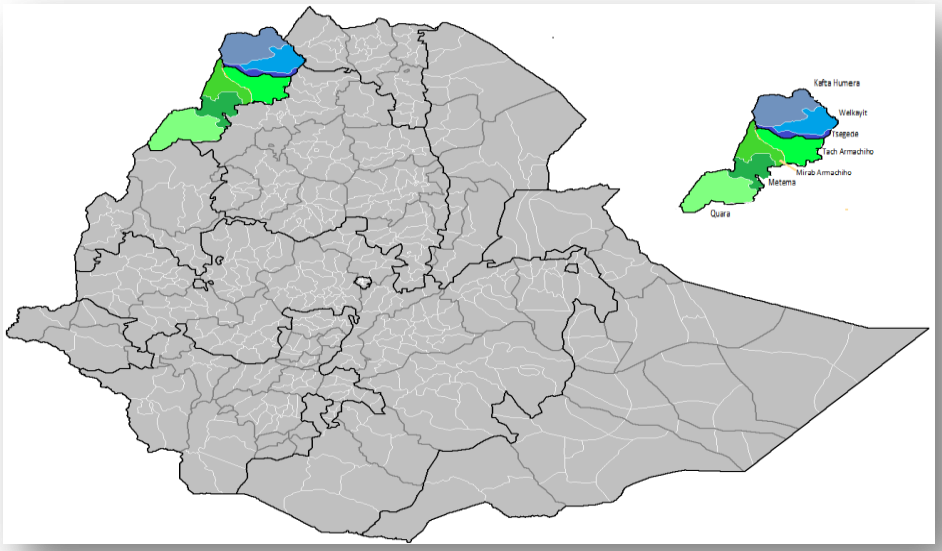
This report is outlined as follows. The next chapter describes the methods that have been used for the yield and (post-)harvest losses studies. Chapter 3 overviews the main results of both studies, followed by conclusions and recommendations in chapter 4. The appendices contain descriptive statistics of the yield study, as well as the yield questionnaire.

2. Methodology

2.1 Yield study

The yield study has been conducted between September and December 2013 with farmers in nine of the Sesame Business Clusters (SBCs), four from the Amhara and five from the Tigray region. These clusters cover the 7 *woredas* in which the SBN support programme was active in 2013.

Figure 1. Location of the region and districts in Ethiopia where the studies have been conducted



The nine clusters are selected purposively out of the 19 existing clusters, based on their production potential, agro-ecology and farm size. For each cluster, farmers were selected randomly within four pre-defined strata. These strata were: micro (less than 5 ha), small (5-10 ha), intermediate (10-30 ha), and investor farms (larger than 30 ha). See table 1 on the next page for the final number of respondents (an average of 9 farmers per cluster in Tigray and 12 in Amhara). As Tigray and Amhara have a slight different farmer population, Amhara respondents were mostly micro and small farmers, whereas in Tigray there were more intermediate and investor farmer respondents.

Data were collected through four steps by a team of SBN staff, research institutes and *woreda* offices of agriculture. First, farmers' yields were measured. This has been done by selecting randomly 20 by 20 meter sample quadrants in farmers' fields. To avoid sampling of border plots, which do not give representative yield results, samples had to be located 5 meters away from the field borders. The selection was done by walking across farmers' fields diagonally or by other methods (depending on the shape of the farmers' field). The harvest was done carefully and the *hillas* (stacked sesame piles, see the second picture on the next page) were placed on plastic sheets, as to measure the complete yield from each quadrant.

Table 1. Respondents for the yield study, per region and cluster

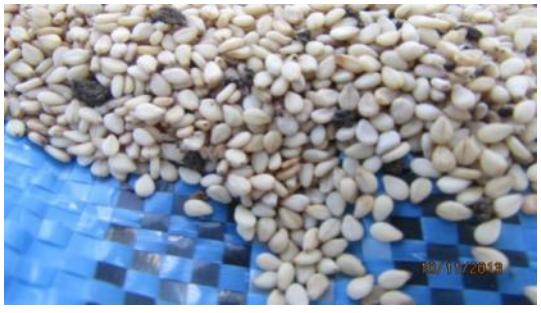
Region	Clusters	Respondents (N)
Amhara	Shinfa	**12**
	Metema Yohannes - Kokit	**12**
	Sanja	**12**
	Abderafi	**12**
	Total Amhara	***48***
Tigray	Dansha	**9**
	Adebay	**11**
	Kafta Humera Sesame Producers & Sales Cooperative (KHSPC)	**8**
	Maykadra	**14**
	Maygaba	**3**
	Total Tigray	***45***
	Total	**93**

Second, the following yield parameters have been measured: plant height, number of capsules per plant, plant population per plot, and seed weight (measured per 1000 seeds). These parameters were measured by selecting randomly five sesame plants per plot. Third, total plot yields were measured and converted into yields per hectare. Fourth, the farmers have been surveyed about their farming practices through a questionnaire, which can be found in appendix 2. The pictures below show the different steps that have been used in the yield study.

Data from the yield measurement has been entered and analysed in statistical software package SPSS. Different statistical analyses have been conducted on the data, such as descriptive statistics, independent samples T-tests, and Analysis of Variance (one-way ANOVA).

A selected 20 x 20m quadrant

Hillas (stacked sesame plants) on plastic sheets



Sesame seeds on plastic sheet

Survey with one of the farmers

2.2 (Post-)harvest losses study

The (post-)harvest losses study was executed in the harvesting and marketing season of sesame, between September and December 2013. Data on losses have been collected by the agronomist and extension coaches of the Amhara and Tigray teams of the SBN support programme.

A series of different methods and procedures were followed to determine the (post-)harvest losses. First, sesame losses on farmers' fields before and during harvesting were measured. Data collection of field losses were combined with yield measurements in the yield study. This means that the same 93 quadrants of farmers' fields were used as in the yield study (see table 1 on the previous page). An additional 14 quadrants from other farmers were sampled for the measurement of the losses due to unharvested / uncut capsules.[1]

On farmers' fields, five main stages of losses have been measured:

1) *Losses due to pre-harvest shattering of plants*
2) *Losses due to unharvested / uncut sesame capsules*
3) *Drying sesame plants in hillas*
4) *Hilla carrying from the field to the threshing site*
5) *Transport from farm to market centre/store*

The methodology that has been used for each of the stages can be found in table 2.

