International Center for Agricultural Research in the Dry Areas

Pakistan Agricultural Innovation Program (AIP)

Scientific Research and Capacity Strengthening to Promote Agricultural Growth, Poverty Reduction, and Food Security in Pakistan

Report on technologies and interventions tested to enhance small ruminant value chain performance in Pakistan

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1 Brief introduction to the AIP project

Agriculture is central to economic growth and development in Pakistan. The sector contributed 25.6 percent to GDP and livestock contributed approximately 55.9 percent to the agricultural value added (Govt. of Pakistan, 2013-14). The majority of the population, depends directly or indirectly, on the agricultural sector. Thus, livestock production is an integral part of the rural economy of Pakistan and affects employment opportunities and poverty in rural areas.

Population growth, urbanization and increasing incomes are stimulating a substantial increase in the demand for animal source food, while also aggravating the competition between crops and livestock (increasing cropping areas and reducing rangelands). In this situation, the livestock industry is facing many challenges, among them changing climatic conditions with unpredictable weather patterns, rangeland degradation and mismanagement as well as reduced fodder production that directly affect feed availability and thereby livestock productivity.

To cope with these challenges, USAID funded the project "Promoting Science and Innovation in Agriculture in Pakistan (PSIAP)" with the main objective of fostering adoption of new technologies and strengthening innovation systems. Within the research for development framework the focus was on smallholder production systems. The International Livestock Research Institute (ILRI) was responsible for Livestock related innovations and commissioned the International Center for Agricultural Research in the Dry Areas (ICARDA) to co-implement the component (i) Feed, Fodder and Rangeland and implement (ii) Small Ruminant Value Chain (SRVC).

In 2014, ICARDA organized training on Small Ruminant Value Chain Rapid Assessment at Islamabad and gave a contract to the Social Science Research Institute (NARC to conduct this study in two areas of Punjab *i.e*. Chakwal and Bahawalpur. The Rapid Value chain Assessment (VCA), conducted in Chakwal and Bahawalpur (Punjab Province) highlighted the following main constraints: inadequate feed resources, degradation of rangelands, lack of rangeland rehabilitation systems, insufficient and improper quality supplies of vaccines, inadequate number of govt. vet staff and budget, lack in capacity of private Vet health workers, shortage of quality bucks/rams for breed improvement, poor housing and hygienic conditions, poor disease control and supply of low quality medicines by service providers, lack of marketing skills and low marketable surplus and supply, limited processing capacity and limited scope for vertical coordination. To address these challenges, a number of technologies were identified and tested or piloted for the improvement of rangelands, fodder production and livestock productivity (Table 1).

Table 1: Tested interventions by component

Interventions by component	**Locations where this intervention was implemented and when**			
	Chakwal	**Bahal-walpur**	**Sindh**	**Balochi-stan**
Component 1: Feed, Fodder and Rangelands				
Sub component 1.1: Identification and promotion of improved forage varieties with high yield potential with appropriate agronomic practices				
1. Fodder production for the Rabbi season				
a) Improved Alfalfa varieties	11/2014	10/15		Lorelai - Dargai Siafulla 11/2016
b) Improved Berseem varieties	10/2015	10/15		
c) Improved Mott grass	7/2014	-	-	
2. Fodder production in Kharif				
a) Improved Guar varieties	6/2014			
b) Improved maize varieties	6/14, 15,16	5/2015	6/2016	7/2016
c) Improved millet varieties	6/2014		6/2016	
d) Rhodes grass introduction		4/2016	4/2016	
3. Village Based Seed Enterprise (VBSE)	Started in 2015			
Sub component 1.2:Rangelands				
1. Rotational grazing	8/2014		4/2016	4/2015
2. Rehabilitation of rangelands				6/2015
Component 2: Small Ruminant Value Chain				
1. Internal parasite control	December 2014 to January 2015			
2. Supplementation strategies for pregnant ewes and does	December 2015 to Jan 2016			
3. Lamb/kid fattening with concentrates	Dhulli 11 August 2015 to 9 Sep 2015		Kunri 15 Jul 2016 to 28 August 2016	Loralai 11 August 2015 to 9 Sep 2015
4. Wintertime supplemental feeding of ewes and does including cactus	1 Dec 2015 to 16 Feb 2016			
5. Development of Model cum Training farms for Small Ruminants	June to August 2016	6/ 2016	5/ 2016	

2 Component 1: Feed, Fodder and Rangelands

2.1 Subcomponent 1.1: Identification and promotion of improved forage varieties with high yield potential with appropriate agronomic practices

2.1.1 Introduction

Livestock plays an important role in Pakistan's economy. Commercial livestock farming is dependent on agro-industrial by-products and fodders. The steep rise in the price of industrial by-products has increased the demand of green fodder in animal feed, which is the most cost effective source. However, due to high prices of quality fodder seed and water shortage, fodder production has undergone a significant decline in most of the country. In Pakistan, about 16% of the total cropped area is planted with fodder crops annually and consequently, the fodder crops grown only meet about 10 to 25 percent of the total livestock feed requirement. The deficiency in energy and protein sources poses a serious constraint for a more efficient livestock production system in Pakistan. In most areas of Pakistan, there is a seasonal shortage of green fodder from mid-April to June (Rabbi season) and mid-October to December (Kaharif season). Rangelands are poor in terms of supply of quality and quantity of fodder but still provide more than 70% of the total feed consumed by small ruminants. Therefore, the animals are hardly able to meet their maintenance requirements in these months. In order to improve livestock productivity, it is crucial to provide additional fodder to compensate for low quality roughages.

Furthermore, climate change is predicted to affect cereal/fodder production due to an increase in temperature and water stress along with other factors that include but not limited to frost, disease and pest dynamics. Under the climate change scenarios, production of maize and other crops such as sorghum, millet, and cluster bean are predicted to decrease in both tropical and temperate regions. In the AIP project, improved varieties of fodder and new more drought tolerant fodder species were demonstrated to resource-poor farmers to improve their livelihoods.

2.1.2 Technology/intervention: Fodder Production for the Rabi season

2.1.2.1 Improved Alfalfa and Berseem varieties

<u>Methods</u>

The seed bed was prepared using moldboard plow and spring cultivator. Alfalfa and Berseem were planted with row to row distance of 0.3 m using a seed rate of 15 kg per ha^{-1}. Phosphorus is needed as a fertilizer for alfalfa more often than other nutrients. In Pakistan especially in arid and semi-arid areas, soils are phosphorus-deficient. In most part of Pakistan these soils are calcareous and have high pH. Phosphorus is transported to the roots by the process of diffusion, which slows down greatly when the soil is cold. Therefore, phosphorus is needed especially during the cooler months of the year. At the time of planting, immediate application of phosphorus fertilizer is recommended. So at both sites, the seedbed was prepared using moldboard plow and spring cultivator and One bag of DAP (N 18, % P 46%), or two bags of SSP (18% P) per acre were applied at time of sowing. The planting of improved varieties of alfalfa (KS 777) and berssem (KS

999) at all AIP sites were completed in the period from 15th October to 15th November. The planation of Alfalaf and Berseem were done on 56 farmers during project lifespan at two target villages (Dhulli and Beghal) in Chakwal, two target villages (Village 54 DB and 93DB) in Yazman, Bahawalpur and one site at Dargai Siafullah, Loralai. On each farmers' field three quadrats (1 m^2) were harvested in the first week of February 2016 at Bahawalpur and in the 4th week of February 2016 at Chakwal sites and fresh biomass was measured.

Results

At the first cutting stage, the biomass production of improved (KS777) and local alfalfa was compared with local alfalfa at two sites of Chakwal (Begal and Dhulli). The biomass production of the improved variety was significantly ($P<0.05$) higher than the local variety at both target sites. However, the biomass production was higher at Dhulli site compared to Begal due to higher rainfall at Dhulli (Figure 1).

