



Summary of research for development ‘best practice’ technologies validated in the Africa RISING Endamehoni site in Ethiopia, 2013-2016

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Through action research and development partnerships, Africa RISING will create opportunities for smallholder farm households to move out of hunger and poverty through sustainably intensified farming systems that improve food, nutrition, and income security, particularly for women and children, and conserve or enhance the natural resource base.

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1. Introduction

In Ethiopia, the main aim of the Africa RISING project is to identify and validate solutions to the problems experienced by smallholder crop-livestock farmers. Some problems arise from the difficulties facing farmers in managing natural resources and achieving efficiencies from managing crops, trees, water and livestock together. These efficiencies are often influenced by other factors such as access to inputs and the reliability of markets. To address this complexity, Africa RISING takes an integrated approach to strengthen farming systems. It conducts participatory research that identifies technologies and management practices that work for farmers and take account of contextual issues like markets for inputs and outputs, community and other institutions and of the policy environments that influence farm households.

In Ethiopia, the project works in eight intervention Kebeles (the lowest administrative units in Ethiopia) in four woredas (or districts): Basona Worena, Sinana, Lemo, and Endamehoni in Amhara, Oromia, SNNP and Tigray regions, respectively.

In Endamehoni woreda the project has been working with different international, national, regional and local partners to assess and validate new technologies and practices on the ground. Key Africa RISING local partner institutions includes Endamehoni Woreda Bureau of Agriculture and administration offices, Southern zone Bureau of Agriculture, Mekelle University, Tigray Agricultural Research Institute(TARI), Alamata Agricultural Research Center (AARC), Mehoni Agricultural Research Center(MARC), Graduation with resilience to achieve sustainable development(GRAD) project, Maichew Agriculture Technical and Vocational Training College(TVET),and Tsibet and Emba Hasti peasant associations. Project research and on farm activities were led by different CGIAR centers such as ILRI, ICRAF, ICRISAT, CIAT, ICARDA, and CIP.

This report summarizes technologies validated/tested in the two Kebeles of Endamehoni woreda: Embahazti and Tsibet during phase one of the project implementation.

2. Area Description of Endamehoni woreda

The Demonstration of the improved feed trough and feed storage was done in the highland of Tigray region, Southern zone, Endamehoni woreda, and Tsibet and Embahasti Kebeles. Endamehoni is one of five rural woredas in Tigray's South Zone. The woreda capital, Maichew, is located 127 km from the regional capital (Mekelle) and 662 km far to north direction from Addis Ababa City.

Its area is approximately 612.33 km². Land use comprises 17,992 ha cultivated land, 16,910 ha forest and 1,094.5 ha under bushes and shrubs. According to the 2007 census, the total population of the woreda is 92,690 people (89,086 in rural areas and 3,604 in urban areas). The woreda's climatic zones are spread across lowland/kola (5%), temperate/weina dega (30%) and highland/dega (65%). Annual rainfall ranges from 600–800mm. In this district, Africa RISING is working in two Kebeles: Emba Hasti and Tsibet.

In general, markets are quite accessible. Visitors to rural areas will encounter a dry environment facing challenges of land degradation, deforestation, water scarcity and shortages of feed for livestock. Given its dryness, climate smart crop and feed interventions along with appropriate management recommendations have been prioritized by Africa RISING. The farming system of the woreda is crop-livestock mixed farming practice. The major crop grown in the area is wheat, Barley, Faba bean, field pea, lentil, potato, Ensasula. Sheep, cattle, poultry, pack animals and apiculture are also the major livestock reared.

3. Participatory variety selection (PVS)

Objectives

The main objectives of the participatory variety selection trial is to test and select new, early maturing, high yielding, marketable and suitable crop varieties and best agronomic practices in a participatory manner (research, extension and farmers together).

Methodology

Approach: multi-disciplinary and participatory approaches were used in undertaking the research. International, national and local institutions participated while validating technologies in the area. Researchers and experts participate in the implementation, evaluation and data collection activities. Farmers also participated in planting, managing and evaluation of the trials. For each trials mid-season evaluation during flowering /pod/grain-setting stages and end season evaluation at maturity stages were organized. Both men and women groups evaluated and ranked varieties with their own criteria. Finally, agronomic data (disease, maturity dates, straw and grain yield) were summarized and compared with farmers' evaluation rankings to select the best varieties.

Location: the research was conducted in Tsibet and Embahazti Kebeles of Endamehoni woreda, Southern zone of the Tigray regional state.

Participatory community Analysis (PCA): before conducting PVS group of researchers, development workers, local institutions and community members conducted PCA with aim of understanding livelihoods, identifying challenges and opportunities in the area.

Site selection: The history of a field to be used for wheat, barley, field pea, and lentil PVS is very important. The cereal legume crop rotation were considered during the site selection. For potato production the field should have a history of being free of bacterial wilt or other soilborne pathogens. The previous crops should not belong to the same plant family (Solanaceae) such as potato, tomato, pepper and egg plants. Ideally legumes such as peas or beans should have been grown on the field; however, cereals such as teff, barley and wheat are also good as previous crops. In addition to the crop history of the field, its accessibility to organize field visits were considered. Therefore, these sites were selected taking all the above points into consideration.

3.1. Potato

Treatment: *Four Potato varieties tested:* Gudene, Jalene and Belete plus locally grown potato

Plot size: 10m * 10m per treatment per farmer replicated in 3 farmers per site in two sites.

Duration: two seasons (2013 & 2014)

Land preparation: 3 to 4 times ploughing was used until fine bed preparation

Seed rate: depending on the tuber size 1800 to 2000 kg of potato tuber per hectare of land

Spacing: 75 cm between rows and 30 between plants for ware potato and 60 by 25 cm for seed potato

Fertilizer rate and time of application: 195 kg of DAP and 165 kg/ha of UREA. DAP is applied at the time planting but UREA was split in to three with 1/3 applied at the time of planting 1/3 during the first hilling (after 40 days of emergence) and 1/3 at the time of second hilling (6-8 weeks after emergence).

Cultivation/hilling: three times hilling with first hilling after 40 days of emergence and second hilling after 6-8 weeks of emergence. Weeds were controlled during hilling.

Late blight control: the varieties used are late blight tolerant but in case there is symptom of late blight it was recommended to use Redomil at the rate of 2 lt/ha in about 360 lit of water. **Tuber harvesting:** Ware potato crops were harvested when tubers mature, that is the foliage has dried up and the tuber's skin was firm and cannot be removed by lightly rubbing the tubers with fingers.

Data collected: both quantitative and qualitative data were collected. Yield data, and participatory Mid-season and final evaluation were conducted. Data on cost of production were also collected

3.1.1. Research findings

Summary of yield of potato varieties are summarized in Table 1. In all sites belete out yielded all other varieties followed by Jalene and Gudene with an average yield of 46.93, 40.01 and 38.93 t/ha, respectively.

Mid-season and end season potato variety evaluation was done by both male (21) and female (17). The results of the evaluation by each criteria are summarized in the table 2 and 3. In both male and female evaluation Belete ranked first for its yield followed by Gudene and Jalene. The local variety was ranked last for its yield, maturity period and other quality attributes.