Table 2. Measurement of (post-)harvest losses at farmers' level

Stages	Methodology
Loss due to capsules shattered before harvest	Count number of capsules shattered before harvest within the 20 by 20 m quadrant Count number of seeds per capsule Measure 1000 seed weight (using a seed counting machine) Extrapolate to loss per hectare
Loss due to unharvested / uncut sesame capsules (additional 14 quadrants used in sample)	Count number of capsules remain un-harvested within the 20 by 20 m quadrant Count number of seeds per capsule Weigh 1,000 seed weight (using a seed counting machine) Extrapolate to loss per hectare
Drying sesame plants in *hillas*	Put *hillas* on plastic sheets Measure weight of fallen sesame on sheets Extrapolate to loss per hectare
***Hilla* carrying from the field to the threshing site**	Carry bunches of sesame while walking over plastic sheet Measure weight of fallen sesame on sheets Extrapolate to loss per hectare
Transport from farm to market centre/ store	Transport bags of sesame while covered over plastic sheet Weigh sesame fallen on a plastic sheet on trucks, donkey carts, and others Extrapolate to loss per hectare

[1] The labourers harvesting sesame on the 93 quadrants were doing this with extra care, probably caused by presence of the researchers. Therefore, an additional 14 quadrants of other farmers were measured (with researchers coming in later), as to measure the actual, more reliable losses due to unharvested capsules.

Second, after measuring the losses on farmers' fields, the study measured sesame losses at traders, cooperatives and ECX level.[2] This involved measuring losses at the following stages:

1) *Cleaning and re-bagging at the spot market*
2) *Storage losses*
3) *Storage losses at ECX for depositors*
4) *Losses during cleaning and processing*
5) *Storage losses for exporters*

The methodology that has followed is described in table 3 and shown in pictures on the next page.

Table 3. Measurement of (post-)harvest losses at traders', cooperatives and ECX level

Stages	Methodology *(sample sizes and procedures)*
Cleaning and re-bagging, spot market	Measure the weight of farmers' bags and traders' bags after cleaning and re-bagging *Re-bagging process measured at 7 sites (for Tigray and Amhara in total)*
Storage losses (private stores of traders and stores of cooperatives)	Measure weight of bags when these are put in stores of traders and/or cooperatives Measure weight of bags when these are taken out of store for sale at ECX (or others) *Bags measured during a 1 ½ month period, by measuring sesame seeds fallen on store floors (weight in – weight out). Three stores in Tigray and 13 stores in Amhara were measured. The average loss is calculate by converting quintals (100kg unit) to kg and into hectares, based on the average yield for the region (as measured in the yield study).*
Storage losses at ECX for depositors	Measure weight of bags when these are put in stores of depositors at ECX Measure weight of bags when these are taken out of store for sale at ECX (or others) *Samples taken by ECX experts, during storage time of 1 month in the Humera regional ECX centre. Samples taken from different sites (weight in – weight out). Results have been adopted by ECX to use as standard deduction from depositors.*
Loss during cleaning / processing	Taking samples from waste after cleaning and weigh amount of sesame seeds Extrapolate to loss per hectare *Samples taken from three different cleaning machines in the Amhara and Tigray region*
Storage losses at ECX for exporters	Measure weight of bags when these are put in stores of exporters at ECX Measure weight of bags when these are taken out of store for sale at ECX (or others) *Same as previous. Results have been adopted by ECX as standard deduction from exporters.*

After the data collection finished, all data have been entered into Microsoft Excel. An analysis of the data was done by calculating means and percentages of losses per stage and in total, and by quantifying the losses in monetary value.

Finally, there are a few limitations to the (post-)harvest losses study. First, the samples sizes for losses at storage and processing were relatively small. Second, we have not been able to capture losses of all parts in the chain. These are: losses due to immature/green harvesting (not considered in study design), sesame seeds that fell out of the plastic sheets during threshing of *hillas* (not able to capture), and storage loss due to insect pest, diseases, and rodents (requires very complicated methodology that did not fit in the time frame of the study). In addition, we have not been able to collect data on storage losses at ECX and beyond (up to export), as this was beyond the scope of our study.

[2] ECX stands for Ethiopian Commodity Exchange, and is a regulated trading system through which most sesame needs to be traded for export. ECX has an open outcry in Addis Ababa, several local market centres and ECX licenced traders who conduct the sesame trade. Only cooperative unions, in-country processors and large investor farmers are allowed to directly export, in doing so, bypassing ECX.

Losses due to wind damage

Losses due to hilla carrying from field to threshing floor

Losses due to drying of hillas on the field

Losses due to sesame seed bugs and worms

Losses due to transport of sesame to spot markets

Losses due to sesame storage

Losses at spot market (re-bagging / cleaning)

Losses due to sesame cleaning for export

3. Results

3.1 Results yield study

3.1.1 Characteristics of respondents

This paragraph overviews characteristics of the respondents (see table 4). The average age of the respondents was 47 years (45 in Amhara and 49 in Tigray). The large majority of the respondents were male (93.5%).[3] Significantly more respondents from the Tigray region are cooperative members as compared to their peers from Amhara (84.4% versus 43.8%). This can be explained by the fact that, contrary to the Amhara region, Tigray has a specific cooperative for (large) investor farmers.

Table 4. Descriptive key characteristics of respondents

Basic characteristics		SBN region (Amhara + Tigray)	Amhara[1]	Tigray
Age respondents (years)		47.35	**45.35***	**49.58***
Male respondents[2](N) [%]		87 [93.5%]	46 [95.8%]	41 [91.1%]
Female respondents[2] (N) [%]		4 [4.3%]	2 [4.2%]	2 [4.4%]
Cooperative membership	Yes (N) [%]	59 [63.4%]	21 [43.8%]	38 [84.4%]
	No (N) [%]	34 [36.6%]	27 [56.3%]	7 [15.6%]
	Mean (0=no; 1=yes)	0.63	**0.44*** **	**0.84*** **
Land & crops characteristics				
Experience in sesame growing (years)		20.02	19.23 [n.s.]	20.87 [n.s.]
Total cultivated land (ha)		61.30	**39.95****	**84.59****
Sesame land size (ha)		39.55	**21.95****	**58.76****
Ratio sesame of total cultivated land (%)		60	57.4 [n.s.]	63.2 [n.s.]
Growing other crops?	Yes[3] (N) [%]	83 [89.2%]	43 [89.6%]	40 [88.9%]
	No (N) [%]	10 [10.8%]	5 [10.4%]	5 [11.1%]
	Mean (0=no. 1=yes)	0.89	0.90 [n.s.]	0.89 [n.s.]
Sesame as precursor crop on soil? (in 2012)	Yes (N) [%]	35 [37.6%]	9 [18.8%]	26 [57.8%]
	No (N) [%]	58 [62.4%]	39 [81.3%]	19 [42.2%]
	Mean (0=no, 1=yes)	0.38	**0.19*** **	**0.58*** **
Other crops as precursor on soil (in 2012)	Sorghum (N) [%]	31 [53.45%]	19 [48.72%]	12 [63.16%]
	Cotton (N) [%]	7 [12.07%]	5 [12.82%]	2 [10.53%]
	Teff (N) [%]	5 [8.62%]	5 [12.82%]	--
	Rice (N) [%]	1 [1.72%]	--	1 [0.053%]
	Fallow (N) [%]	14 [24.14%]	10 [25.64%]	4 [21.05%]

[1] Significance for these variables tested between Amhara and Tigray. Only significant if indicated with asterisks (*). * = Significant at 90%. ** = Significant at 95%. *** = Significant at 99%. N.s. = Not significant.