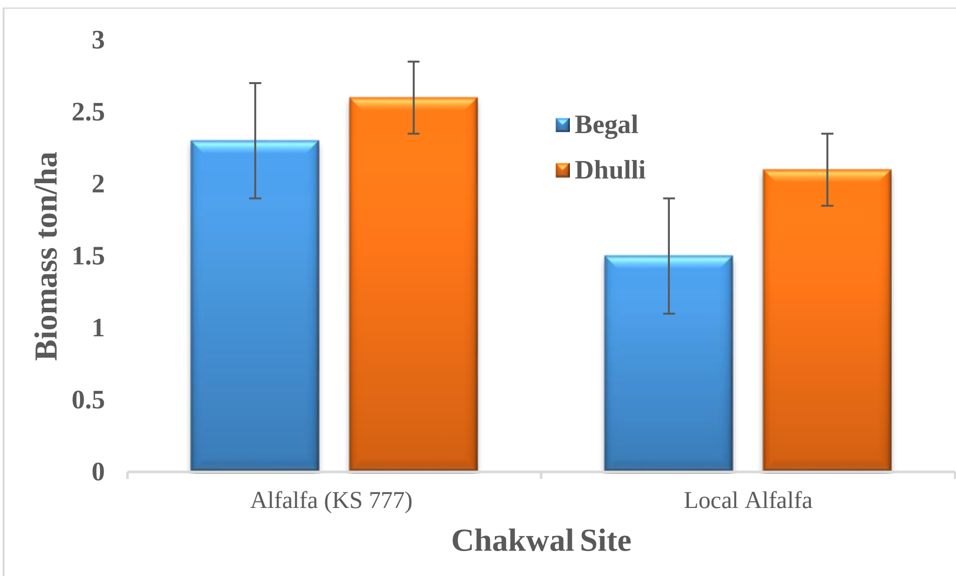

Figure 1: Comparative biomass production of improved and local alfalfa on farmers' fields in Dhulli and Begal

Similarly, the biomass production of improved Berseem (KS 999) was compared with local varieties at first cutting in two villages (54 DB and 93 DB) in the *Yazman* Tehsil of Bahawalpur *District.* The results indicate that the improved varieties performed better than local ones. The site comparative analysis showed there was higher biomass production of Alfalfa (KS 777) at 54 DB than 93 DB. While, Berseem (KS999) biomass production was higher in 93 DB than 54 DB. Among the two local varieties, the Berseem biomass production was higher than the alfalfa (Figure 9).

Alfalfa is a perennial crop but it is observed that in warmer areas of Pakistan, it starts dying off due to the desiccating heat and/or growth of weeds after monsoon rainfall which depresses its growth. So it is recommended to plant berseem in warmer areas and alfalfa in cooler zone of Pakistan.

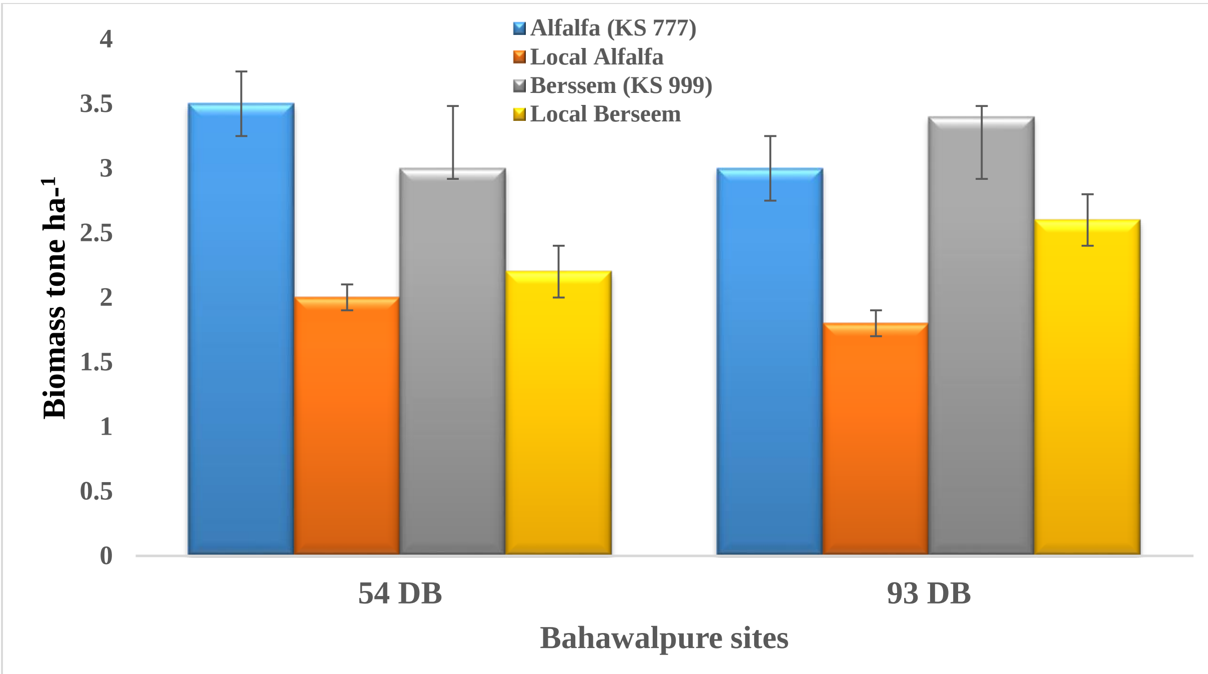

Figure 2: Comparative biomass production of improved alfalfa and berseem on farmers' fields at 54 DB and 93 DB to local varieties of the species.

2.1.2.2 Improved Mott Grass (Pennisetum purpureum)

Elephant grass (Pennisetum purpureum Schum) cv. Mott is a perennial high yielding, nutritious and palatable bunch grass of tropics and subtropics. It has high leaf: stem ratio and digestibility (70-75%) compared to other summer forage crops such as maize (62%), sorghum (64.32%) and sudan-grass (59%). Mott-fodder will be available during the months of May-June and October-November, which are forage scarcity periods in the country. Being perennial in nature it can also save a lot of money, being spent on cultivation of annual fodder crops. In Chakwal at both sites, Mott grass (Pennisetum purpureum) has been introduced first time as a forage option due to its potential to provide good quantities of biomass per unit area through multiple cuts.

<u>Methods</u>

Mott grass was planted after peanuts. First a mould board plough was applied to decrease weeds infestation. Later on the plot was irrigated and spring cultivator was applied twice with planker to provide a fine seed bed for better growth of mott grass. One bag 50 kg Acer^{-1} Di-ammonium phosphate (46% P, 18 % N) was applied at the time of ploughing on each plot. Mott grass cuttings were planted at a distance of 1 m from plant to plant and row to row (1x1 m) in August after monsoon rain. The plants were allowed to establish for about 6 months and then the first cut of green fodder was taken in March 2015. Subsequent cuttings were made at intervals of 35-40 days.

(a) (b) (c)

Figure 3. (a) Plots of Alfalfa and (b) Mott grass; (c) Alfalfa, Mott grass and wheat straw before feeding to small and large ruminants.

Results

In the three months from April to June, alfalfa produced 86 t ha^{-1} green biomass while Mott grass produced 69 t ha^{-1} green biomass (Figure 4). In both villages the farmers were utilizing the plants as green fodder for large ruminants twice a day and for small ruminants in the evening as a supplemental feed.

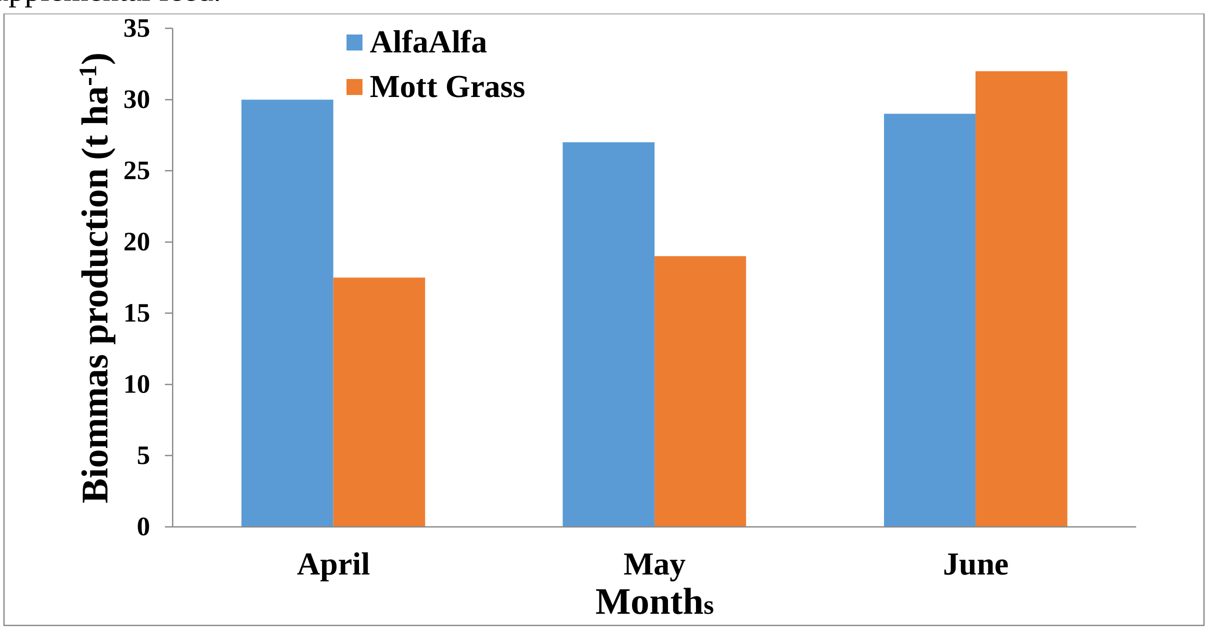

Figure 4. Green biomass production of Alfalfa and Mott grass

2.1.3 Technology/Intervention: Fodder production in Kharif

2.1.3.1 Improved Guar (Cyamopsis tetragonoloba) varieties

Guar or cluster bean (***Cyamopsis tetragonoloba***) is an annual legume. It is a native fast growing crop. It is drought tolerant and suitable to low rainfall areas. It is a multipurpose crop and usually grown for feed, fodder and green manure for soil improvement.