The results of partial budget analysis revealed that the use of improved potato varieties with its packages resulted in the net benefit of 122,535 Birr/ha compared to the use of local variety and practice (43,920 Birr/ha). The Marginal Rate of Return (MRR) in the use of improved potato varieties with its packages is 333%. This implies that every unit of investment in the use of improved potato varieties with its packages resulted in about 3.33 Birr/unit extra returns. Considering the rule of thumb of marginal analysis, the percentage of MRR on the use of improved potato varieties with its packages compared to the local variety and practice is profitable. Therefore, much effort is needed to promote on the use of improved varieties with its cultural practices to tap these benefits.

Both the yield data and economic analysis suggests on the feasibility of using the improved varieties with their packages. Therefore, it is recommended to scale-out these varieties with their packages to similar agro-ecologies in Tigray region and beyond.



Photo 1: Potato PVS at Embahasti Kebele, 2014

Table 1: Mean Yield (t/ha) of potato participatory variety Selection in Tsibet and Endamehoni for 2013 and 2014

Variety	# of farmers	Average yield t/ha		
		Emba hasti	Tsibet	Mean
Belete	6	46.20	47.65	46.93
Gudene	5	42.05	35.80	38.93
Gera	3	30.45	35.50	32.98
Jalene	2	40.72	39.30	40.01
Local	3	12.00	16.80	14.40

Table 2: Ranking of potato varieties tested under PVS, by Male farmers (15 farmers)

No.	Attributes	Potato varieties			
		Belete	Gudena	Jalene	Local
1	No. of tubers /plant	1	2	2	3
2	Average weighy of single tuber/plant	1	2	2	3
3	Total yield of tubers	1	2	2	3
4	Marketable tuber yield	1	2	2	3
5	Unmarketable tuber yield	1	1	1	2
6	Eye deepness	2	2	2	2
7	cooking time	0	0	0	0
8	Disease tolerance	2	2	2	3
9	Pest tolerance	2	1	2	1
10	Maturity period	1	1	2	3
		12	16	16	21

Note: Rating scale: 1=Excellent; 2=Very good; 3=Good/medium; 4=Poor; 5=Very poor

Table 3: Ranking of potato varieties tested under PVS, by Female farmers (11 farmers)

No	Attributes	Potato varieties			
		Belete	Gudena	Jalene	Local
1	No. of tubers /plant	1	2	2	3
2	Average weighy of single tuber/plant	1	2	2	3
3	Total yield of tubers	1	2	2	3
4	Marketable tuber yield	1	2	2	3
5	Unmarketable tuber yield	1	1	1	2
6	Eye deepness	2	2	2	2
7	cooking time	NA	NA	NA	NA
8	Disease tolerance	2	2	1	1
9	Pest tolerance	2	2	2	1
10	Maturity period	1	2	2	3
		12	17	16	21

Table 4: Partial budget analysis of PVC of the improved variety and management practices with a local variety

		Betete (preferred new variety)			Local variety			Difference
Main crop	Units	Yield	Price	Total	Yield	Price	Total	
Marketable tuber yield (t/ha)	tonne	46.92	3500	164,220	14.4	3500	50,400	
Sub-total			A	164,220			50,400	113,820
Other								
Unmarketable tubers	quintal	1.5	1500	2250	2.5	1500	3750	
Sub-total			B	2250			3750	-1,500
Total Output value		A+B		166,470			54,150	112,320
Purchased Inputs	Units	Amount	Price	Total	Amount	Price	Total	Difference
Seed	quintal	20	1,200	24,000	5	600	3,000	
Sub-total			I	24,000			3,000	21,000

Fertiliser								
DAP	kg	195	14.5	2827.5	100	14.5	1450	
Urea	kg	165	13.5	2227.5	50	13.5	675	
Sub-total			II	5,055			2125	2,930
Chemical								
Ridomil applied to both			III	-			-	Same for both
Other								
Packing material	sacks	480	10	4800	15	11	165	
Sub-total			IV	4800			165	4635
Total purchased inputs		(I+II+III+IV)		33,855			5,290	28,565
Outputs less purchased inputs	(A+B)(I+II+III+IV)	132,615			48,860	83,755		
Labour + draft animals	Unit	No	Cost	Total	No	Cost	hours	Difference
Land preparation	days							Same for both
Planting	days	24	80	1920	15	80	1200	
Fertilising	days							Same for both
Weeding and ridging	days	48	70	3360	32	70	2240	
Harvest	days							Same for both
Transport	quintal	48	100	4,800	15	100	1500	
Selling	days							
Total labour and draft animals			V	10,080			4,940	5,140
Total purchased inputs and labour				43,935			10,230	33,705
Total outputs less costs				122,535			43,920	78,615
Benefit: cost ratio (B:C) ¹				3.79			5.29	
Marginal rate of return (MRR) ²				3.33			-	

3.2. Faba bean

Treatment: Gebelcho, Tumsa, Dosh and local varieties were tested.

Plot size: 10m *10m for each treatment and replicated in 2 farmers.

Duration: one seasons (2014 and 2015)

Land preparation: two times ploughing was made

Seed rate: 2000 kg/ha

Spacing: between row 40 cm and 10 cm b/n plant

Fertilizer rate: 100 kg DAP/ha at planting

Weeding: three times

Chemical application: Redomil chemical was applied three times in ten days interval after the first 30 days; 2.5 Kg of Redomil and 160 liter of water per hectare)

3.2.1. Research findings

General finding from the two years on farm research result

After applying all the above management practices Gebelcho, Tumsa, Dosh and local varieties were provide 61.6, 59, 57 and 48 Quintal of grain yield per hectare respectively. Among the tested varieties the highest yield was recorded for Gebelcho and Tumsa varieties. The varieties provide more and more yield as the rain/moisture availability is good. The redomil chemical application well prevent the severity and the incidence of the faba bean gall disease. Currently without applying the chemical it is not possible to produce faba bean. Faba bean production is much economical and profitable, the price of fabe ban is almost two times higher than wheat. In addition to its high grain yield potential; the variety has also high biomass for livestock feed. Since the Redomil is fungicide chemical it did not affect the beekeeping like insecticide.

The results of partial budget analysis showed the use of improved faba bean varieties with its packages resulted in the net benefit of 80350 Birr/ha compared to the use of farmers practices (13740 Birr/ha) which is 5.8 time higher than the farmers practice. The Marginal Rate of Return (MRR) in the use of improved Faba bean varieties (Gebelcho) with its packages is 600%. This implies that every unit of investment in the use of improved faba bean varieties with redomil chemical and other packages resulted in about 6 Birr/unit extra returns.

Both the yield data and economic analysis suggested the use of improved faba bean varieties, row planting, redomil chemical, and weed control are more profitable.

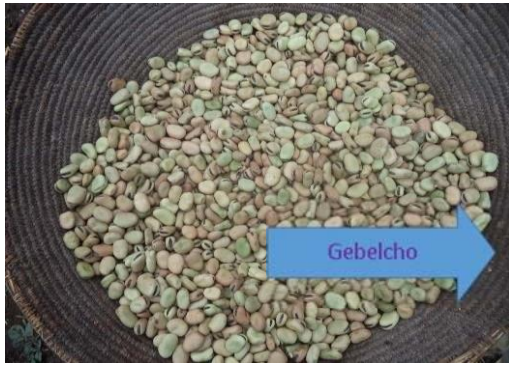
Table 5: Yields and farmers evaluation rank for tested Faba bean varieties

Research Kebele	Trial year	Varieties	Grain yield quintals/ha	Straw yield quintals/ha	Farmers evaluation rank	Remark
Embahasti and Tisbet	2014	Gebelcho	61.6	64	1	
		Tumsa	59	62	2	
		Dosha	57	64	3	
		Local	48	57	4	

Photo 2: Faba Bean PVS performance at the field level-2014 Embahasti



Besides demonstrating improved varieties in smaller plot Africa RISING project were multiply some selected varieties on few farmers field for further promotion and to foster farmer to farmer seed exchange. In 2015 main cropping season at community seed multiplication field farmers applied same inputs and agronomic practices like the participatory varieties selection trials and produced from 54-63 q/ha with good straw/feed, while the other farmers field is totally devastating by the faba bean gall disease.