[2] Two respondents are missing, these were institutions, f.e. a regional government office (gender neutral)

[3] Mostly sorghum alone, or sorghum in combination with teff, cotton, millet and/or maize.

[3] Female farmers usually rent their land to others due to the intensive labour requirement of sesame production and because of their financial constraints.

With regards to farmers' agricultural production characteristics, farmers from both regions have an averaged 20 years of experience in sesame production. Table 4 shows that farmers in the Tigray region have significantly more hectares of cultivated land and sesame land, which can be explained by the large number of investor farmers in the Tigray region. In addition to sesame, 89.2% of the famers grow other crops (mostly sorghum alone or sorghum in combination with teff, cotton, millet and or maize).

Regarding crop rotation, more farmers in Tigray (57.8%) had sesame as precursor crop on the same soil in 2012) as compared to farmers in Amhara (18.8%). Sorghum is the major precursor crop for both regions (48.7% for Amhara and 63.16% for Tigray). Next to sorghum, both regions practice fallowing (24.14%), rotation of sesame with cotton (12.07%) and teff (8.62%). The major varieties sown in the area were Hirhir (48.4%), Setit 1 / Humera 1 (17.2%) and Gojam (16.1%).In Amhara region in addition to the above varieties, Kenya (5.41%) Abasena (5.41) and Tejareb (3.2%) were sown by farmers (this can be seen in table 12 in appendix 1).

3.1.2 Sesame production practices

This paragraph presents the results of the different management practices for growing sesame, as measured in the survey. The main results can be found in table 5 on the next page, while more detailed data on production practices can be found in the tables in appendix 1.

The major sesame production practices employed by farmers are land preparation, sowing, maintaining seed quality, fertilizer application, weed control methods, and weeding frequency. Table 5 shows that farmers in Tigray prepare their land (through ploughing) significantly more times (2.38 times) than Amhara farmers (1.42 times). The sowing method is mainly by broadcasting (97.8%), however 4.4% of the respondents in Tigray apply row planting.

The majority of the farmers (71% for both regions) conduct different practices to improve the quality of their seed. The dominant practice for seed quality improvement is selecting the best stand from the field (55.9% of the farmers of both regions). This is followed by cleaning/sieving the seed for Amhara farmers (10.4%), whereas Tigray farmers prefer to purchase improved seeds from Offices of Agriculture.

There is a significant difference among the two regions in fertilizer use. The majority of the farmers in Amhara (81.3%) do not use fertilizers, where as in Tigray the majority (71.1%) *does* use fertilizer. Reasons for not applying fertilizers in Amhara are: high expenses for fertilizer (20.8%), lack of knowledge on fertilizer use (18.8%), assuming land is fertile (18.8%), and low resistance to moisture stress (14.6%) (see table 10 in appendix 1). If fertilisers are applied, farmers use both Urea and DAP fertilizers, as done by broadcasting. Most farmers do not apply recommended rates of fertilisers (100 kg DAP and 50 kg UREA per hectare). With regards to weeding control methods, all farmers in Tigray and Amhara use hand weeding.

Table 5. Descriptive statistics sesame production practices

Production practices		SBN region (Amhara+Tigray)	Amhara	Tigray
Land preparation	1-4 times of land preparation (mean)[1]	1.88	**1.42*** **	**2.38*** **
Sowing method	Broadcasting (N) [%]	91 [97.8%]	48 [100%]	43 [95.6%]
	Rows (N) [%]	2 [2.2%]	--	2 [4.4%]
Conducting practices for quality seed improvement	Yes (N) [%]	66 [71%]	35 [72.9%]	31 [68.9%]
	No ((N) [%]	27 [29%]	13 [27.1%]	14 [31.1%]
	Mean (o=no. 1=yes)[1]	0.71	0.73 [n.s.]	0.69 [n.s.]
Seed quality practices (N) [%]	Select best stand from the field	52 [55.9%]	26 [54.2%]	26 [57.8%]
	Cleaning/sieving the seed	5 [5.4%]	5 [10.4%]	--
	Purchase improved seed from Offices of Agriculture	5 [5.4%]	--	5 [11.1%]
	Select best stand from field + sieve seed	6 [6.5%]	6 [12.5%]	--
	No response	25 [26.9%]	11 [22.9%]	14 [31.1%]
Fertilizer use	Yes (N) [%]	52 [55.9%]	**9 [18.8%]**	**32 [71.1%]**
	No ((N) [%]	41 [44.1%]	39 [81.3%]	13 [28.9%]
	Mean (o=no. 1=yes)[1]	0.44	**0.19*** **	**0.71*** **
Weed control method	Hand weeding (N) [%]	92 [98.9%]	47 [97.9%]	45 [100%]
	No response (N) [%]	1 [1.1%]	1 [2.1%]	--
Weeding frequencies	1-4 times of weeding (mean)	2.54	**2.34** **	**2.76** **

* = Significant at 90%. ** = Significant at 95%. *** = Significant at 99%. N.s. = Not significant.

3.1.3 Actual yields

This paragraph overviews the actual yields of farmers that was measured for the 2013 production season. These results can be seen in table 6 on the next page. The average yield of both regions was 449.88 kg / ha. An important outcome is that the average yields in the Amhara region are significantly higher (at confidence interval of 95%) than in Tigray (Amhara 480.42 kg / ha versus Tigray 419.42 kg / ha).

The difference between the regions can be explained by the shortage of rainfall in the 2013 production season in Tigray. This can be seen by the results in table 11 (in appendix 1), which shows that 86.7% of the Tigray farmers indicated that rainfall for 2013 had not been sufficient, and 91.1% of the Tigray farmers confirmed crop failure as reason for rainfall (as compared to only 25% in Amhara). This also leads to a significant difference (at 99% confidence interval) between Amhara and Tigray farmers on the question whether yields were increased compared to previous years (93.8% yes for Amhara, 51.1% for Tigray). Amhara farmers indicated good rainfall in their region (60.4%) as the main reason for their high yields, followed at distance by using improved varieties (10.4%), better weed management and using improved varieties and fertilizers (both 6.3%).

Table 6. Sesame yields (2013) per cluster and region

Region	Clusters	Yields Mean [st.dev]	Sign.
Amhara	Shinfa	441.32 [100.92]	
	Metema Yohannes – Kokit	498.58 [160.32]	
	Sanja	484.47 [149.83]	
	Abderafi	501.08 [48.25]	
	Total Amhara [N=45]	***480.42 [123.12]***	**
Tigray	Dansha	414.54 [94.67]	
	Adebay	466.33 [212.02]	
	KaftaHumera Sesame Producers & Sales Cooperative (KHSPC)	443.52 [121.92]	
	Maykadra	378.50 [73.56]	
	Maygaba	388.50 [17.18]	
	Total Tigray[N=45]	***419.42 [129.42]***	**
	Total [N=90]	**449.88 [129.30]**	

* = Significant at 90%. ** = Significant at 95%. *** = Significant at 99%.