Results

The improved variety of guar BR-99 was planted at farmers fields' of Dhulli and Begal villages. The improved variety produced higher yield (28 t/ha) compare to the local variety (16 t/ha) in Begal village. In the low rainfed area of Dhulli BR-99 produced 16 t/ha and local variety 11 t/ha (Figure 5).

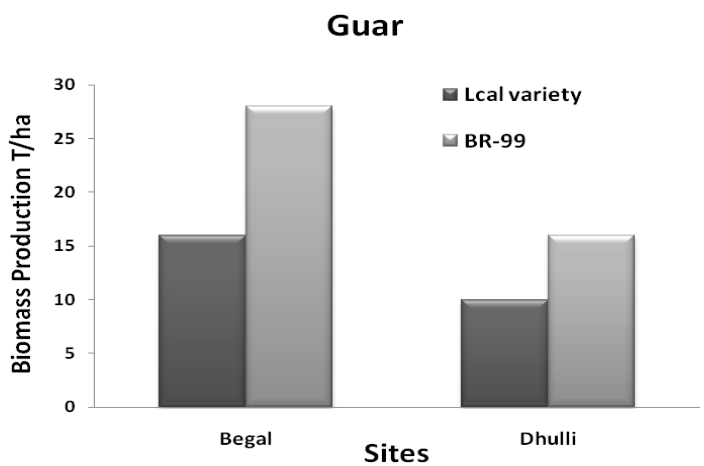

Figure 5: Green fodder yield of improved verses local varieties

2.1.3.2 Improved maize varieties

In Pakistan, maize is used extensively as a source of energy in animal feeding because of its high net energy content and low fiber content. Further maize fodder can safely be fed at all stages of plant growth without danger of prussic acid, oxalic acid or ergot poisoning. Maize is amongst the main fodder crops of the target sites.

Results

Improved variety of Maize Sargodha-2002 was planted at farmers' fields of Dhulli and Begal villages under irrigated conditions. The data presented in the Figure 6 indicate that improved variety (Sargodha-2002) produced higher yield of 70 t/ha than the local variety (30 t/ha) in Begal village. However, at Dhulli under limited water supplementation improved variety also gave higher yield of 45 t/ha compared to 16 t/ha by local variety.

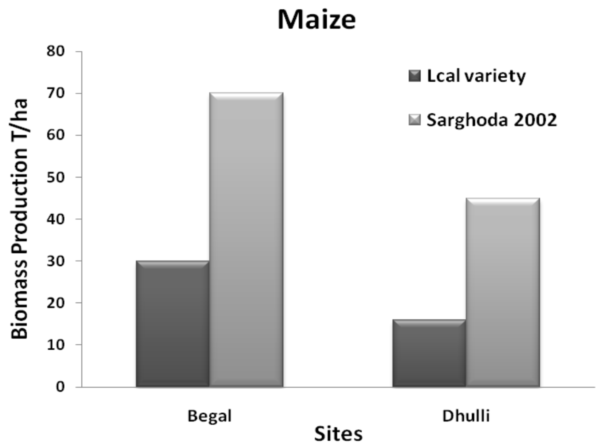

Figure 6: Green fodder yield of improved verses local varieties of maize

2.1.3.3 Improved millet varieties

Millet is a main fodder crops grown in rainfed areas of the country. It is drought tolerant and can perform well under limited moisture conditions even on marginal land.

Methods

Improved variety of Millet (8781) was planted at 8 farmers' fields of Dhulli and Begal villages in comparison with farmers' variety.

Results

Green fodder yield data showed 26% increase over farmers' local variety under medium rainfall area in Begal. In this village the improved variety produced higher yield (41 t/ha) than the local variety (30 t/ha). In low rainfall area of Dhulli, Millet variety 8781 produced 33 t/ha compared to local variety of 21 t/ha (Figure 7).

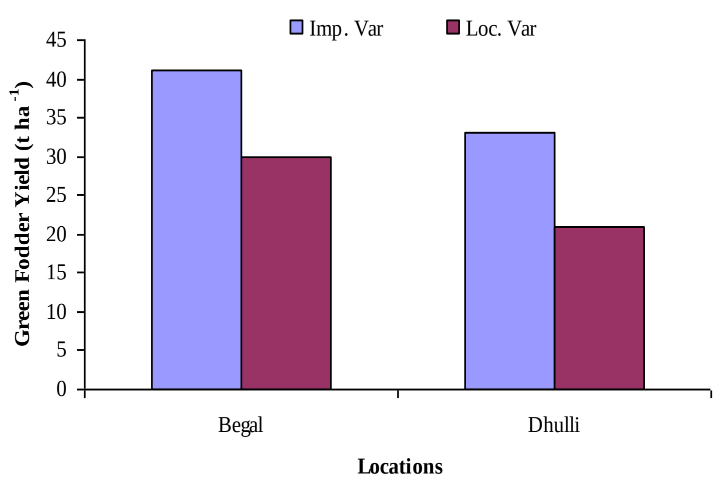

Figure 7: Green fodder yield of improved verses local varieties of millet

2.1.3.4 Introduction of Rhodes grass in Bahawalpur

Methods

Rhodes grass (*Chloris gayana*) (Kotambora) was planted to improve the fodder availability on an area of two ha in Chalk N 54**,** Bahawalpur under irrigated conditions, during the first week of May 2016 (Figure 8 and 9). After the application of recommended fertilizer rates, the seed of Rhodes grass was broadcasted and the seed covered using a light scarification using a plank. One month after seeding, a one meter quadrat was used to measure the fresh biomass produced.

Results

Under the prevailing conditions 6 tons per ha^{-1} was produced in a single cut of Rhodes grass.

Figure 8: Rhodes grass plot

Figure 9: Rhodes grass being harvested

2.1.3.5 Demonstration of improved fodder varieties in Sindh

Improved varieties of Maize (S-2002), Millet (KS.05), Sudan Sorghum grass (hybrid JS2002), *Sesbania bispinosa*, commonly called Jantar in Pakistan (KS.TG.1ong), and Rhodes grass (Katambora) were planted under irrigated conditions in Umerkot Sindh. Rhodes grass was newly introduced while the other fodder species were planted in direct comparison with traditional varieties.

Results

The biomass production of improved varieties was significantly ($P < 0.05$) higher than of the local traditional varieties (Figure 10). The yield of all improved varieties were close to the maximum potential for Pakistan. Through the increase in fodder production the farmers did not only meet their own feed requirements but were also able to sell the surplus to neighboring farmers.

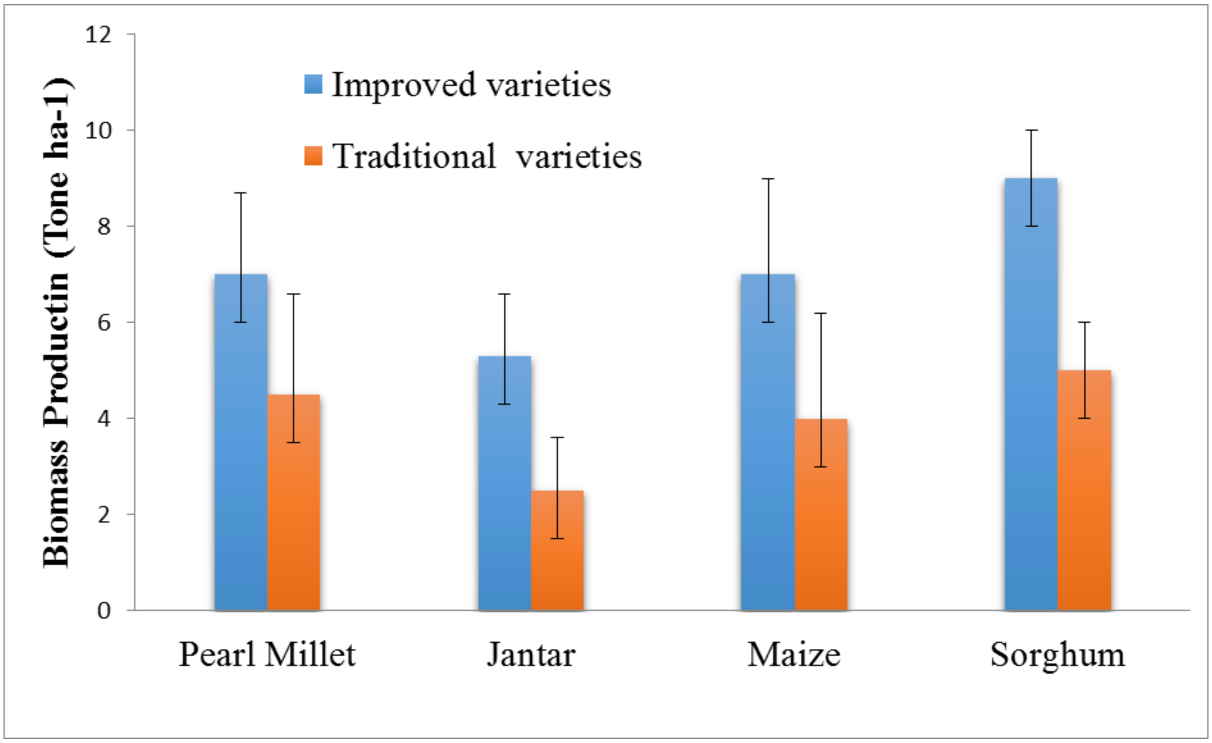

Figure 10: Fresh biomass production (mean ± se) of improved vs traditional cultivars at Kanri Sindh site

Conclusion:

The use of Rhodes grass has spread rapidly in irrigated areas of Pakistan especially in southern Punjab and Sind province due to the fodder market in the Middle East. The improved variety of Rhodes grass “Katambora” produced 2 tons per ha green fodder at the first cut (Figure 11).