Gebelcho



Row planting



Red ches



Gebe Performa



Far f dam w F g dis

Photo 3: Faba bean (Gebelcho) varieties seed multiplication and disease control.

Table 6: Partial budget analysis of Faba bean (Gebelcho) production and redomil chemical application for faba bean gall disease control.

Inputs type and costs	Farmers practice	Improved practices	Remarks
Fertilizer	0	1600	
Labor for fertilizer application and seeding	0	480	
Chemical cost	0	6750	
Labour for chemical application	0	600	
Labour for weeding	$(35*60) = 2100$	2700	
Labor for harvesting and threshing	$(16*60) = 960$	1920	
Grain yield Q/ha	10.5	61	
Straw yield Q/ha	20	77.5	
Grain selling price /Q	1600	1600	
Straw selling price/Q	0	0	Wasted on the field, not stored because of its spoilage nature.
Total cost/ha	3060	14050	
Total revenue/ha	16800	97600	
Net benefit	13740	80350	Plus 57.5 Q of straw
Benefit cost ratio	5.49	6.94	
MRR	6.06		

3.2.2. Recommendations

Recently the faba bean is becoming out of production because of the serious fungal disease. Improved varieties resist disease and moisture shortage, crop rotation, and weed control lower the disease incidence. Improved varieties (Gebelcho), row planting, proper seed rate, fertilizer application (DAP), and chemical application (Redomil), weed control as listed in the trial management part helps to control the fungal disease and increase the faba bean production. Using of improved varieties with its full package is more profitable. Therefore faba bean production is sound in economically, environmentally and in nutrition aspect. With Faba bean helps to improve the soil fertility, balance both animal and human diet. Therefore, much effort is needed to promote on the use of improved varieties with its disease management and other cultural practices to get all these benefits.

3.3. Bread wheat

Treatment: Mekele-4, mekele-3, Mekele-1 and Hidassie varieties were tested.

Plot size: 10m *10m for each treatment and replicated in 2 farmers.

Duration: two seasons (2013 and 2014)

Research recommendation

Land preparation: 3 to 4 times ploughing was used until fine bed preparation

Seed rate: 125 kg/ha

Spacing: B/n row 20 cm and drilling

Fertilizer rate: 100 kg DAP/ha at planting and urea 100 kg/ha in split application (50% at planting and 50 % top dressing)

Weeding- three times weeding was carried out.

3.3.1. Research findings

Mekele-4, Hidassie, Mekele-3 and mekele-1 wheat varieties tested in participatory way and recorded average grain yield of 80, 66.6, 54.95, and 54 quintal per hectare respectively. Among the tested varieties Mekele4 gave the highest yield, at fertile plot with good rainfall mekele-4 can yield 94 Quintal per hectare (2013 variety selection trial). From the two year trial an average grain yield of 80 quintal per hectare were recorded for which is 20, 46 and 48% higher than the yield of Hidase, Mekele 3 and Mekele 1 respectively. Besides, farmers preferred Mekele 4 for its spike size, tillering capacity, marketability and bread quality. In addition, research findings of Alamata agricultural research Center in 2015 indicated moderately resistance reaction to stem and yellow rust, which are threatening wheat production in Ethiopia in general and In Sothern Tigray in particular. Hiddasie was the second high grain yielding variety (66.6 Q/ha) and the first in stray yield (88 Q/ha).

Table 7: Yield and farmers evaluation rank for tested wheat varieties

Resear ch Kebele	Tri al ye ar	Select ed Whea t Varie ties	Grain yield quintals /ha	Str aw ye ld	Farmer s evaluat ion rank	Remarks
Tsibet and Embah asti	20 13 and	Meke le- 4	80	81	1	Farmers prefer Mekele -4 for its tillering capacity, spike size, marketin g and
		Hidas e	66.6	88	2	
		Meke le 3	54. 5	70. 2	4	

	20 14	Meke le 1	54	62. 5	3	home consumpt ion.
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Photo 4: Wheat PVS and field visit at Tsibet Kebele -2014

3.3.2. Recommendations

Mekele4 and Hidassie varieties with its full agronomic practice can increase the wheat production up to 80 quintal per hectare and above. Therefore the two varieties should be scaling further in highland areas which have relatively good rain fall and areas like Tsibet, Embahasti Kebeles and in other similar agro-ecologies with optimum moisture.

3.4. Food barley

Treatment: HB1307, Cross 41/98, HB 1493 and local varieties were tested.

Plot size: 10m *10m for each treatment and replicated in 2 farmers.

Duration: one seasons (2014)

Land preparation: 3 to 4 times ploughing was used until fine bed preparation

Seed rate: 100 kg/ha

Spacing: Between row 20 cm and drilling

Fertilizer rate: 100 kg DAP/ha at planting and urea 100 kg/ha in split application (50% at planting and 50 % top dressing)

Weeding- three times weeding was carried out

3.4.1. Research findings

Three varieties of food barley, Namely HB1307, Cross 41/98, HB1493 were tested and average grain yield of 72.5, 47, and 46.5 quintal per hectare recorded respectively. Among the tested the highest grain yield was recorded for HB1307 varieties (72.5 quintal/hectare). In addition to its productivity potential it high logging resistant and there is no yield reduction due to logging and associated problem (rodent attack). The white grain color also makes it more marketable than the other varieties. Farmers also found HB1307 the best food barley variety for home consumption.

Table 8: Yield and farmers evaluation rank for tested food Barley varieties

Resear ch Kebele	Varieties	Tri al ye ar	Grain yield quintals /ha	Str aw yield Q/ H	Farmer s evaluat ion rank	Remarks
Tsibet and Embah asti	HB13 07	20 14	72.5	10 7	1	Good plot and managem ent
	Cross 41/98	20 14	47	11 5.5	4	
	HB 1493	20 14	46.5	10 5.5	2	

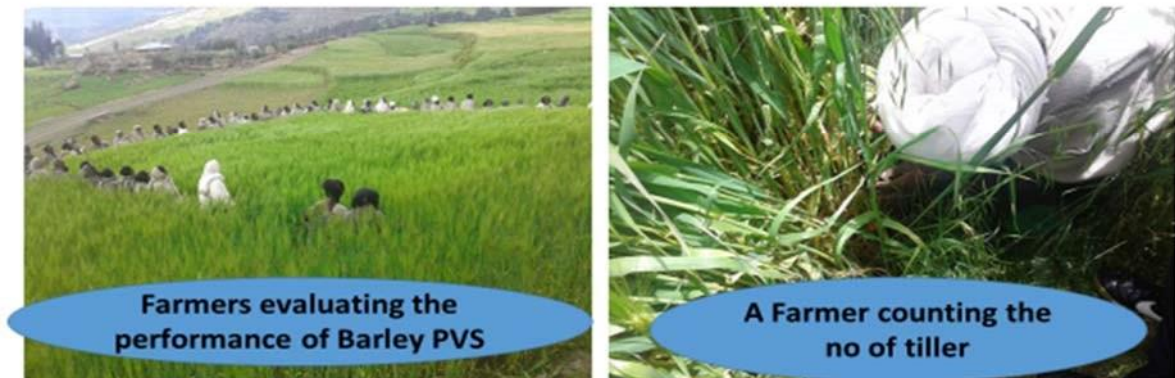


Photo 5: Farmers evaluating Barley PVS at Tsibet Kebele

3.4.2. Recommendations

Improved barley varieties like HB1307 can increase the barley production more than 72 quintal per hectare. In addition to its high grain yield potential HB1307 is high lodging resistant varieties and can be planted at fertile farms. It is also the most preferred barley varieties for home consumption and market. Therefore HB1307 with its agronomic practice should be scale up to the highland areas of Tigray and other similar agroecology to increase the barley production and productivity.