Table 7 shows the yields as differentiated per micro, small, intermediate and investor farmers. Even though there are small differences between the groups, the results of one-way ANOVA tests show that yields are *not* significantly different between micro, small, intermediate and investor farmers in both regions. Explanations for non-significance can be the small sample sizes of the study and the relatively large standard deviations with farm sizes (especially for larger farms).

Table 7. Mean yields for Amhara and Tigray as compared to average sizes of farms

	SBN region Mean [St.dev.]	Amhara Mean [St.dev.]	Tigray Mean [St.dev.]
Micro (0-5 ha)	423.31 [113.65]	471.59 [125.75]	379.06 [83.59]
Small (5-10 ha)	437.80 [114.49]	454.38 [124.92]	393.61 [70.82]
Intermediate (10-30 ha)	461.28 [125.84]	471.16 [88.58]	450.94 [164.20]
Investor (>30 ha)	474.28 [153.57]	546.76 [141.38]	439.94 [150.41]
Total	**449.88 [129.30]**	**480.42 [123.12]**	**419.34 [129.42]**

Finally, the reason for measuring yields in both regions was to triangulate and verify the data that was collected in the SBN baseline, as well as provided by the *woreda* office of Agriculture. Table 14 (Appendix 1) shows that for 2012, the estimated average yield was 6,24 quintals / ha, and a total production of 3.1 million quintals for northwest Ethiopia (7 *woredas*). Our data shows lower productivity figures (450 kg per hectare), which would imply a total yield of 2.23 million quintals for the region. This is a difference of 870.000 quintals. This difference in results confirms the necessity of data measurement and triangulation.

3.2 Results (post-)harvest losses

3.2.1 Quantity and percentages of (post-)harvest losses

Table 8 below shows the quantity and percentages of (post-)harvest losses for each sesame handling stage that was measured. The quantities are shown in kilogram per hectare, and the percentages are relative to the average yield, as measured in the yield study.

The main result of this study is that the total loss of sesame, as measured during the different handling stages is **55.56 kg/ha**. Given that in 2013, almost 500,000 hectare of land was covered by sesame in northwest Ethiopia, this means an expected loss of 277,800 quintals of sesame. Based on the average productivity of 4.5 quintals / hectare (as measured in the yield study), which implies that from all sesame handled at the measured stages, **12.67% is lost**.

Looking at the different stages of losses, most sesame losses occur during drying of *hilla*s (5.54%), followed by pre-harvest plant shattering (3.25%), *hilla* transport to threshing sites (1.85%) and re-bagging at market centres (1.12%).

Table 8. Quantity and percentage of sesame losses for different handling stages

Loss factor	Kg/ha	% loss
Loss due to capsules shattered before harvest	13.62	3.25
Loss due to unharvested / uncut capsules	0.68	0.15
Drying of *hilla*s	24.98	5.54
Hilla carrying to threshing site	8.34	1.85
Transport loss from farm to market centre / store	0.46	0.1
Storage loss market centre and farmers' store	0.13	0.03
Loss due to re-bagging at market centres	4.71	1.12
Storage Losses at ECX for depositors	0.63	0.15
Storage Losses at ECX for exporters	0.105	0.02
Loss during cleaning / processing	1.91	0.46
Total loss	**55.56**	**12.67**

An elaboration of the causes for losses at each handling stage:

***Hilla* placement losses:** This loss is caused by many factors, due to opening of the pods prior to threshing:

1) When labourers leave the sesame bundles on the field for multiple days, upper parts of the bundle will be exposed to sunlight, open and shed its sesame seeds
2) Climatic factors, like strong winds destroy *hillas*. Also through excessive rainfall, with water running into the open capsules, subsequently, sesame seeds will fall out).
3) Disturbance of *hilla* by rodents, animals, insects (termites, sesame seed bugs) and dampness
4) Improper placement of *hilla*s (not stacking on clean and high-levelled spot areas, which also depends on the skills and experiences of labourers).

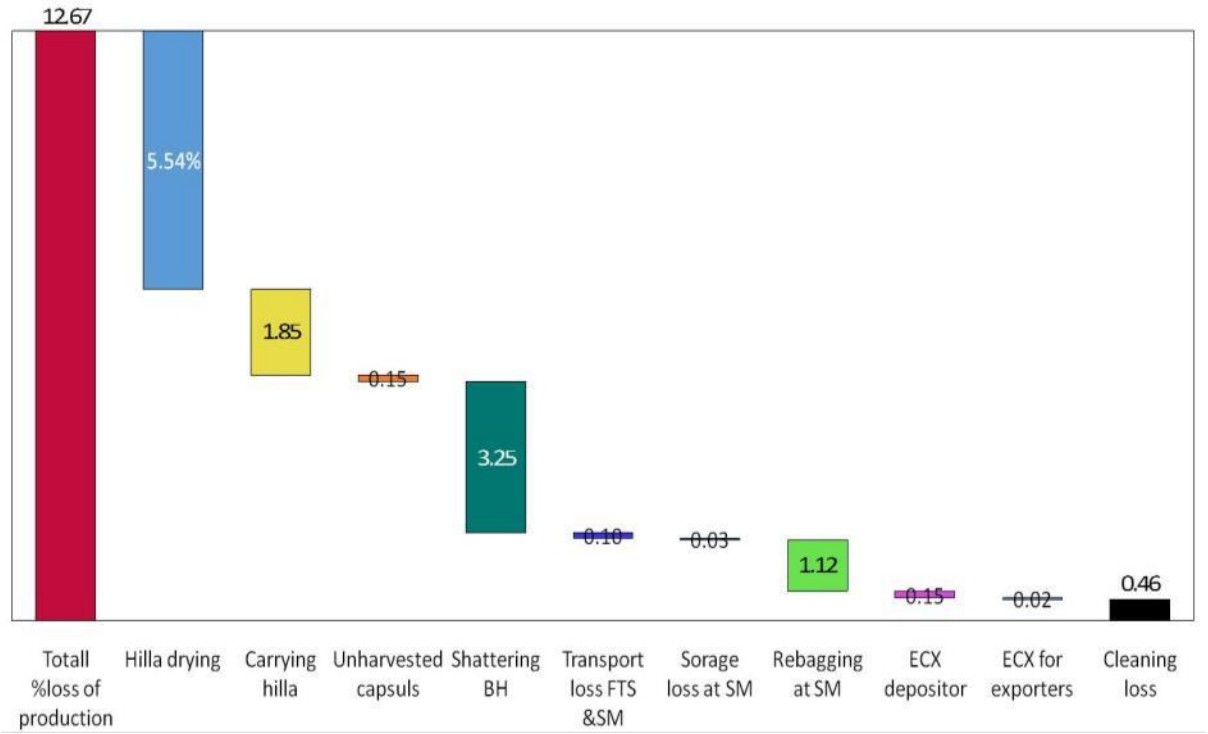
Non-uniform maturity (loss due to capsules shattering before harvest): This loss is caused when capsules in the lower portion of the plant mature earlier than those in the upper portion. This results in a poor filling of seeds in the capsules of the upper portion of the plant, which will have fewer weight and hence will get lost during winnowing. This is probably aggravated by the use of local and mixing of varieties by farmers and their poor access to clean and improved varieties.