(a) (b)

Figure 11: Demonstration plot of Rhodes grass (a) and Sudan Sorghum Hybrid (b) at famers’ fields at Kanri Sindh site

Major benefits include:

- Due to high prices of cotton seed cake, a mixture of berseem and alfalfa are commonly fed in winter at almost all farms.
- Growing forage crops on their own field, fulfill the requirement of their own animals and also sol in market to improve their livelihood.
- The use of quality forage helps farmers to replace expensive concentrates and enhance their total farm income.
- The net income per hectare was highest for Alfalfa and berseem amd was higher than for forage maize and sorghum.

Major Challenges are availability of quality seed and the high prices of fodder seeds.

2.1.4 Technology/Intervention: Village Based Seed Enterprise (VBSE) in Chakwal

Introduction

Agriculture is the most important sector of Pakistan's economy and contributes almost 32% of GDP and employs 65% of the labor force (either full or part-time). According to projected population growth for 2030, it will be difficult for Pakistan to support a population of 230 - 260 million, with current technology and best practices alone. Pakistan's agriculture remains vulnerable, with low productivity levels, a large proportion of land tied up in smallholdings, and with much of the area under larger farming units rented out to subtenants by absentee landlords. In this situation along with other advance technologies, formal and informal seed enterprises have the potential to significantly improve the supply of improved varieties to farmers. In Pakistan, from 1947 to 1960, it was the responsibility of Pakistan agriculture department to produce good quality seed which after 1972 was shifted to Provincial Governments. The Food and Agriculture Organization of the United Nations (FAO) developed a Seed Industry Project with participation of private sector in 1973. In 1976 the "Seed Act″ was approved and circulated to organize seed production/ distribution in the public sector.

Despite having approximately 800 registered public and private companies in Pakistan, the seed processing capacity of both the public and private sectors is concentrated in the Punjab and Sindh. This may in part be the reason for slightly higher productivity in both provinces due to the steady flow of new genetic material from research into agriculture and availability of improved seed. None of the seed corporations are involved in fodder seed production. The development of an 'informal seed sector' is an approach to assist farmers directly rather than supporting national institutions. The informal seed sector is based mainly on seed, preserved on the farms, and exchanged at a community level or traded in local markets without any official oversight. Many farmers are unaware of institutionally available seed or are unable to access it and several studies have shown that farmers receive information through informal networks including for the distribution of seed.

Methods

Having certified seed available is important at the institutional level to assure quality and improvement of seed varieties for distribution through formal and informal networks. Local farmers often do not have certified improved seed of wheat, barley and oats. Addressing this constraint, ICARDA in collaboration with the National Agricultural Research Center (NARC) established improved varieties of barley and oats in comparison with wheat production with selected farmers to initiate village based seed enterprises at two sites (Beghal and Dhulli) in Chakwal district on two farmers field. The NARS scientists were involved throughout this activity to identify clear procedures for quality control. In seed multiplication trials at Dhulli, pre-soaking irrigation was used at sowing time in order to obtain uniform establishment, while at Begal planting was undertaken in soil that had retained moisture from the monsoon rain and field water runoff.

Planting of improved wheat (Chakwal 50,), barley (Rukshan 2010), and oats (NARC Oat) were completed in mid-November 2014 on fields of two progressive farmers (Figures 12-15). The fields were planted with a seed drill and seeding rate of 100 kg ha^{-1}. Di-ammonium phosphate (46% P, 18% N) 125 kg ha^{-1} was applied at the time of plowing. To obtain optimal yields, 62.5 kg ha^{-1} urea (46% N) was applied at the time of planting in November 2014 and the remaining 62.5 kg ha^{-1} at the vegetative stage in March 2015. Weeds were removed manually throughout the cropping season whenever necessary. At Dhulli harvesting was undertaken by hand with sickles, while at Begal the farmer used a combined harvester. The time of harvesting was from mid-May to the first week of June, depending on elevation, which affected the time of maturity. Threshing was achieved using locally made threshers with all precautions required to avoid any contamination of the seeds; the seeds were stored in 100 kg plastic bags.

Results

Characteristics of seed growers: Farmers who were involved in seed VBSE during 2014-15 were educated and experienced (Table 2). The contribution of farm income to total household income was more than 80%. Seed entrepreneurs were mainly full-time farmers and both farmers' owed tractors. Relatively larger irrigated and rainfed lands were owned by seed growers at the two sites (Table 2).

Table 2. Characteristics of seed entrepreneurs in target districts

Characteristics	Dhulli	Begal
Age	51	56
Family size (number)	25	22
Irrigated area (acre)	40	30
Rainfed (acre)	30	50
Education	Secondary	Middle
Farming experience (years)	30	40
Farm income share (%)	75	90
Involvement in farming	Full-time	Full -time

Tractor ownership	Owned	Owned
Distance to AO office (km)	60	32
Cooperative membership	Yes	Yes
Visit to extension office	Yes	Yes
Distance to seed dealer (km)	100	40


Figure 12: NARC Oat variety planted at Begal **Figure 13:** Oat Seed Production plot at Dhulli


Figure 14: Demonstration plot of wheat **Figure 15:** Barley seed production plot

VBSE Seed Varieties, Quality and Marketing: The VBSE improved diversity of wheat varieties planted by the farming communities. The number of varieties planted by the farmers varied between 1 to 4 (Table 3). Both VBSE farmers of the Chakwal district planted new varieties released from Barani Agriculture Research Institute (BARI), Balochistan Agriculture Research Center (BARC), and National Agricultural Research Center (NARC). The varieties planted at VBSE farms included wheat (Chakwal 50,), oats (NRAC Oat) and barley (Rakhshan-10). The quality of seed produced was medium to good, which could be further improved by ensuring sufficient water availability, better management practices and accessibility to seed cleaning machines. Farmer's preferences and demand for varieties were quite different with the yield performance being the main factor that influenced farmer's choices for adopting new varieties.

Table 3. Varieties, quality and marketing of VBSE during 2014-2016

	Chakwal District	
	Old Entrepreneurs 2014-15	**New Entrepreneurs 2015-16**

	Begal	Dhuli	Begal	Dhuli
	Ashiq	**Saleem**	**Adial**	**Masoom**
Number of varieties planted	2	2	2	2
Most demanded variety	Rakhshan-10 NARC Oat	Rakhshan-10 NARC oat	Rakhshan-10 NARC Oat	Rakhshan-10 NARC oat
Quality of seed	Good	Good	Good	Good
Seed Marketed (Tons)	7.3	6.5	6	8
Number of farmers purchased seed	39	28	32	43
Quantity purchased by each farmer (kgs)	100-200	100	50-100	100
Used on own farm(tons)	2.6	1.9	1.8	2.4
Selling Month	Oct/Nov	Oct/Nov	Oct/Nov	Oct/Nov
Selling price (Rs/50kg)	Oat: 55 Barley: 55	Oat: 60 Barley: 60	Oat: 60 Barley: 55	Oat: 65 Barley: 60

Production costs and returns

Seed produced in VBSE is intensively managed in terms of accessing pure breeder seed, better tillage practices, intensive weeding, roughing, harvesting, cleaning, storage, and marketing. Inputs used at all VBSE farms were averaged out for developing a standard budget showing costs and returns (Table 4). However, certain VBSE farmers were able to achieve a doubling of yield than average yields used in enterprise budget analysis. The differential in yields at VBSE farms was greater than input use levels. Agricultural inputs that include seeds/fertilizers and harvesting/threshing costs are major variable costs compared with other inputs.