3.5. Malt barley

Treatment: Bekoji, Holker, and M-21 varieties were tested.

Plot size: 10m *10m for each treatment and replicated in 2 farmers.

Duration: one seasons (2014)

Land preparation: 3 times ploughing was used until fine bed preparation

Seed rate: 100 kg/ha

Spacing: between row 20 cm and drilling

Fertilizer rate: 100 kg DAP/ha at planting and urea 100 kg/ha in split application (50% at planting and 50 % top dressing)

Table 9: Yield and farmers evaluation rank for tested malt Barley varieties

Research Kebele	Varieties	Trial year	Grain yield quintals/ha	Straw yield Q/H	Farmers evaluation rank	Remark
Tsibet and Embahasti	Bekoji	2014	43.25	93	3	
	Holker	2014	54.25	98	1	Select ed varieties
	M-21	2014	55.5	95.5	2	Select ed varieties
	Local Check	2014	34	80.5	4	

3.5.1. Research findings

Bekoji, holker, M-21, and local malt barleys tested; Holker and M-21 are selected for its high grain yield potential; 54.25 and 55.5 quintal per hectare of grain respectively.

3.5.2. Recommendation

To respond the expansion of brewery factory and its malt demand, linkage with the factory should be done, testing the malt quality of the barley and creating agreement between the factory and farmers should be done to substitute import with domestic production.

3.6. Field pea

Treatment: Bilalo, Megeri, Markos, Gume and Burkitu varieties were tested.

Plot size: 5m*5m for each treatment and replicated in 4 farmers.

Duration: one seasons (2015)

Land preparation: two times ploughing was made

Seed rate: 150 kg/ha

Spacing: between row 20 cm and 10 cm b/n plant

Fertilizer rate: 100 kg DAP/ha at planting

Weeding: three times

3.6.1. Research findings

From trial result it was found that grain yield of 43.28, 42.9, 40.08, 38.16 and 32.9 quintal per hectare for Bilalo, Megeri, Burkitu, Gume and Markos varieties respectively. Bilalo and megeri are the first and the second varieties both in their grain yield and farmers evaluation rank. In addition the varieties are also mature earlier than the local variety.



Photo 6: Field Pea PVS - 2015

3.6.2. Recommendations

Bilalo and Megeri field pea with the recommended inputs and management practice can provide more than 42 and 43 quintal grain yield per hectare. Therefore the two varieties can be scale up-out in the high land areas like Embahasti, Tsibet and other similar agro-ecological areas.

Table 10: Yield and farmers evaluation rank for tested field pea varieties

Research Kebele	Trial year	Varieties	Grain yield quintals/ha	Straw yield quintals/ha	Days to maturity	Farmers evaluation rank	Remark
Emba Hasti and Tsibet	2015	Bilalo	43.28	54.84	150.33	1	Selected variety
		Megeri	42.9	40.44	144.66	2	Selected variety
		Markos	32.90	47.52	150.33	4	
		Gume	38.16	49.97	144.66	3	
		Burkitu	40.08	46.08	145.66	3	

3.7. Lentils

Treatment: Alem tena ,Alamaya, Chekol ,Denbi and Derash varieties were tested.

Plot size: 5m *5m for each treatment and replicated in 4 farmers.

Duration: one seasons (2015)

Land preparation: two times ploughing was made

Seed rate: 80 kg/ha

Spacing: between row 20 cm

Fertilizer rate: 100 kg DAP/ha at planting

Weeding: three times

3.7.1. Research findings

From trial result it was found 28 and 26.5 quintal of grain yield and 43.5 and 47.6 quintal of straw per hectare for Derash and Alemaya lentil varieties respectively. These varieties grain yield are almost two times higher than the farmers' production. Farmers during the mid and end season evaluation ranked Derash and Alemaya in the first and the second place. In addition the varieties are also mature earlier than the local variety.

Table 11: Yield and farmers evaluation rank for tested Lentil varieties

Research Kebele	Varieties	No of replication	Trial year	Grain yield quintal s/ha	Straw yield quintal s/ha	Days to maturity	Farmers evaluation rank	Remark
Emba Hasti and Tsi	Chekol	4	2015	21.22	32.84027	119.5	5	
	Alem Tena	4	2015	23.86	32.63973	121.5	3	

be t	Derash	4	2015	28.06	43.51503	128.5	1	Select ed variety
	Alemaya	4	2-15	26.58	47.66063	125.5	2	Select ed variety
	Denbi	4	2015	23.92	42.17462	133.5	4	

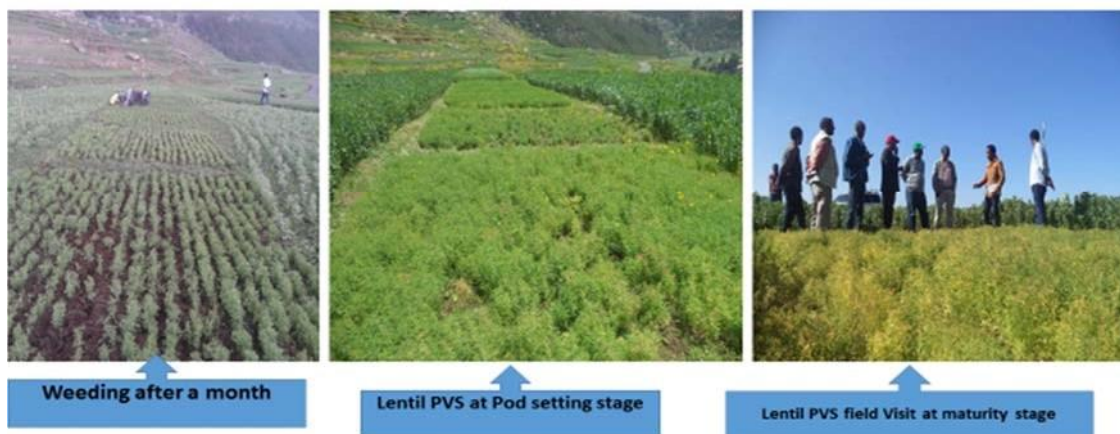


Photo 7: Lentil PVS performance and field visit -2015

3.7.2. Recommendations

In the highland areas there are only few cash crops, Lentil can be one of the cash source for the farmers. Derash and Alemaya varieties will increase the lentil production by half and can be scale to the highland areas using the above input and management practice.

3.8. Durum wheat

Treatment: Bakalcha, Mangude, Ude, Yerer, and Ginchi varieties were tested.

Plot size: 5m *5m for each treatment and replicated in 4 farmers.