Carrying *hillas* to threshing site losses: This loss is mainly caused by carrying *hillas* to threshing sites, movement and friction of the labourers through body contact with the plants, through holding the *hillas* askew (because of carrying of more bundles at a time), during handling and lifting the bundles, and by dropping bundles. The loss occurs especially at investor farms, where the *hillas* are dispersed at distant from each other and are far from the threshing ground/floor (hence *hillas* are carried over a larger distance and have higher possibilities to lead to losses). As well seasonal labourers operating at investor farmers treat the sesame with les scare than by family operating at small farmers, leading to higher losses).

***Hilla* transport and storage losses**: Losses occur through the use of old and damaged bags, which are improper sewn and are exposed to high temperatures, which can all lead to piercing of the bags. During transport of sesame to the market place, there are different sharp objects on the donkey carts and tractors that pierce bags. Another transport loss is caused by farmers who often put more than 120 kg of sesame in bags (which have the capacity to hold 100 kg). As a result, bags tear open and shed considerable amounts of sesame. Sesame losses during storage were mainly caused by the (poor) quality of the store, or during loading and unloading of the bags. In addition, samples of sesame are taken by traders, by using big spears that pierce bags and hence causes losses.

Finally, the percentages of the losses for each handling stage are portrayed in figure 2.

Figure 2. Percentages of losses for different sesame handling stages



3.2.2 Economic value of (post-)harvest losses

Table 9 shows how the quantity of losses for each sesame handling stage is converted into monetary value. In other words, it shows how much money is lost due to (post-)harvest losses in sesame.

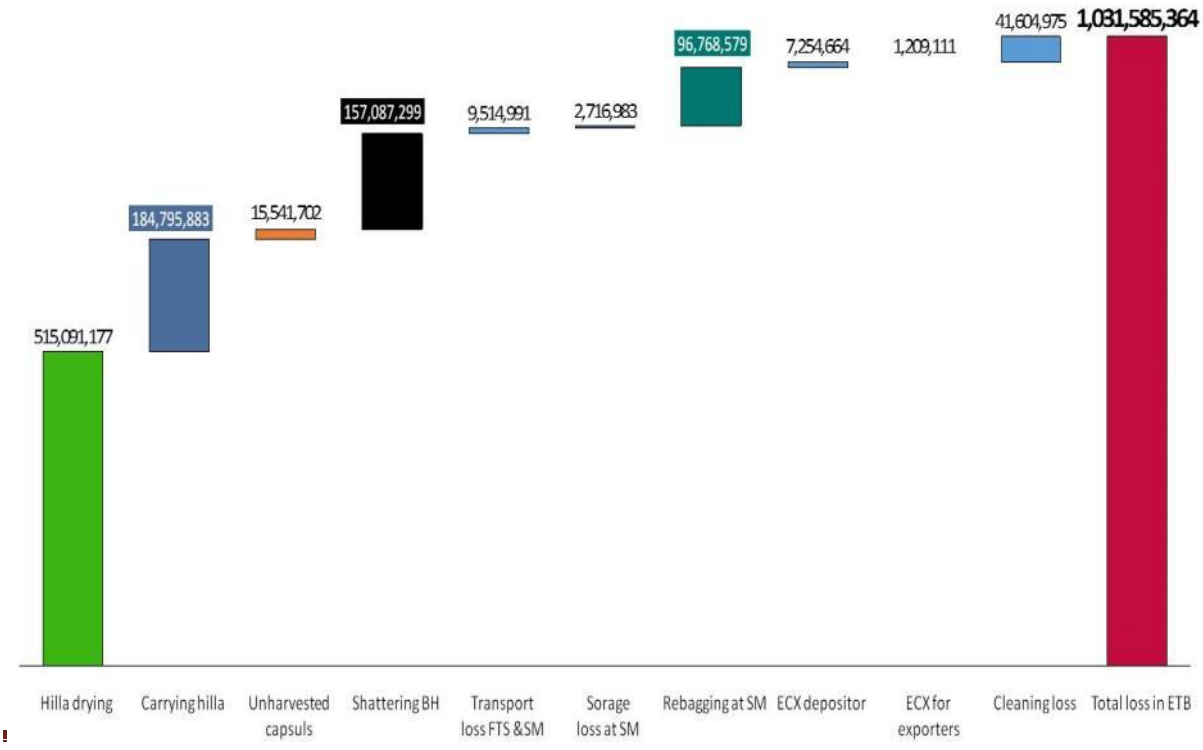
By using the ECX selling price of 4,000 ETB/quintal (average price for the 2013-2014 sesame marketing season), the total loss exceeds ETB 1 billion, which is more than 40 million euro and 50 million dollar. This translates in an important missed income for the country as well as for farmers (around 2,200 ETB/ha). Even when sesame prices would drop in subsequent years, the economic losses will still be significant. How much money is lost per each stage can be seen in table 9 and in figure 3 below.

Table 9. Economic losses caused by (post-)harvest losses, shown in ETB, USD, Euro

Losses at each stage	In ETB	In USD	In euro
Drying of *hillas*	515,091,177	25.6 million	20.6 million
Hilla carrying to threshing site/floor	184,795,883	9.2 million	7.4 million
Loss due to unharvested / uncut capsules	15,541,702	772,356	621,089
Loss due to capsules shattering before harvest	157,087,299	7.8 million	6.3 million
Transport loss from field to market centres / storage	9,514,991	472,853	380,265
Storage loss from market centre and farmers' store	2,716,983	135,022	108,584
Loss due to re-bagging at market centres	96,768,579	4.8 million	3.9 million
Storage losses at ECX for depositors	7,254,664	360,525	289,896
Storage losses at ECX for Exporters	1,209,111	60,088	48,316
Loss during cleaning/processing	41,604,975	2.1 million	1.6 million
Total economic loss	**1,031,585,364 (1 billion)**	**51.3 million**	**41.2 million**

Note: Losses in Ethiopian Birr (ETB) are converted to USD and euro on 01/12/2014 through www.xe.com.

Figure 3. Monetary value of losses for different sesame handling stages (in ETB)



3.2.3 Local solutions to recover losses

Due to considerable amounts of sesame losses in the field, local solutions to recover losses have arisen. A particular interesting story is the work of women of the *Kunama* tribe in northwest Ethiopia (see Box 1).

Box 1. Collecting lost sesame

Given the sesame losses in the field, harvesting time comes as a blessing for some Kunama women. For them, fallen sesame is an important source of income. Hawa first collects the left sesame in the field (after harvesting has finished), along with the dirt and other aggregates that clings to it.