Table 4. Wheat Grain Production Costs and Returns on irrigated lands

Parameters	Unit	Quantity	Rate (PR)	Amount (PR)	
Yield		**Per acre**		**Per Acre**	**Per Ha**
Inputs					
Land preparation					
Deep ploughing	Hour	1.5	1200	1800	4446
Land preparation	Hour	3	1200	3600	8892
Seed	Kg	25	40	1000	2470
Ridge/blocks making	Day	0.5	1200	600	1482
Seed drill	Hour	0.75	1200	900	2223
- Male labor	Days	0.5	1000	500	1235
Fertilizer(s)				0	0
Urea	Bag	2	2000	4000	9880
DAP	Bag	1	3400	3400	8398
FYM	Tons	0	2000	0	0
Weeding cost	Day	0	500	0	0
Elect. Well irrigation cost	m^3	2569	1.5	3853.5	9518
Harvesting labor	PR	2500	1	2500	6175
- Male				0	0
Threshing	Day	3.5	800	2800	6916
Storage and marketing cost	Kgs	1200	3	3600	8892
Transport	PR	1500	1	1500	3705
Interest @ 12% per annum (for 6 months)	PR	25	50	1250	3087.5
Land rent for 6 months	PR	2500	0.1	250	617.5
Total input cost				**31553.5**	**77937.145**
Outputs					
Wheat grain	Kgs	1000	30	30000	74100
Wheat straw	Kgs	600	10	6000	14820
Gross returns	PR			**36000**	**88920**
Net income (Rs)				**4446.5**	**10982.855**

The estimated investment cost for seed production was around Rs. 78,000 per ha. If the cost benefit ratio for wheat production in Pakistan is calculated using average yields, wheat production in Pakistan is not economical (Table 5). In comparison with general cereal production, VBSE farmers can earn net income of up to Rs. 20,000 per ha from wheat, while for oat and barley it is almost double to triple (Rs. 60,000). This may in part be due to the extra effort that goes in the production of quality seed by the VBSE farmers along with the support of research staff and guidelines from seed certification departments. The premium prices received for quality seed would provide a definite advantage to VBSE farmers over mere wheat grain producers.

Table 5. Seed production and marketing by the VBSEs in 2014-15

Varieties	**Talgang (Chakwal)**		**Total**
Chakwal-50	**Dhulli**	**Begal**	
Area planted (ac)	1	1	1
Total wheat seed produced (kg)	1700	1800	1750
Kept for use at own farm (kg)	600	500	550
Price (Rs/kg)	50	45	47.5
Amount of seed sold (kg)	1100	1300	1200
Total earned from seed sales (Rs)	55000	58500	56750
Production costs (Rs	31554	31554	31554
Net earned (Rs)	**23446**	**26946**	**25196**
NARC Oat			
Area planted (ha)	1	1	1
Total wheat seed produced (kg)	3646	3153	3399.5
Kept for use at own farm (kg)	900	600	750
Prices(Rs/kg)	60	55	57.5
Amount of seed sold (kg)	2746	2553	2649.5
Total earned from seed sales (Rs)	164760	140415	152587.5
Production costs	77937.00	77937.00	77937.00
Net earned (Rs)	**86823**	**62478**	**74650.5**
Rakhshan-10	**Dhulli**	**Begal**	**Average**
Area planted (Acre)	1	1	1
Total wheat seed produced (kg)	1809	2046	1927.5
Kept for use at own farm (kg)	600	500	550
Prices(Rs/kg)	60	55	57.5
Amount of seed sold (kg)	1209	1546	1377.5
Total earned from seed sales (Rs)	72540	85030	78785
Production costs	36000	36000	36000
Net earned (Rs)	**36540**	**49030**	**42785**

Conclusion

About 70% of the seed produced at VBSE was successfully marketed at premium price. The market price for wheat was around Rs. 1500/50 kg, whereas VBSE farmers were able to sell seed from Rs. 2500 to 3500 per 50 kg bag. All VBSE farmers had stored the seeds for 4-5 months and sold at the time of sowing to achieve the best prices. Certain VBSE farmers exchanged new seeds with friends and neighboring farmers. Generally this innovative approach of VBSE was appreciated by the local community due the availability of quality seed in close proximity to their villages which negates the need travel long distance to purchase new seed. In view of the excellent income from informal village based seed enterprises, farmers have extended their area compared to the previous year and 3 farmers from Dhulli and 2 from Begal have entered into the business of growing quality seed due to increased incomes.

During the seed production process (from planting to threshing), it became clear that, the performance of village-based seed enterprises depends on the skills and capacities of farmers own seed management (storage, pest control, selling at planting time), technical support from research organizations (provision of new seed) and funding from the public sector. The key elements of a successful enterprise include regular contact with the supplier of source seed, clear procedures for quality control (including relations with the regulatory authority), and contacts with customers. In the scenario of Chakwal, the local seed producers must be linked with seed traders who contract with them for seed production, and the trader organization should also take responsibility for providing the source seed according to their demand.

Major benefits include:

- The VBSEs can meet small-scale farmers' seed requirements in less favorable and remote areas.
- VBSEs are a dependable source of reasonably priced supplies, especially during shortages or emergencies.

Major Challenges are:

- Sustainability of the village base seed enterprise
- VBSEs needs continuous support from federal and provincial research organizations for providing and advice on improved varieties of seed,
- To convince Governments of all provinces to encourage the development of small seed enterprises to meet the diverse needs of farmers.
- The linkage between marketing and VBSEs farmers to get information and advice on ways to produce quality products and to maintain that quality in the marketing process.

2.2 Subcomponent 1.2: Rangelands

2.2.1 Introduction

In Pakistan rangelands cover almost 51% of the total area. After independence, little attention has been given to this sector as emphasis was on the improvement of agricultural products. The population in a given area have equal rights of grazing their livestock on the rangelands of this area. But no one takes the responsibility to manage and protect the rangelands which are deteriorating gradually particularly due to mismanagement, year round grazing, fuelwood cutting, and more frequent droughts and if this situation perpetuates, the rangelands will turn into deserts. There is little information and experience on grazing strategies that have the potential to rehabilitate degraded rangelands (Figure 16 & 17). Two strategies proposed for rangeland rehabilitation and management are resting and rotational grazing which were tested in the AIP project.

Figure 16: Poorly managed rangelands in Balochistan **Figure 17:** in Thar desert Umerkot

2.2.2 Technology/Intervention: Rotational Grazing

Introduction

Under AIP, we initiated rotational grazing in Chakwal, Bahawalpur (Punjab Province), Umerkot (Sindh) and Ahmadun Ziarta (Balochistan). To implement rotational grazing rangelands are divided into several blocks, livestock graze only in one portion (a paddock) and are systematically moved from one block to another based on the stage of growth of the shrubs ad grasses. During 2014-16, at each selected site after intensive discussions with the local communities, different sized plots were delimited in the field. The community in Cholistan then backed out from their commitments. During 2015 and 2016, aboveground biomass production measurements were taken twice every year (after spring and monsoon rains) to measure biomass production (Figure 3 & 4).

Figure 18: Properly managed rangelands in Balochistan **Figure 19:** in Thar Desert Umerkot

2.2.2.1 Chakwal site (Punjab)

<u>Methods</u>

In September 2014 in Chakwal (Dhulli. 33° 02'48.77" N 72°39' 01.12" E and Begal 33°02'48.77" N 72°39'01.12" E), after discussion with the local communities, 25 ha land was delimited at each of the selected sites. During 2015 and 2016, aboveground biomass production measurements were taken twice every years (after spring and monsoon rains). We used the 100 meter line transect method to estimate total biomass and species composition at an interval of 10 meters. The biomass was estimated using the 1 m^2 quadrate. All species were clipped at stubble height. The palatable species were separated and weighed again to find out their proportion in the overall biomass. Samples were dried in an oven at 80°C for 24 hours and weighed again for dry matter estimation.

<u>Results</u>

Since the protection of rangeland areas in Chakwal from grazing in September 2014, biomass production is being monitored regularly and compared with unprotected areas. The average biomass production differed significantly ($p<0.05$) between the sites.