Duration: one seasons (2015)

Land preparation: three times ploughing was made

Seed rate: 150 kg/ha

Spacing: between row 20 cm and drilling

Fertilizer rate: 100 kg DAP/ha at planting and urea 100 kg/ha in split application (50% at planting and 50 % top dressing **Weeding:** three times

3.8.1. Research Findings

Ude variety grain yield was 66.7q/ha that exceeds mangude, bakalcha, yerer and Ginchi by 24.4, 24.8, 31.8, 46.4% respectively. This variety also showed nearly similar maturity days with the rest tested varieties. Farmers also preferred this variety for its high tillering capacity and good stand. Besides, Alamata Agricultural Research Center research findings showed durum wheat are more resistance to rust diseases than bread wheat.

Table 12: Yield and farmers evaluation rank for tested lentil varieties

Research	Varieties	No of replication	Trial year	AV Grain yield quintals/ha	AV Straw yield quintals/ha	AV Days to maturity	Farmers evaluation rank	Remark
Emba Hasti and Tsi bet	Bakalcha	4	2015	53.42	52.92	154.75	4	Selected variety
	mankude	4	2015	53.62	57.22	160	2	Selected variety

Ude	4	2015	66.72	50.6	160	1	Select ed variety
Yerer	4	2015	50.87	73.62	160	3	
Ginchi	4	2015	45.55	68.37	153.25	5	



Photo 8: Drum wheat PVS - field visit and evaluation -2015

3.8.2. Recommendations

Ude and mankude can be recommended for further scaling up activities in the study Kebeles and in other similar agro-ecologies of Tigray or/and Ethiopia, but as durum wheat is industrial crop, grain quality of the variety is as important as amount produced. Hence, the quality produced has to be confirmed if it fulfills the requirements of the industry. Then Linkage between spaghetti factories and producers should be created to scale up the varieties further.

4. Livestock feeds and forages

4.1. Improved feed trough and storage

4.1.1. Introduction

Ruminants are major asset for rural households throughout the country in general and Tigray region in particular. The regions have crop-livestock mixed farming system. Most of the area in the region is dominated by hillsides and sloppy areas which lead to fragmented and farm land shortages, then the small scale farmers are forced to cover this small farm land using crops to full fill their food shortage. The uncontrolled grazing system was also aggravated the soil degradation and erosion. Due to the above challenges livestock of the rural areas are characterized by feed shortage in quality and quantity. Crop residue is becoming the major feed source of animals in the area. But farmers are also observed practicing poor management and low efficient utilization of the crop residue that expose to large wastage during storage and feeding their livestock. Then to alleviate the problem, complementary efficient feed utilization, storage system and feeding management options need to be developed. Therefore this manual can help the small scale farmers to reduce wastage of crop residue biomass during, storage, utilization and increase their income through improve their animal productivity.

4.1.2. Main objectives

- To Create farmers awareness on how to preserve/store and efficient utilization of their crop residue
- To reduce the damage and wastage of crop residue during storage and feeding
- To promote cereal-pulse straw mix storage (in quantity* and quality*)

4.1.3. Materials and methods

Approach

Demonstrations of the improved feed trough and feed storage were done in the highland of Tigray region, Southern zone, Endamehoni woreda, and Tsibet and Embahasti Kebeles. Endamehoni is one of five rural woredas in South Zone of Tigray. The woreda capital, Maichew, is located 127 km from the regional capital (Mekelle) and 662km far to north direction from Addis Ababa City.

The Improved model feeding trough and storage was constructing in the interested small scale farmers that have dairy cattle and sheep and willing to provide locally available materials for the feed trough and storage construction.

Specification of the trough

The feed trough type was single and double faced and constructs to serve 3-6 animals at a time. The feed trough was constructed 40cm height above ground and 50-70 centimeter width, 160 cm length, 20-25 centimeter height from the floor of the trough and 80-90 cm height from the floor of the trough to the roof (see figure-1 below). The feed trough has roofed shade protection from rain and sun and has straw storage within it. It was demonstrated in about 20 farmers in the two Kebeles. Out of which 2 participates were women headed households.

Materials

The Participant farmers were provided the local material such as land for construction, eucalyptus tree and labor. Africa Rising project was provide industrial materials like corrugated iron sheet (5 iron sheet/feed troughs and 11 iron sheet/feed storage), nails and carpenter labor cost. The size of the feed trough and feed storage can be depending on the number of the animals and the interest of the farmers. Initially one sample feed trough and feed storage was constructed in each kebelles and the other farmers was invited to observe and evaluate the technology. Then after considering the participant farmers comments and modification ideas it was constructed in the other farmer's house in a better way.

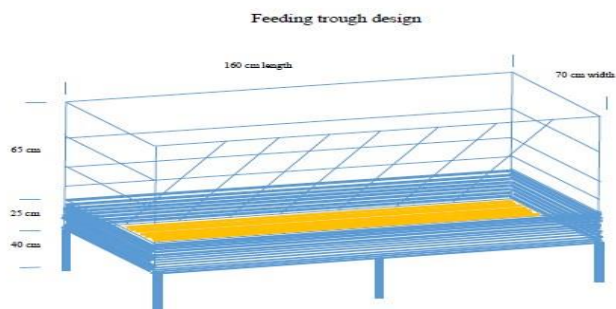






Figure 1: Prototype/Model of improved feed trough

Duration: 2014-2016

4.1.4. Research findings

Table 13: Comparison of the improved and Traditional Feed Trough and feed shed/storage

Improved Feed Shed/Storage	Traditional Feed Shed/Storage
 <p>The Improved Feed storage avoid crop residue wastage from 25-30% due to the following reasons</p> <ul style="list-style-type: none"> ➤ The feed storage was constructed 40 cm above ground and it has well construct roof that protected from rain, flood, sun, termite and other animals damage. ➤ It also helps to store the mixture of pulses and cereals crop residue, which increases both the quality and quantity of the feed. ➤ The quality of the straw is not deteriorating due to the above reasons ➤ Indeed, this technology enable farmers to have enough feed for their animal until green feeds are well available ➤ Farmers are not forced to purchase addition feed ➤ Costs for double sided Improved feed storage was=1500 birr (carpenter and industrial material)] ➤ The incurred will return in one year 	 <p>The crop residue stored outside the home in open space at the ground which results</p> <ul style="list-style-type: none"> ➤ Exposed to rain, flood, termite, poultry/birds scavenge, sun, wind, animal's damage, dog urinate and leading to about 25-30% of wastage. ➤ The Crop residue quality was decreasing due to the above reasons ➤ As a result, the crop residue was finished in the months of May-June and the farmers were forced to purchase additional feed for their animals. Causes additional expense for feed purchase ➤ Needs labor to look after animals or to fence/protect the hip from animal contact ➤ In addition, because of it's easily spoilage nature they did not store the pulse residue mixing with cereal residue and left in the threshing area to be eaten by pack animals at field.
Improved Feed Trough	Traditional Feed Trough
	