She can collect between 5 and 35 kg of sesame in a day. In areas that are prone to windy conditions, the rates are even higher, up to 50 kg, as a result of damages to *hillas*. Hawa sieves what she collected using mosquito nets or porous cloth. After sieving, she takes the already some-what cleaned sesame to the nearby river or water source to wash and dry it. In some cases she is able to harvest and clean one quintal of sesame within two days.

In recent years, Hawa managed to collect 300 kg, which she sold for ETB 2,300 (approximately 92 euro). Her more valuable harvest fetched 7,000 ETB (280 euro). This income was generated without any investment in ploughing, planting, weeding, harvesting and threshing.

Hawa Anesha while separating the dirt from the seeds

The key message of this story is that there is a business in recovering sesame losses. In some cases there are arrangements made between farmers and different groups, who collect sesame on a recovery deal specifying a 50-50 share of the collected harvest. Because not all losses can be avoided, these arrangements are very important to recover losses. There are also other business minded farmers who do re-cleaning of sesame seeds that were lost during harvesting. Some of these farmers process this sesame into traditional sesame oil (see pictures below).

Drying cleaned and washed sesame

Local farmers cleaning lost sesame

Finally, the SBN support programme has produced a short documentary entitled *"The Long Road of Sesame and the Many Losses along the Way"*, which shows the significance and causes of harvest, transport, and storage losses in northwest Ethiopia.

4. Conclusions and recommendations

4.1 Yield study

4.1.1 Conclusions

Results of the yield study show that the major sesame production practices employed by farmers are ploughing, sowing, maintaining seed quality, fertilizer application, weeding control (methods) and weeding frequency. There are some differences in production practices between Tigray and Amhara farmers. Farmers in Tigray significantly plough their land more often, they use more fertilizers, and weed more times as compared to Amhara farmers.

The measured yields for the 2013 production season show that average yields of both regions was 449.88kg per hectare. The average yield in the Amhara region for 2013 is significantly higher (at confidence interval of 95%) than in Tigray (Amhara 480.42 kg /ha and Tigray 419.42 kg / ha). The difference between the regions can be explained by the shortage of rainfall in the 2013 production season in Tigray. With regards to yields for micro, small, intermediate and investor farmers, there have been no significant differences in both regions.

The reported yields of nearly 450 kg per hectare is remarkably lower than the estimates of 624 kg that was made by the *woreda* Office of Agriculture during the baseline of the SBN support programme (for the 2012 agricultural season). This, and given that our data has only recorded the yields on a relatively small sample size and during only one production season, demands a close monitoring of yield data of a large sample of farmers in both regions for a longer period of time. This allows for analysing the impact of different climatological conditions during the years.

In addition, a massive yield gap exist. Our reported average yields of 450 kg for the 2013 production year is much lower than potential yields in the region. The application of improved production technologies can lead to yields of 800 kg per hectare (at farmer plots and up to 1,500 kg under controlled research conditions).

This massive yield gap is largely caused by poor management practices of farmers. If all farmers will yield 800 kg instead of 450 kg, they would get an additional 14,000 ETB/ha (average ECX in 2013/2014 being 4000 ETB/quintal). With the total acreage of approximately 500,000 hectare, the additional production could have reached 1,750,000 quintal which is equivalent to more than 7 billion Ethiopian birr (280 million euro).

4.1.2 Recommendations and ways forward

Although this report on the yield study had not yet been finished for the 2014 sesame production season, the results were already shared within SBN and recommendations and practical options for ways forward have already been implemented by the SBN support programme and its partners in 2014.

In an attempt to improve the yields of farmers, and hence contribute to SBN's key objectives, the SBN support programme, in collaboration with the Ethiopian Institute of Agricultural Research (EIAR) and the Gondar Agricultural Research Centre (GARC) and Humera Agricultural Research Centre (HuARC), have developed a sesame production guide entitled *"20 Important Steps to Double Yields and Improve Quality of Sesame"*. The guide has been distributed to farmers, development agents and others in the 2014 production season. See box 2 for the key activities undertaken in 2014 to contribute to improving farmers' yields.

In 2014, the coaches of the SBN support programme, together with *woreda* Offices of Agriculture, have been providing field level support and technical backstopping to model farmers. Model famers have been recording operations and related costs in logbooks, for the purpose of conducting cost-benefit analyses and marginal rates of return on different recommended practices. These economic analyses, which will be shared with farmers, are meant to enhance farmers entrepreneurial capacities.

The SBN support programme and its partners, farmers and other stakeholders will evaluate the experiences of 2014 for further improvement of sesame production in northwest Ethiopia. Lessons learned will be harnessed for the efforts to improve yields and reduce losses. Key points of attention are access to inputs, credit and machinery (especially row planters).

Box 2. Practical implications taken in 2014 to improve yields of farmers

- Roll-out of improved sesame production practices in 3 *woredas* of West Tigray and 5 *woredas* of North Gondar
- 100,000 copies of the "20 Important Steps to Double Yields and Improve Quality of Sesame" guide have been published and distributed to farmers and others
- 793 model farmers and 291 development agents (1084 in total) have been trained as trainers of the application of improved sesame production technologies
- Improved sesame technologies were demonstrated on 916 plots in northwest Ethiopia; 502 in West Tigray and 414 in North Gondar
- 823 demo plots conducted in the fields of model farmers and 93 at Farmer Training Centres (FTCs)
- Over 75,000 farmers were targeted; most farmers have received the manual and at least 50,000 have visited field days
- Throughout the season, an average of two field days were organised in each demo plot during different stages in the maturation and management of sesame.

Based on the logbooks that will be monitored by large numbers of farmers and the ongoing monitoring and evaluation of the SBN support programme and its partners, data on yields and (improved) sesame production practices for the coming years will be available, analysed and published by the SBN support programme and its partners.

4.2 (Post-)harvest losses

4.2.1 Conclusions

The main result of the (post-)harvest losses study is that the total loss of sesame as measured during the different handling stages is **55.56 kg/ha**. With a land coverage of 500,000 hectare of sesame in 2013, this means a loss of 277,800 quintals of sesame. Using the average productivity of 4.5 quintals of sesame yields per hectare (result of the yield study), it means that a **sesame loss of 12.67**%. Based on the results of the current study, annual economic loss of sesame from the area covered with this crop in 2013 in northwest Ethiopia (i.e. 497,466 ha) and the average productivity of 4.5 quintals / ha with selling price of 4000 birr/quintal, **sesame losses exceeded 1 billion ETB,** which is **more than 40 million euro or 50 million USD**!

Sesame (post-)harvest losses are closely related to the management and handling of the product both at harvest and after harvest. Quantification of all sources of losses in the sesame chain (from production to consumption) requires diverse methods and resources. Our study has not captured the later stages in the value chain (from ECX handling and onwards), and for some measurements a small sample size is used.

Additional future research is therefore needed to measure sesame losses at all stages in the value chain, and to verify and triangulate the data from this study. Nonetheless, the information derived from this study is useful to quantify sources and the economic value of sesame losses in northwest Ethiopia, and leads to a number of recommendations on reducing these losses.