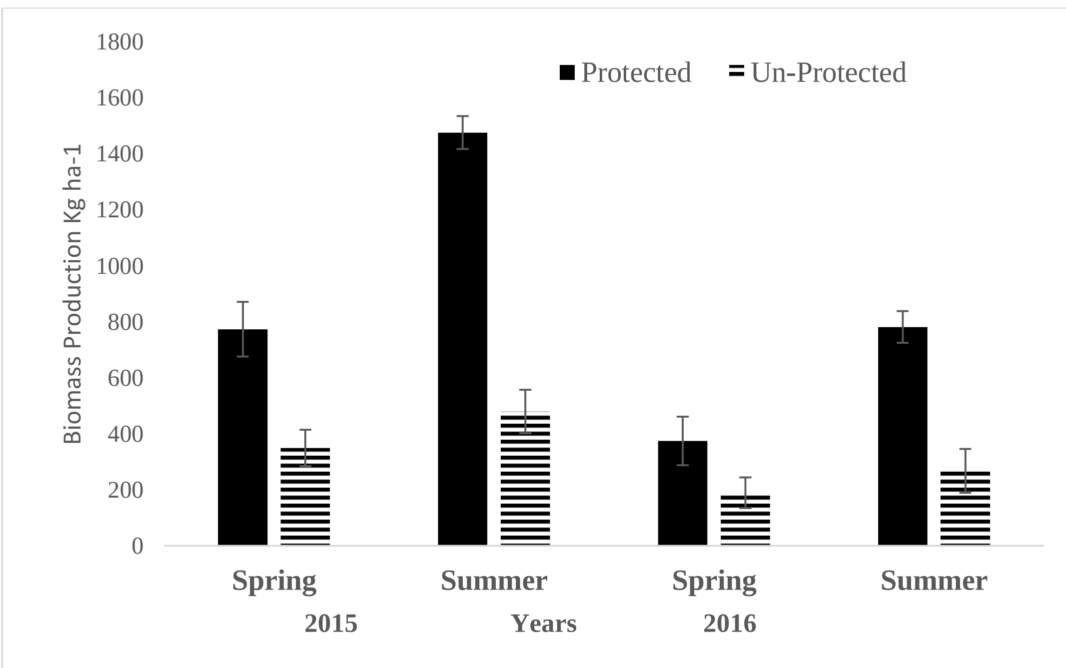

Figure 20: Aboveground biomass production at Dhulli during 2015 and 2016

Preliminary results showed that in May 2015 after winter rains (Figure 20 & 21), total biomass in protected area was 774 and 669 kg ha^{-1} and in the unprotected area 350 and 286 kg ha^{-1} at Dhulli and Begal sites, respectively. In August during monsoon total biomass in protected area was 1476 and 780 kg ha^{-1} and in the unprotected area 480 and 310 kg ha^{-1} at Dhulli and Begal sites.

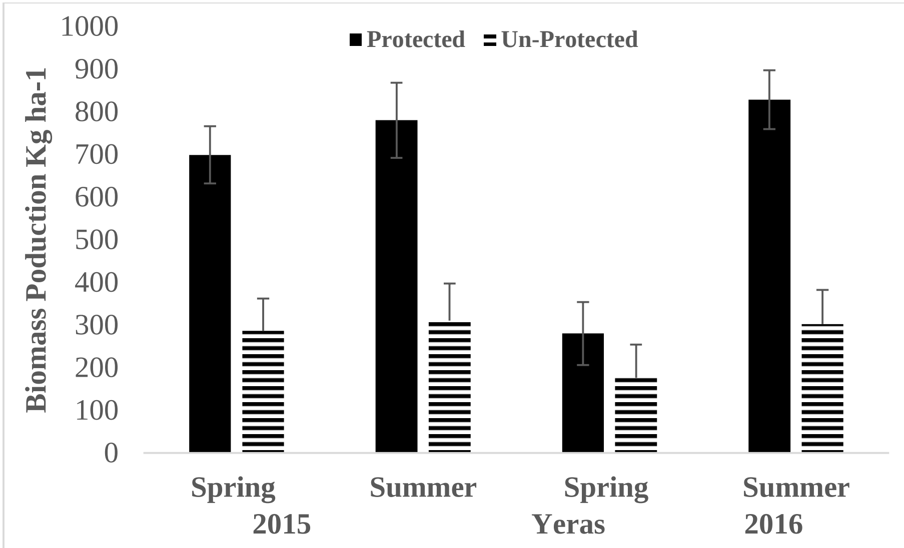

Figure 21: Aboveground biomass production at Begal during 2015 and 2016

After allowing a five month rest period for the protected areas (Nov. 2015 to March 2016), vegetation sampling was undertaken after the spring rains in April 2016 in protected and un-protected areas at both research sites, Dhulli and Begal village. The total quantity of biomass in the protected area was 375 and 280 kg ha^{-1} and in the unprotected area, 190 and 176 kg ha^{-1} at Dhulli and Begal sites respectively (Fig 3 & 4). After monsoon, the vegetation sampling was repeated in August 2016 at both research sites. In the protected area the total biomass was 782 and 828 kg ha^{-1} and in the unprotected area 268 and 302 kg ha^{-1} at Dhulli and Begal sites, respectively. After a preliminary survey of rangeland productivity and community composition, stocking rates were calculated using the methodology of Holechek *et al.* (1995). In 2015,at both sites in spring and after monsoon the stocking rate in the protected area was set at 6 and 6 animals/ha/month while it was 4 and 4 animals/ha/month in unprotected (control) plots at Dhulli and Begal sites, respectively. In 2016, the stocking rate in the protected area was set at 2.7 and 2 animals/ha/month while it was 1.4 and 1.3 animals/ha/month in unprotected (control) plots at Dhulli and Begal sites, respectively. After monsoon rainfall, the stocking rate in the protected area was set at 5.8 and 6 animals/ha/month while it was 2 and 2.3 animals/ha/month in control plots at Dhulli and Begal sites, respectively

In the rotational grazing trial, during 2015 and 2016, the experimental ewes that grazed on protected rangelands showed higher live-weight gain (48-80 gram/day) compared to ewes (19-24 gram/day) that grazed on un-protected rangelands during the experimental period of 127 days at Dhulli site. The live-weight gain during the first year (2015) was higher in two groups than second year (2016). Similarly, the weight gains were higher before monsoon compared with post monsoon. The statistical analysis showed significance difference among groups, season and years. The average live-weight gain (kg) per hectare also increased in a similar trend (Table 1). The total live-weight gain of entire group (kg) per hectare showed a similar trend with higher gains on protected and lower gains on protected and un-protected rangeland, respectively during the two years (Table 6).

Table 6. Impact of rotational grazing on live-weight (kg) gain of sheep at Dhulli, Pakistan

Parameters	2015				2016			
	Phase-1		Phase-2		Phase-1		Phase-2	
	P	UP	P	UP	P	UP	P	UP
Total area (ha)	24	8	24	8	24	8	24	8
Numbers of plots	3	1	3	1	3	1	3	1
Hecters per plot *(a/b)*	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**
Stocking rate (head/ha) *(h/c)*	6	4	6	4	2.7	1.4	5.8	2
Day grazing/plot	30	30	30	30	30	30	30	30
Days rest period /plot	60	0	60	0	60	0	60	0
Total days on pasture	58	69	58	69	58	69	58	69
Number of heads *(cxd)*	**18**	**12**	**18**	**12**	**18**	**12**	**18**	**12**
Mean initial weight (kg)/head	62.5	61.66	67.16	63	40.84	40.72	44	42
Mean final weight (kg)/head	67.16	63	70.5	64.7	44	42	46.8	43.3
Mean daily gain (gram) *(j-i)/gx1000*	**80.34**	**19.42**	**57.59**	**24.64**	**54.48**	**18.55**	**48.28**	**18.84**
Difference of wt. gain (kg) *(j-i)*	**4.66**	**1.34**	**3.34**	**1.70**	**3.16**	**1.28**	**2.80**	**1.30**
Total weight gain (kg)/ha *(l/cxh)*	**10.49**	**2.01**	**7.52**	**2.55**	**7.11**	**1.92**	**6.30**	**1.95**

At Begal site, during 2015 and 2016, in the rotational grazing trial, the experimental ewes that grazed on protected rangelands showed higher live-weight gain (33-63 gram/day) compared to ewes (17-21 gram/day) that grazed on un-protected rangelands during the experimental period of 127 days. The live-weight gain during the first year (2015) was higher in two groups than second year (2016). Similarly, the weight gains were higher before monsoon compared with post monsoon. The statistical analysis showed significance difference among groups, season and years. The average live-weight gain (kg) per hectare also increased in a similar trend (Table 2). The total live-weight gain of entire group (kg) per hectare showed a similar trend with higher gains on protected and lower gains on protected and un-protected rangeland, respectively during the two years (Table 7).

Table 7. Impact of rotational grazing on live-weight (kg) gain of does at Begal, Pakistan

1	2015				2016			
	Phase-1		Phase-2		Phase-1		Phase-2	
	P	UP	P	UP	P	UP	P	UP
Total area (ha)	24	8	24	8	24	8	24	8
Numbers of plots	3	1	3	1	3	1	3	1
Hecters per plot *(a/b)*	8	8	8	8	8	8	8	8
Stocking rate (head/ha) *(h/c)*	6	4	6	4	2	1.3	6	2.3
Day grazing/plot	30	30	30	30	30	30	114	114
Days rest period /plot	60	0	60	0	60	0	60	0
Total days on pasture	58	58	69	69	58	58	69	69
Number of heads *(cxd)*	18	12	18	12	18	12	18	12
Mean initial weight (kg)/head	51	52.33	54.66	53.5	41.5	41.1	44.4	42.2
Mean final weight (kg)/head	54.66	53.5	58	55	44.4	42.2	46.7	43.4
Mean daily gain (gram) *(j-i)/gx1000*	63.10	20.17	48.41	21.74	50.00	18.97	33.33	17.39
Difference of wt. gain (kg) *(j-i)*	3.66	1.17	3.34	1.50	2.90	1.10	2.30	1.20
Total weight gain (kg)/ha *(l/cxh)*	8.23	1.76	7.52	2.25	6.53	1.65	5.18	1.80

Conclusion

The difference in primary biomass production and its impact on animal productivity at both locations are mainly affected by location along with inter-annual variations in spring and monsoon rainfall, summer temperature norms; and annual precipitation norms. During both years, after spring rainfall the biomass increased 40 -45 % while after monsoon rainfall it increased 30-35 % in protected plots. In the result of this increase in biomass the no of animals per ha was higher than the un-protected plots and its impact was prominent in the form of better body condition and attain higher live-weight in shorter periods and 20 % high price of animals in the local market which improved the livelihood of the local community. The other ecological benefit of rotational grazing is of improved rangelands with reduced soil erosion, better plant diversity, vigor and production. Improving grazing management resulted in better vegetative cover and improved soil structure that allowed a higher percentage of the rainfall to infiltrate the soil where it is used for plant growth rather than running off where it can result in soil erosion and sedimentation problems in adjacent dams in Chakwal areas.