<p>Construction of the improved feed Trough is important due to the following reasons</p> <ul style="list-style-type: none"> ➤ It Avoided feed wastage/loss of 20-25 % from the provided feed ➤ The children labor and time is also saved and enable them to go to school. ➤ Labor of farmers was minimized and help to undertake other activities 	<p>Farmers feed their animal in traditional trough mostly on ground based that constructed by stone or wooden materials and the feed can be exposed easily to ☒ To rain fall, poultry/birds scavenge</p> <ul style="list-style-type: none"> ➤ ☒ The animals can urinate or put their dung on it, soil and dung was easily mixed with the straw,
<ul style="list-style-type: none"> ➤ The uncontrolled grazing system due to feed shortage was one of the challenges of the community that expose for environmental degradation. This practice has also promoted the control animal grazing /Zeros grazing practice, which increases the soil and water conservation or environmental rehabilitation and crop productivity. ➤ It also help to have healthy animals, controlled breeding practice, and it saves the animal energy and enhance the livestock production and productivity improvement ➤ It can be fully constructed using locally available materials such as any tree for its sides, plastic sheet/ grass/soil or other available materials for its roof and nail/ rope/wire for fixing the linkages ➤ Double sided improved feed trough construction cost can be 1500 birr (it includes the carpenter and industrial material cost, but it is not included the local materials cost such as eucalyptus tree, land and farmers labor) ➤ The cost can be recovered in one and half year 	<ul style="list-style-type: none"> ➤ Children or elders were also busy on feeding the animals in such type of local trough even at times of too cold weather condition. ➤ Then due to the local feed trough the wastage was from 20-25% of the provided feed to the animals. ➤ This condition was forced the farmers to send their animal for free grazing and conservation structures and forestation was destructed and contributed to degradation and erosion ➤ Animals was also exposed to disease and unwanted breeding practice at the filed ➤ Animals loss their energy during travelling and decrease their productivity potential

4.1.5. Conclusions and recommendations

The improved feed trough and feed storage can be easily constructed by any person using locally available materials and this technology saves 50% of crop residue wastage as compare the traditional feed trough and feed storage. This also helps to avoid the cost incurred for purchasing additional feed to their animal by small scale farmers. Moreover, It minimizes children labor and let them to go to school and the productive labor can be also encouraged to work other activities and this promotes zero grazing practice, in turn it enhances environmental rehabilitation and increase livestock productivity. So it can be scale up/out to wide areas of the region at small scale farmer's level.

4.2. Tree Lucerne (*Chamaecytisus palmensis*) as fodder and fertilizer trees



Photo 9: Tree Lucerne

4.2.1. Action on-farm research on tree Lucerne

- Tree Lucerne- is multipurpose and leguminous tree species that adapts well in the highlands
- Research locations- 8 Africa RISING Kebeles
- Research approach- 8 Farmer research groups (FRGS) established. Each FRG consisted of 25 and more farmers
- Seedling delivery- Each farmer participating in the research received on average 50 seedlings. A total of 253 farmers participated in the research.

4.2.2. Information for scaling/ extension package formulation

- Household size, access to reliable water supply, and management factors—including fencing planted-seedlings to protect browsing, mulching during dry periods, clean spot weeding and applying organic fertilizers—significantly enhanced survival and growth of tree lucerne in the planting sites.
- Tree Lucerne requires well drained soil and appropriate planting site. It can be planted as live fence, fodder lot (block planting), Soil and water conservation (SWC) structures, and boundary planting and intercropped with crops and vegetables.
- Tree lucerne is one of the few fodder and fertilizer tree species that perform on high altitude areas (2000-3100 masl) and fix N that improve livestock, crop and soil productivity.
- Tree Lucerne can produce more than 4 -7 t ha⁻¹ dry biomass per year under farmers' management condition and when planted at 1 m X 1 m spacing. A cutting height of 1 m

to 1.5 m provides good biomass. The plant can be harvested 2-3 times per year depending on the management.

- Tree lucerne in well-managed farm fields can reach for the first harvest and use as animal feed within 9 months after planting.
- The leaf and edible branches of tree Lucerne are very good sources of nutrients for ruminant livestock, containing high amounts of crude protein and (app 20-25%), and digestible organic matter ($\geq 70\%$). The foliage of this fodder can be fed green or preserved in the form of hay and used as needed.
- Nutritionally, tree Lucerne leaf is comparable to concentrate feeds. For smallholders whose access to concentrate feeds is limited can serve as a perfect substitute
- Supplementation of 1 kg of dried tree Lucerne leaf to a lactating dairy cow can give up to 1.2 Lts of extra milk supplementation 300-400 g of tree Lucerne hay to a fattening sheep is adequate to achieve a daily body weight gain of 70 grams, with a significant improvement in carcass dressing percentage (from about 40% in un-supplemented animals to about 48% in supplemented ones).
- In addition to the foliage, seeds of tree Lucerne can serve as good sources of poultry feed.
- Tree Lucerne flower is also a preferred bee fodder to produce quality honey.
- Tree Lucerne stems are good sources of farm implements and fire wood.

4.3. Oat-vetch forage development



Photo 10: Oat-vetch mixture forage field

4.3.1. Brief introduction

Oat and vetch are annual forages, which, when grown by intercropping, provide high biomass yield of good nutritional quality. While oat is a grass family vetch is a leguminous forage. Oat vetch mixture is as a result a balanced feed in terms of energy and protein contents and has very high feed values for animals as green fodder and hay. Moreover, vetch has the ability to offer substantial improvements in soil fertility, structure and organic matter as well as offering a weed and disease break for cereals in a crop rotation. A number of oat and vetch varieties have been released through the national system, and the value of intercropping oat and vetch has been established. However, this technology has not been adopted widely due to poor extension approach, limited awareness among farmers and limited accessibility of seeds.

Action research was therefore initiated through Africa RISING project to allow farmers to experiment with oat-vetch mixture production using irrigation and under rain-fed conditions. The main objective was to demonstrate and evaluate the yield of oat-vetch mixture in the farmers' field and its effect on performance of animals.

4.3.2. Methodology

Framer research groups (FRGs) were established in each of the 8 Africa RISING sites. Formation of FRGs was based on interest and willingness to allocate a minimum of 100m² land for the experiment. A total of 160 farmers were involved in the research across the eight Kebeles. Training was given on land preparation, sowing, managing plots, the right time of harvesting, hay making and supplementation for different classes of animals. Afterwards, farmers were provided with starter seeds, and data were collected at different stages of the trials

Agronomic practice:

1) Land preparation:

- As any other cereal and legume forages, oat and vetch need standard land preparation: ploughing repeatedly (2-3 times) to prepare a smooth plot before sowing the seeds.
- The land needs to be well drained. Water logging affects the yield considerably.

2) Seed rate:

- 90 kg/ha for oats and 30 kg/ha for vetch (seeds mixed in a 3:1 ratio for oats and vetch respectively)
- With confirmed high germination percentages (eg. 95% and above), the seed rate can be reduced to 75kg/ha for oats and 25kg/ha for vetch
- Seeds can be sown both in rows and using broadcast. In case of row planting, oats and vetch are sown on alternate rows with 15 cm space between rows. When broadcast method is used, the seeds need to be thoroughly mixed to make sure uniform distribution of the two forages

3) Weeding:

- Weeding may be needed at early stages of growth deepening on the land preparation. However, oat-vetch grows aggressively and can effectively suppress weeds after the early stages of growth

4) Harvesting and use:

- The ideal stage of harvesting oat-vetch is when the forage reaches 50% bloom stage. The forage can be conserved in the form of hay or used as green feed mixed with other locally available feed resources
- To prepare hay, the fodder is harvested to the ground and spread-thin under a well ventilated shed or in the sun.
- The biomass should be gently turned upside down once daily to ensure even drying of the biomass.
- A sunny and windy weather is necessary to make hay and it is thus important to check weather forecast and choose the right days for this activity.
- Under good weather condition, the hay can be sufficiently dry within 48 hours, to be stored safely. However, longer periods may be needed depending on the weather condition.
- A good quality hay maintains its greenish color and is leafy. Leaf shattering and bleaching reduce the quality of the hay produced. It is therefore important to avoid over-drying to minimize leaf shattering and bleaching.