4.2.2 Recommendations and ways forward

Based on the data on sesame losses, different interventions have been introduced and tested with farmers in the 2014 sesame production season. The recommendations that are given in the text and in box 3 on the next page have been included in the "*20 Important Steps to Double Yields and Improve Quality of Sesame"* guide. In the coming years, the recommended interventions will be further tested, developed and evaluated, as to reach our target of a 30% reduction of the (post-) harvest losses of sesame in northwest Ethiopia.

Improving farmers awareness on (post-)harvest losses is important to increase the adoption levels of new techniques or to improve current techniques used by farmers. It is recommended to use clean, uniformly maturing and improved seeds. In addition, timely harvesting, the use of proper methods of harvesting, and proper care and handling of *hillas* and threshing sites are vital to reduce losses.

It is important to integrate new practices and introduce revised technologies for better understanding traditional practices and conditions that facilitate or hinder corrective measures. Therefore, changing traditional practices of stacking *hilla*s in a dispersed manner by gathering 10 and more *hilla*s and stacking them (using water permeable plastic or polyethylene bags or sheets) would be important to reduce the losses caused by *hilla* drying and transport. The use of these bags and sheets for reducing losses is currently tested by micro, small, intermediate and investor farmers.

Sesame should be properly dried and cleaned to avoid quality loss before storage. Equipping farmers, traders and exporters with storage and store management techniques and capacitating market

centres to have standardized storage facilities, would be important to reduce storage-related losses. Besides, introducing hermetic storage technologies for long periods of storage and for export should be considered.

Box 3. Overview of recommendations to reduce (post-)harvest losses

- Sesame should be harvested when 2/3 of plants and pods turn from green to yellow and prior to shattering. Too early and too late harvesting lead to high losses
- Gathering more *hilla*s to one place (> 10 *hilla*s) and use the same site for threshing
- Stacking *hilla*s parallel to wind direction and be placed in dry, levelled and well cleaned high spots
- It is recommended to use canvas or plastic sheets for threshing
- Drying *hilla*s should not last for more than two weeks
- Use alternative sesame bundle tying materials like threads
- Non-shattering variety development and use of wind break plantation could be used as a long term interventions
- Improve farmers awareness on (post-)harvest losses
- During transporting, bagged seed should be placed on smooth surfaces (carts, wheel-barrows, trucks). Placing plastic sheets in the floor of the trucks is advisable
- Use of improved (standardized) storage and store management techniques
- Use of hermetic storage technologies for long storage and export
- Improve the sampling methods and equipment for grading at both ECX and market centres
- Use standard sewing machine for making better quality of sesame bags

Some concrete ways forward and strategic issues for the SBN support programme:

- *Training and coaching in pre-and (post-)harvest management techniques, as part of the scaling out of the ' 20 steps'*
- *Further exploration of possibility of acquiring / developing non-shattering varieties*
- *Monitoring and evaluation of the use of plastic sheets at hilla sites*
- *More emphasis on storage handling practices*
- *Investments in infrastructure, storage and transportation, in collaboration with several stakeholders, including other projects*
- *Improving the sampling and grading system at ECX and other spot markets*

Long-term interventions to reduce (post-)harvest losses can be the development and introduction of non-shattering varieties and the use of windbreak plantation.[4] Moreover, investments in infrastructure can significantly contribute to reduce (post-)harvest losses in northwest Ethiopia. These can include the improvement of storage facilities, the access of good materials for packaging and storing sesame, adequate road and communication networks for timely transport, and basic infrastructure for optimizing spot market trade.

Finally, given the importance of sesame for Ethiopia, losses of sesame in the chain should be addressed not only at local, but also at regional and national level. The costs of losses are high. Besides, assessing costs loss reduction measures should be assessed better to judge if these pay off.

[4] Varieties currently scatter and therefore are highly dependent on careful human handling during harvesting. As labour is scarce and high losses during harvesting, the development of non-scattering varieties can be an important intervention to reduce harvesting losses.

Appendix 1: Descriptive statistics yield study

Table 10. Descriptive statistics fertilizer use

Additional info on fertilizer use		SBN region (Amh + Tigr)	Amhara	Tigray
Fertilizer use	Yes (N) [%]	41 (44.1%)	9 [18.8%]	32 [71.1%]
	No (N) [%]	52 [55.9%]	39 [81.3%]	13 [28.9%]
	Mean (o=no. 1=yes)	0.44	**0.19*** **	**0.71*** **
Fertilizer application method (if used)	Broadcast (N) [%]	26 [65%]	8 [100%]	18 [56.2%]
	Top dressing (N) [%]	3 [7.5%]	--	3 [9.38%]
	Broadcast + top dressing (N) [%]	11 [27.5%]	--	11 [34.38&
Type of fertilizer (if used)	DAP(N) [%]	7 [17.07%]	2 [22.22%]	5 [15.63%]
	Urea (N) [%]	6 [14.63%]	2 [22.22%]	4 [12.50%]
	DAP + Urea (N) [%]	28 [68.29%]	5 [55.55]	23 [71.88%]
Reason no fertilizer use (multiple answers possible)	Lack of knowledge (N) [%]	29 [31.2%]	9 [18.8%]	20 [44.4%]
	Unwillingness (N) [%]	2 [2.2%]	--	2 [4.4%]
	Initiate over growth (N) [%]	3 [3.2%]	1 [.1%]	2 [4.4%]
	Limited supply of fertilizer (N) [%]	11 [11.8%]	1 [2.1%]	10 [22.2%]
	Lack of knowledge + limited supply of fertilizer (N) [%]	5 [5.4%]	--	5 [11.1%]
	Lack of knowledge + low resistance to moisture (N) [%]	2 [2.2%]	--	2 [4.4%]
	Assuming the land is fertile (N) [%]	9 [9.7%]	9 [18.8%]	--
	High expense of fertilizer (N) [%]	11 [11.8%]	10 [20.8%]	1 [2.2%]
	Low resistance to moisture stress (N) [%]	9 [9.7%]	7 [14.6%]	2 [4.4%]

* = Significant at 90%. ** = Significant at 95%. *** = Significant at 99%..