Local farmers who have smaller areas for rotational grazing and large herd sizes, have to acquire grazing lands from larger farmers. This, will provide the opportunity to maintain the grazing reserves and the use of crop residue as livestock feed helps avoid overgrazing and loss of livestock during the dry season or even drought.

Major Challenge include:

- Generally most grazing lands are communal and it is difficult to stop community animals from grazing and can create conflicts among farmers community when trespassing .

- Historically, local community allow nomads from outside to graze in the marginal rangelands and it is difficult to stop the nomads to graze in these areas and is considered unethical.

2.2.2.2 Ahamdun site (Balochistan)

Balochistan has an area of 34.7 million ha and is the largest province of Pakistan and constitutes about 44% of the country. The gross rangeland area of Balochistan is 34.72 million ha, which comprises 78.9% of the total area of the Province. In Balochistan, looking into historical perspective of the rangeland resource use, when the economy was pastoral, the government used to charge a grazing fee for the nomads called “Terni”. The local livestock keeper, mostly sedentary in nature, were set aside part of the rangeland resource called “pergore” or “Rakh” as rotational grazing. Due to these good practices rangelands were in good condition, but now this is mostly vanished due to social and economic changes. Good data and demonstrations can assist in promoting these lost practices to assist in restoring rangelands and supporting a growing livestock population. Keeping in view the above issues, the objectives of this study were to examine the biomass production, plant nutritional values and the scope of the rotational grazing on community rangelands of Balochistan to assess the effect of controlled grazing on small ruminant productivity compared to continuous grazing.

Methods

The study area named Ahmadun Tangian, in the District Ziarat is located in north and extends to the southern part of Balochistan, Pakistan (30º31’49.99″ N, 67º27’02.64″ E) and the elevation ranges from 2287 m in the north to 2146 m in the south. The region has a Mediterranean climate, characterized by a cold winter and a hot dry summer. Annual rainfall varies between 250 and 300 mm and is dominated by winter snowfall. The mean maximum temperature in summer is 36ºC and the mean minimum temperature in winter is -1ºC.

In Ahmadun, the total area was 115 ha which was divided into 4 blocks (approx. 28 ha each). The site which had been protected from grazing since 2014, was divided into four blocks (A, B, C, and D); another Block E was considered as a control (grazed area). Total biomass was measured in June 2015 using the line intercept method, (Herrick et al., 2015).

Results

In May 2015, biomass was measured in each block and dry biomass production was 1706, 1499, 1042, and 1690 kg ha^{-1} in block A, B, C, and D respectively while in the grazed area the biomass was 630 kg ha^{-1} (Figure 22). Despite the experimental area received rainfall in July 2015, the biomass in protected area was 823, 840, 724, and 858 kg ha^{-1} in block A, B, C, and D, respectively while in un-protected area the biomass was 348 kg ha^{-1}. In April 2016, the dry biomass production in each block was 746, 711, 597, and 749 kg ha^{-1} in block A, B, C, and D, respectively while in the grazed area (control) the biomass was 457 kg ha^{-1}. In July 016, the biomass in protected area was 670, 616, 598, and 580 kg ha^{-1} in block A, B, C, and D, respectively while in un-protected area the biomass was 426 kg ha^{-1}.

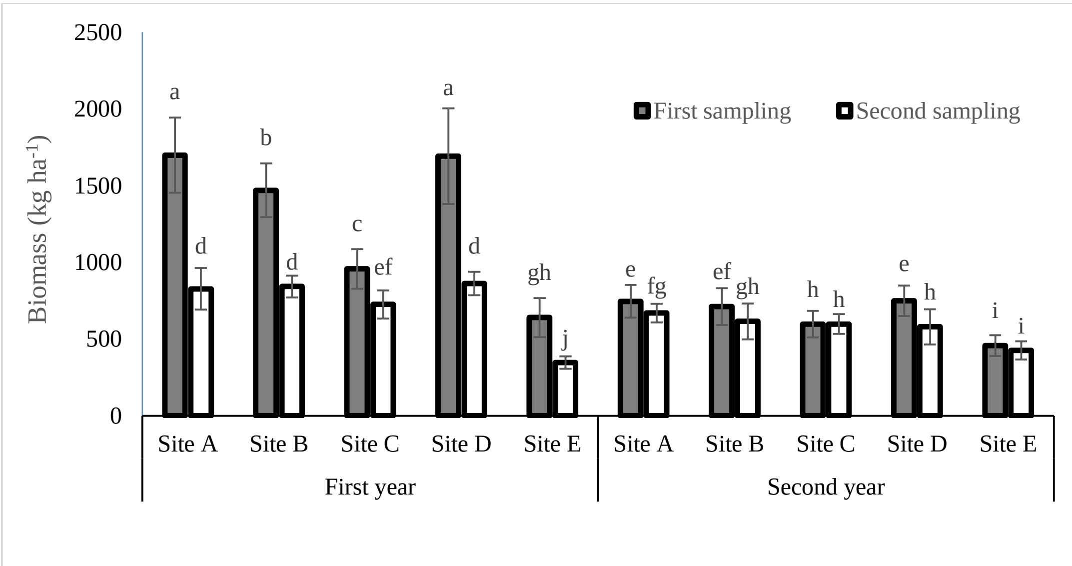

Figure 22: Aboveground plant biomass at site A site B site C, site D and site E sampled during 2015, 2016 in June and August. Different upper case letters represent significant difference (P<0.05) between sampling time of a given site while different lower case letters represent significant difference (P<0.05) between sites of a given sampling time

In the rotational grazing trial, the experimental ewes that grazed on protected rangelands showed higher than average daily live-weight gain (46.05 and 41.18 g, respectively during 2015 and 2016) compared to ewes (17.76 and 22.89) that grazed on un-protected range lands during the experimental period of 152 days during the two years.. The average live-weight gain (kg) per hectare also increased in a similar trend (Table 3). The net live-weight gain for ewes grazed on protected rangeland in a 152 day period was almost double (7 and 6 kg) than the ewes (3 kg) grazed on un-protected rangeland during 2015 and 2016 (Table 3). The total live-weight gain of entire group (kg) per hectare showed a similar trend with higher gains (36.94 and 33.10 kg) on protected and lower gains (14.25 and 18.4 kg) on protected and un-protected rangeland, respectively during the two years (Table 8).

Table 8. Impact of rotational grazing on live-weight (kg) gain of sheep at Ahmadun, Ziarat, Pakistan

Parameters	2015		2016	
	Protected	Unprotected	Protected	Unprotected
Total area (ha)	115	115	115	115
Numbers of plots	4	4	4	4
Hecters per plot (a/b)	28.8	28.8	28.75	28.75
Stocking rate (head/ha) (h/c)	5	2	5	3
Day grazing/plot	30	30	30	30
Days rest period /plot	30	0	30	0
Total days on pasture	152	152	152	152
Number of heads (cxd)	144	58	144	86
Mean initial weight (kg)/head	51	50.5	33.82	27.52
Mean final weight (kg)/head	58	53.2	40.08	31
Mean daily gain (gram) (j-i)/gx1000	46.05	17.76	41.18	22.89
Difference of wt. gain (kg) (j-i)	7	3	6	3
Total weight gain (kg)/ha (l/cxh)	36.94	14.25	33.10	18.40

Conclusion

In Ahmadun, the total biomass was considerably affected by rainfall fluctuations between spring and summer. Despite variation in rainfall pattern, but our two years complete protection form grazing, it improves the rangeland productivity by 55 and 40% during 2015 and 2016 but previous heavy grazing in protected and continues grazing in un-protected plots has a major impact on loss of species, diversity and lack of opportunity for plant regeneration. For the first time in Pakistan, a nondestructive method was used to estimate vegetation cover of rangelands. Thus, the VegMeasure® software was successfully used to quantify vegetative ground cover in Balochistan rangelands. Our results demonstrate that VegMeasure allows a low cost and rapid measure of early vegetative cover in the field that could easily be incorporated into future rangeland programs for rangeland managers to develop their regular planning.