4.3.3. Results

4.3.3.1. Biomass yield and nutritional quality

In the Africa RISING sites the biomass yield ranged from 7.5 to 16.2 tons DM/ha. The highest biomass yield was obtained in Sinana (16.2 ton DM/ha) and Endamohoni (14.9 ton/ha) sites compared to the other sites (Table 1). The forage yield observed is generally impressive with very good nutritional profile for ruminant animals. The mixture contained high crude protein, acceptable fiber content, and high metabolizable energy content. The oat-vetch mixture, therefore, can serve as an ideal supplement for lactating cows, fattening animals and also draft oxen. Lactating cows need metabolizable energy in the range of 5-7 MJ to produce a liter of milk. It therefore means that 1kg of oat-vetch DM can yield more than a liter of milk. According to the yield data, 1kg DM of oat-vetch mixture is produced, from less than 1m² plot of land. This shows that production of oat-vetch mixture under farmers' conditions is economically feasible.

Table 14: Yield and nutritional quality of oat-vetch mixture from two growing season observations across the AR research sites (Mean±SD)

Variable	Research sites			
	Endamohoni	Lemo	Basona	Sinana
Biomass yield (ton DM/ha)	14.9±1.0	9.2±.6	7.5±.5	16.2±.1.1
Crude protein (%)	15.4±1.5	15.8±1.2	16.3±.8	14.5±1.2
Neutral Detergent fiber (%)	58.5±2.5	59.0±3.3	57.0±1.2	61.5±2.3
Acid Detergent fiber (%)	28.2±1.4	30.4±1.3	27.5±1.4	33.2±1.7
Acid detergent Lignin (%)	6.2±.2	7.1±.6	7.5±.8	8.3±.9
IVTOMD (%)	66.1±3	67.2±3	68.4±4	65.2±3
Metabolizable energy (MJ/kg DM)	9.5±.5	9.6±.4	9.9±.6	9.4±.5

4.3.3.2. Effects of supplementing oat-vetch mixture

On-farm observation of the effect of oat-vetch supplementation to lactating and fattening animals appeared to be consistent with the theoretically expected output based on the feeding value of the mixture and animal requirements. In the Endamohoni site, supplementation of 2kg of oat-vetch hay daily resulted in an increase in milk yield by up to 60% (Table 2). Fattening sheep supplemented with about 200-300g hay per day were also able to achieve acceptable body weight gain (50-106g/day) in southern Ethiopia.

Table 15: Milk yield of cattle fed on basal diet crop residue and supplemented with 2 kg of oatvetch mixture hay per day for sixty days in Endamohoni (n=17).

Treatments		Milk Yield		
		Final daily milk yield (Litter)	increases in milk yield per cow or per total experimental days	daily additional milk yield (litter)
Breed				
Crossbreed cow	3.0±1.0	5.33±1.04	140±17.3	2.33±0.29
Local cow	1.75±0.5	2.75±0.65	60.0±24.5	1.00±0.41

4.3.3.3. Conclusion and recommendations

- As oat-vetch is an annual forage with a short growing cycle (about 60 days), its competition for land with other crops is relatively less
- It produces significant amount of high quality biomass from small plots
- Supplementation of oat-vetch mixture to ruminants yields considerable increase in animal performance, and it is economically feasible when compared to reference crops
- Oat-vetch mixture can be produced both under rain-fed conditions and using irrigation, enabling farmers to have access to good quality supplement throughout the year
- As vetch is a leguminous forage it also contributes to soil fertility by fixing atmospheric nitrogen
- It is therefore recommended to encourage farmers to adopt this forage cultivation at scale in order to encourage market oriented livestock production
- Although oat-vetch is a balanced feed and can be offered alone, it is advisable to mix it with the locally available resources for maximum benefit, and efficient utilization of existing feed resources
- Farmers can schedule the oat-vetch production period in such a way that it does not compete with major crops for land. This can be done by using supplemental irrigation immediately after the main rainy season or during the belg season.
- Conservation of oat-vetch mixture in the form of hay is important in order to maintain its quality and use is as needed

4.4. Summary of Sweet Lupine technology description



4.4.1. Brief introduction Photo 11: sweet Lupine picture and field visit at Embahsti Kebele

Sweet lupine is a leguminous crop which has been introduced to Ethiopia recently. As opposed to the local bitter lupine variety which has high alkaloid content, sweet lupine has minimal levels of secondary metabolites, and its crude protein content is high (37%), which makes it suitable for use as food and feed. As a legume crop it contributes considerably to soil fertility and can serve as rotation crop. Currently, there is a nationwide disease problem of pulse crop, mainly faba bean. Use of sweet lupine as an alternative pulse crop is expected to break disease cycles and improve overall farm productivity.

The objective of this action research was therefore to test the adaptability and productivity of faba bean varieties released by ARARI for subsequent wider adoption and scaling.

4.4.2. Methodology

As a new introduction the varieties were tested on-station across the four AR sites. Four sweet lupine varieties namely: Sanabor, Vitabor, Proboy, Bora, were planted on 3×2m² plots, with each replicated three times. Routine agronomic data were collected including germination, plant height at flowering and harvest, date of flowering, pod setting, date to full maturity, and grain and straw yields. Farmers and experts were invited for mid-season and end of season evaluation of the adaptability and performance of the sweet lupine varieties.

Agronomic practice

1) Land preparation

- Sweet lupine requires standard land preparation, the land needs to be loosened well by ploughing at least twice.
- Sweet lupine tolerates medium level of acidity, but it is highly sensitive to water logging, and so it does not perform well on vetrisols.
- The land generally needs to be adequately drained. It is important to make sure that sideway drainages are sufficiently built to avoid overflowing of runoffs on sweet lupine fields

2) Seed rate

- 80 kg/ha
- When planted in rows, the national recommendation is 7cm between plants and 30 cm between rows
- Early week of July is the ideal time of planting

3) Weeding

- Weeding needed at early stages of growth (2 weeks after seed emergence), and just before flowering. At later stages the plant is able to branch and suppress weeds growing underneath

4) Fertilizer

- A starter fertilizer (100kg DAP/ha) proves effective in increasing production. But the crop can also be planted without artificial fertilizer in well maintained soil

5) Harvesting and use

- When mature, sweet lupine pods tend to shatter. It is therefore important to closely monitor sweet lupine fields and harvest the plant before it shatters
- Farmers in North Western Ethiopia use the grain as food. They process it into Shiro and Kik and mix it with that of faba bean and field pea
- Sweet lupine grain is a very good protein supplement for fattening animals. Daily body weight gain of about 75 g was achieved due to supplementation of the grain at 200g/d

4.4.3. Results of action research

4.4.3.1. Grain and biomass yield

The grain yield of sweet lupine showed considerable variation from site to site. The highest yield was recorded in the Endamohoni site which ranged from 2.4 to 3.0 tons/ha. The grain yield in Lemo ranged from 1.5 to 1.7 tons/ha. There was some level of difference in yield performance between the sweet lupine varieties, especially in the Endamohoni trials, in which the variety Proboy excelled followed by Vitabor (Fig 1). But In the Lemo site the yield variability between varieties was limited. The residue yield followed the same trend as the grain yield (Fig2).