Table 11. Descriptive statistics about rainfall and yields

Rain fall + yields influences		SBN region (Amh + Tigr)	Amhara	Tigray
Has rainfall been sufficient for sesame in 2013?	Yes (N) [%]	43 [46.2%]	37 [77.1%]	6 [13.3%]
	No (N) [%]	50 [53.8%]	11 [22.0%]	39 [86.7%)
	As mean (o=no. 1=yes)[1]	**0.46**	**0.77*** **	**0.13*** **
Crop failure due to shortage of rainfall?	Yes (N) [%]	53 [57%]	12 [25%]	41 [77.4%]
	No (N) [%]	40 [43%]	36 [75%]	12 [22.6%]
	As mean (o=no. 1=yes)[1]	**0.57**	**0.25*** **	**0.91*** **
Yields increased in comparison to previous years?	Yes (N) [%]	68 [73.1%]	45 [93.8%]	23 [51.1%]
	No (N) [%]	22 [23.7%]	3 [6.3%]	19 [42.4%]
	As mean (o=no. 1=yes)[1]	**0.76**	**0.94*** **	**0.55*** **
Reason high yield (as perceived by farmer)	Using improved variety (N) [%]	15 [16.1%]	5 [10.4%]	10 [22.2%]
	Better weed management (N) [%]	4 {4.3%]	3 [6.3%]	1 [2.2%]
	Good rainfall condition (N) [%]	30 [32.3%]	29 [60.4%]	1 [2.2%]
	Using improved variety + fertilizer (N) [%]	6 [6.5%]	3 [6.3%]	3 [6.7%]
	Other…..[2] (+29% non-response)	11 [11.8%]		
Reason low yield (as perceived by farmer	Shortage of rainfall (N) [%]	11 [11.8%]	1 [2.1%	10 [22.2%]
	Other[3] …..(N) [%]		--	9 [20%]
	No response (N) [%]	73 [78.5%]	47 [97.9%]	26 [57.8%]

[1] * = Significant at 90%. ** = Significant at 95%. *** = Significant at 99%.

[2] Row planting, good land preparation, early sowing, minimum tillage, rotation: all minor percentages given.

[3] Pest problem, high rainfall, poor distribution of rainfall, sowing, etc.

Table 12. Varieties used by respondents

Varieties used (N) [%]	SBN region (Amhara + Tigray)	Amhara	Tigray
Beshbesh	2 [2.2%]	2 [4.2%]	--
Gojam	15 [16.1%]	14 [29.2%]	1 [2.2%]
Hirhir	45 [48.4%]	17 [35.4%]	28 [62.2%]
Setit 1 / Humera 1	16 [17.2%]	--	16 [35.65%]
Abusufa	2 [2.2%]	2 [4.2%]	--
Kenya	5 [5.4%]	5 [10.4%]	--
Tejareb	3 [3.2%]	3 [6.3%]	--
Abasena	5 [5.4%]	5 [10.4%]	--

Table 13. Yields for SBN region, Amhara and Tigray as compared to varieties of sesame

Yields by variety	SBN region Mean [st.dev]	Amhara Mean [st.dev	Tigray Mean [st.dev
Beshbesh	446.46 [53.33]	446.46 [53.33]	--
Gojam	443.27 [134.93]	440.57 [140.04]	478,33 [n.a.]
Hirhir	445.74 [110.92]	530.22 [115.36]	400,49 [78.43]
Setit 1 / Humera 1	448.66 [190.39]	--	448.66 [190.39]
Abusufa	481.25 [2,96]	481.25 [2,96]	--
Kenya	453.33 [146.23]	453.33 [146.23]	--
Tejareb	398.61 [42.5]	398.61 [42.5]	--
Abasena	524.00 [122,38]	524.00 [122,38]	--

Table 14. Sesame area coverage as estimated by Woreda officials (2012 production season)

Woreda	Total cultivable land (ha)	Area allocated for sesame (ha)	Yield Estimation (qt)	Estimated Productivity qtl/ha
Welkait	64,160.25	25,796	189,292	7.34
Tsegede	96,129	32,734.6	198,905	6
K/Humera	376,398	222,575	1,386,143	6.23
Sub total	536,685	28,1105	1,774,340	6.3
Quara	-	43,295.5	259,773	6
M/Armachiho	-	90,482	588,133	6.5
Metema	-	60,731	392,929.57	6.47
Tach Armachiho	-	21,852	120,186	5.5
Sub total		216,360.5	1,361,021.57	6.12
Total		497,465.5	3,135,361.57	6.24

Appendix 2: Yields study questionnaire

Name		**Land location (Kebele&ketema)**			
Age		**Sesame acreage**			
Telephone number		**Cooperative**			
Experience in sesame farming		**Coop membership status**	**Yes**	----------	
			No	**Why? ----------**	

1	**General information**							
	1.1	Total land size : (you can use hectare or local measurement)						
	2.2	Land under cultivation :						
	2.3	Fallow land:						
	2.4	Is the rainfall sufficient for crop growth ?						
			excess			sufficient		
			insufficient			very low		
	2.5	Is there any record of crop failure in the area due to shortage of rain fall?						
			Yes			No		
	2.6	If yes, indicate the years?						
2	**Information on sesame production**							
	2.1	**Land Preparation**						
		A. frequency of land preparation						
		i. One times						
		ii. Two times						
		iii. Three times						
		B. Time of land preparation (Day/Month/Year)						
		i. First land preparation						
		ii. Second land preparation						
		iii. Third land preparation						
	2.2	**Sowing date and method**						
		A. date of sowing : (day, month, year)						
		B. Method of sowing						
		i. Row planting						
		ii. Broadcasting						
	2.3	Type of variety grown?						
	2.4	Do you try to improve planting seed quality? If yes how?						
	2.5	If your answer is yes what are the practices you do?						
	2.6	**Fertilizer application**						
		A. Type and amount of fertilizer used, (circle the answer)	i. DAP Yes No	---------- kg				
			ii. Urea Yes No	---------- kg				
		C. Method of fertilizer application						
		i. Side dressing		When?				
		ii. Broadcasting		i. during planting				
		iii. Other		ii. During flower initiation				

2.7	Do you use compost/organic fertilizer?						
		Yes			No		
2.8	If your answer is no what is the reason?						
	i. Lack of knowledge						
	ii. Unwillingness						
	iii. Other reason						
2.9	**Weed Control**						
	A. Method of weed control						
	i. pre-plant herbicide application						
	ii. Hand weeding						
	iii. Other method						
	B. If you use hand weeding						
	i. How many times it is weeded						
	ii. When weeding has done	First weeding					
		Second weeding					
		Third weeding					
2.1	**Insect pest and disease control**						
	A. Is there any insect outbreak?						
		Yes			No		
	B. If your answer is yes what was the type of insect pest?						
	C. Is there any disease outbreak?						
		Yes			No		
	D. If your answer is yes what was the type of disease?						
2.11	**Cropping system**						
	A. Do you grow other crops ?						
		Yes			No		
	B. If your answer is yes what are those crops?						
	C. What are the crops sown for the last three years?						
	2012 cropping season						
	2011 cropping season						
	2010 cropping season						
2.12	**Harvesting**						
	A. Date of harvesting						
	B. Yield/plot (20m *20m)						
	C. Is the amount of yield you get better than the previous years?						
		Yes			No		
	D. If your answer is yes what are the factors contributed to the yield increment?						
	i. using improved variety						
	ii. using fertilizer						
	iii. using row planting						
	iv. Other						
	E. If the yield is low what are the factors?						
	i. Shortage of rainfall						
	ii. Lack of improved seed						
	iii. pest problem						
	iv. High rainfall (unprecedented rainfall)						
	v. others specify						