Detailed analysis of the nutritional profile of the sweet lupine grain and biomass, including amino acid contents, is being conducted. However, research reports from ARARI showed that sweet lupine grain has no anti-nutritional factors that affect its utilization as food and feed.

Figure 2: Grain yield of sweet lupine varieties under Endamohoni and Lemo conditions

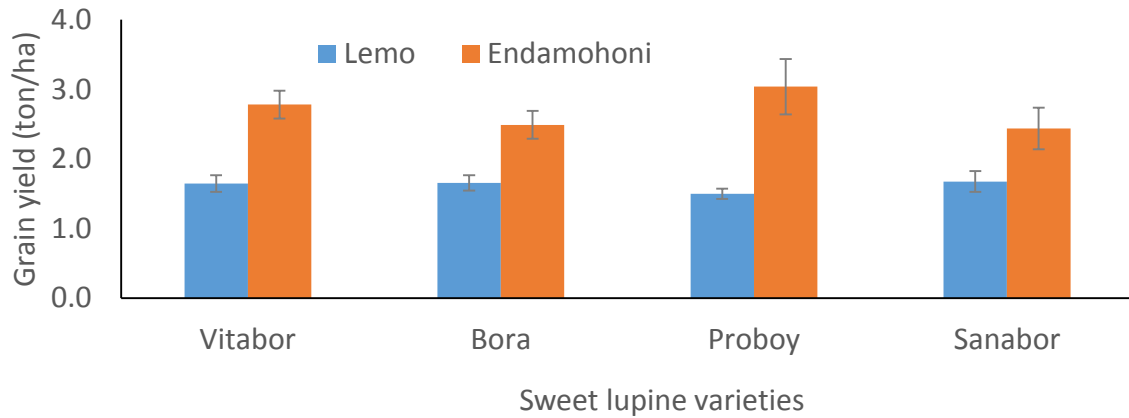
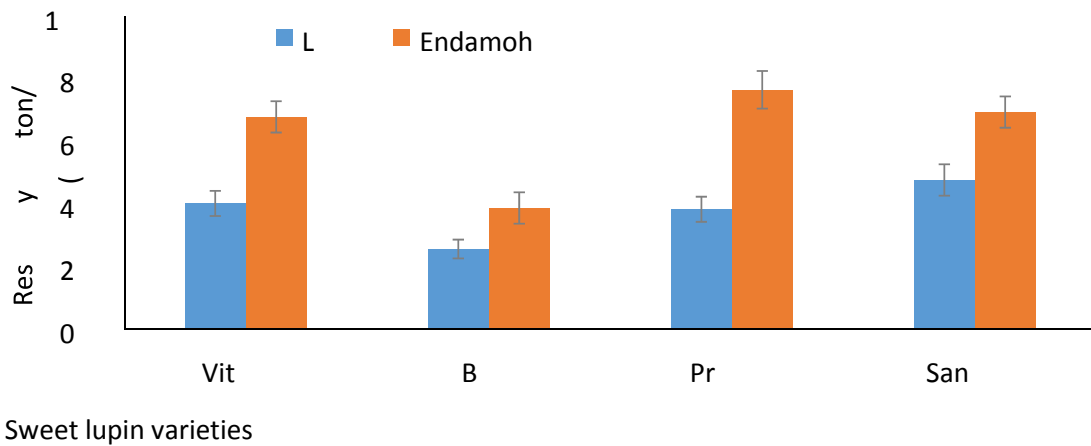


Figure 3: Residue biomass yield of sweet lupine varieties under Endamehoni and Lemo conditions



4.4.4. Conclusions and recommendations

- The grain yield of sweet lupine is comparable to other commonly used pulse crops such as faba bean
- There are no disease incidents that deter the production of this crop
- This crop will therefore play a vital role as an alternate crop to grow in areas where faba bean disease has become a major problem.
- Using this crop in crop rotation with for example barley and wheat will serve the same purpose as faba bean crop
- In other countries like Australia, sweet lupine is used in the food processing industry to produce cooking oil, and milk of plant origin (in the same way as soya milk). This shows

that sweet lupine has also a potential to enter the commercial market like soya bean in Ethiopia

- The plant has deep root system, and contributes considerably in enhancing the soil organic matter and nitrogen content for subsequent cropping
- The plant is highly sensitive to water logging. Vertisols and other water logged areas should not be used for sweet lupine production

5. Enhancing food and nutritional security through high value fruit trees

5.1. Key research activities and findings

- Introducing high value trees (HVT) 5 varieties of *Persea americana* (Avocado), *Malus domestica* Borkh (Apple), 5 varieties of Walnut from china
- Testing and identifying their suitability through on farm, experimental, laboratory and socio economic survey, supported by onsite training
- Effect of management practices, (watering regime, irrigation, mulching, fruit thinning, root stock compatibility) on survival, growth, yield and fruit quality
 - Survival rate ranges (between 90 and 100%) for avocado and (between 75 and 96%) apple across sites
 - **Impact of fruit thinning on fruit quality:** At higher crop loads tree growth and fruit qualities drop off significantly ($P \leq 0.05$). Crop load of 2 fruits per spur resulted in best yield and marketable quality (*journal article in review*)
 - **Among study sites and gender** there was a significant difference in management practice, female managed apple and avocados saplings have showed better growth performance.
 - Determinants of adoption and impact of sustainable intensification technologies in the Ethiopian highlands: Almost all Africa RISING SI technologies had positive effects on yield, its value and sold quantity.
 - **Capacity development** of 300 farmers were trained
 - **Nursery site establishment**, strengthen sinana shyaa nursery/government nursery site, fruit tree seedling propagation shed net were constructed and apple and avocado mathore block established and fodder tree species such as *calindria* and *thphrosia* were tested

5.2. Technologies to scale in Phase II

- Tested Avocado and apple varieties will scale up through facilitating availability and affordability of quality planting material.
- Address the **huge knowledge gap on HVT** both at lower and national level through

training

- Continue the **ongoing research** to have a complete understanding (from establishment, flowering fruiting quality and marketing), to provide context specific evidence for scaling up
- Adopting ICRAF's ample Experience on Multipurpose tree species selection for the right tree seed and seedling access that can be useful for fodder, fuel, medicine and timber.
- **Quantify tradeoffs** between the socio-economic and environmental benefits
- Develop **Rural Resource Centres and community tree nursery** with partners as source of quality planting material and income (focusing on women and youth).

5.3. Implications of the research outputs for generating development outcomes

- Promising high value species/varieties and management interventions identified, supported by **evidence on their scalability**
 - create **job** opportunity for **women and youth**
 - Country stakeholders have access to improved **knowledge & ability** to engage in promoting high value trees and inform key policy and investment decisions with evidence for **larger investment**
 - Contributes to **meet** Growth and Transformation Plan (**GTP-II**) reduced poverty, End hunger achieve food and nutrition security and substantially to improved natural resource systems and ecosystem services

5.4. Current partnerships and future engagements for scaling

- Strengthening existing partnership with: MoA, MEF, EIAR, OARI **integrating the package to the extension systems** and implementation
- Relevant Univ. in all regions and private farms (e.g. FIJI) for **capacity building and joint research**
- New partnership ATA, GIZ, SLM, AGP and other potential GOV and NGO to enhance synergy and impact