In both years, during rotational grazing, the weight gain in protected area was significantly higher ($p<0.05$) 7 to 6 kg per head during 2015 and 2016 respectively in five months compared to un-protected area where the weight gain was 3 kg per head. After this study, our results can be helpful for range mangers to see the possible effects of changes in grazing pressure on the Ahmadun rangeland but still it is not sure that how small ruminants are managed (light or light/moderate grazing or greater levels of grazing) to maintain and improve the rangeland productivity.

Major challenges include:

- To stop trans-boundary movements of nomads
- To bring all the community of the area on one pitch for rangeland protection and deferred grazing

- During rotational grazing, herder's capacity building is very important to get a positive results during rotational grazing

Partners (institutes, international organizations, NGO:
This activity implemented with the collaboration of following partners.

i. Forest & wildlife Department Govt. of Balochistan
ii. Pakistan Agricultural Research Council, Islamabad
iii. Balochistan Agricultural Research Center, (BARC) Quetta,

2.2.2.3 Thar Umerkot site(Sindh)

In Thar desert Hurrabad area, district Umerkot, located in the south-eastern part of Pakistan (25.3614° N, 69.7436°E). The average annual precipitation is 180 mm (range 100–500 mm) in surrounding of Umerkot district. Generally most of the seasonal precipitation (80%) received in summer (June, July, and August). The fall and spring (December, January February March) mostly receives 20% of the annual rainfall. Average daily air temperatures at the site in summer ranged maximum of 24–48°C, while in winter daily air temperature averages can range from a minimum of 1–16°C.

Methods
At experimental site the range area was protected from grazing since 2015, and divided into three blocks of 15 ha each. Same size blocks were also developed in un-protected area but in results, showed the mean of three blocks. The biomass from each block was estimated during April after spring rainfall and August 2016 after monsoon, which corresponded approximately to the time of peak biomass. At each site, three 100 m transects spaced 5 m apart were selected along each transect. A 1x1 m^2 quadrate was used, and all living and recent dead herbaceous biomass was clipped at ground level and separated by species. All samples were dried for twenty four hours at 55 □C and weighed. Harvesting current live plus recent dead biomass at the time of peak standing crop has been used to estimate biomass productivity.
After a preliminary survey of rangeland productivity and community composition, stocking rates were calculated using the methodology of Holechek *et al.* (1995). In April 2016, based on availability of green fodder, the stocking rate in protected area was set at 2.5 animals/ha/month while it was 0.35 animals/ha/month in the un-protected area. After monsoon rainfall the stocking rate in the protected area was set at 6 animals/ha/month while it was 2.5 animals/ha/month in un-protected area.

Results
Biomass yields were significantly different ($p>0.05$) among sampling during various harvested timing at both landscapes (protected and un-protected). Protected and un-protected plots were sampled after spring and monsoon rainfall. Total dry-matter production in protected and un-protected plots were variable from spring to summer harvesting after monsoon rainfall. In April,

the dry matter production was 152, 170 and 181 kg ha^{-1} in block A, B, and C, respectively, while the biomass was 28 kg ha^{-1} in the un-protected plot. After monsoon rain, the biomass increased significantly ($p<0.05$) from June to August at protected and un-protected plots. The dry matter production was 1010, 1044 and 1036 kg ha^{-1} in block A, B, and C, respectively. In the un-protected plot the dry matter production was 306 kg ha^{-1}.

The experimental does (Patari breed) that grazed on protected rangelands at Umerkot site after spring and summer (during monsoon) showed significantly higher ($p>0.05$) mean daily live-weight gains 2.8 and 15.8 kg, respectively, than livestock on un-protected rangeland 0.8 and 11.33 kg, respectively in 42 (from mid-April to May, 2016) and 96 days (June to 1st week of Sep, 2016) of grazing, respectively Table 9.

Table 9. Impact of rotational grazing on live-weight (kg) gain of sheep before and after monsoon rain at Hurrabad, Umerkot site

Parameters	**Umerkot-Phase-1 (Before monsoon)**		**Umerkot-Phase 2 (During/after monsoon)**	
	Protected	**Unprotected**	**Protected**	**Unprotected**
Total area (ha)	45	15	45	15
Numbers of plots	3	1	3	1
Hecters per plot *(a/b)*	**15**	**15**	**15**	**15**
Stocking rate (head/ha) *(h/c)*	2.5	0.4	6	2.5
Day grazing/plot	30	30	114	114
Day’s rest period /plot	60	0	60	0
Total days on pasture	30	30	122	122
Number of heads *(cxd)*	38	6	90	38
Mean initial weight (kg)/head	33.12	33.2	36	34
Mean final weight (kg)/head	36	34	51.8	45.3
Mean daily gain (gram) *(j-i)/gx1000*	**96.00**	**26.67**	**129.51**	**92.62**
Difference of wt. gain (kg) *(j-i)*	**2.88**	**0.80**	**15.80**	**11.30**
Total weight gain (kg)/ha *(l/cxh)*	**7.20**	**0.32**	**94.80**	**28.25**

Conclusion:

In Thar Desert Hurrabad area, district Umerkot, the protection not only increased 50% higher biomass compared to un-protected areas. Despite all climatic problems, due to higher biomass, the carrying capacity of the area not only increased but also kept the animals for more than four months and increased animal’s body weight compared to un-protected areas.

Partners

This activity implemented with the collaboration of following partners.

i. International Livestock Research Institute (ILRI),
ii. Pakistan Agricultural Research Council, Islamabad
iii. Arid Zone Research Institute (AZRI) Umerkot,

2.2.3 Technology/Intervention: Rehabilitation of degraded rangelands in Balochistan

Introduction

The situation warrants to exercise grazing management at Ahmadun, Ziarat rangelands through local communities so that part of these areas annually rested; moreover, the local communities should be encouraged to improve the condition of their rangelands through sowing & planting of foraging species through water harvesting techniques. In this way not only the forage will be made available to livestock but key rangeland areas will also be rehabilitated, which will be a demonstration to the local rangeland stakeholders for adaptation.

The main objective was to reduce degradation of the rangeland resources through the introduction and development of sustainable management and improvement practices for the improvement of rangelands (and greater carrying capacity), increased production and incomes (increased production value and profit margin of sheep), reduced workload for women and human resource development.

Methods

A 50 ha demonstration site was prepared to demonstrate water harvesting combined with shrub planting. Construction of micro-catchments (crescent-shaped) were developed on land slopes of 1 to 8 percent with variable soil depth (except shallow soils) to trap water and seedlings *Atriplex lentiforms* and *Acacia victoria* were implemented. (Figure 6). Microhabitats did not influence natural recruitment of perennial seedlings. Seedlings transplanted under micro catchments, shrubs showed higher survival rates compared to seedlings in unmodified areas.

Figure 23: Rehabilitation of rangeland with *Atriplex lentiforms* and *Acacia Victoria*

In arid areas, surface water is usually the main source of water for purely pastoral livestock. In rainy seasons, precipitation over limited catchment basins runs off and concentrates in natural ponds where the soils are sufficiently impervious to prevent leaking. Most of these ponds dry out

a few weeks after the end of the rainy season, due to the combined effect of evaporation and seepage. Keeping in view of above issues, two stock water ponds were developed at Ahmadun, Balochistan. The main purpose was to increase the storage capacity of water ponds to extend their period of utilization, and to create new surface water reservoirs in order to better utilzie the rangeland resources.
The stock water ponds had a capacity of 372.42 m^3 water with a dimension of 94 ft x 17.5 ft x 8 ft.

Figure 24: Stock water pond at Ahmadun, Ziarat

Conclusion

The water harvesting techniques provide the opportunity to grow shrubs and help to conserve water in dry periods. In last two decades, in most of the foreign aid projects in Balochistan, water harvesting techniques were successfully implemented in many areas of Balochistan. Unfortunately, in one year, we were unable to show good results but previous experience shows that this technology can be implemented in arid and semi-arid areas of Pakistan but that it takes least five years to achieve some good results.

Major challenges include:

- High cost of developing water harvesting structures
- Poor awareness of local communities of understanding of rain water harvesting and conservation (RWH&C) techniques, e.g. the benefit of combining various techniques.

Partner**:**

- Forest and wildlife Department, Govt. of Balochistan (took over the initiative after end of the project).

3 Component 2: Small Ruminant Value Chain

3.1 Introduction

The livestock sector occupies a unique position in the National Agenda of the economic development of Pakistan. This sector plays a vital role in revenue generation of the country and is presumed to play an important role in poverty alleviation to uplift the socioeconomic condition of Pakistan's rural masses. The animal production operations provide 35% income directly or indirectly to nearly 8 million rural families in Pakistan. In country prospective, livestock contributes approximately 58.6 percent to the agriculture value added and 11.6 percent to the overall GDP during 2015-16. Gross value addition of livestock at constant cost factor of 2005-06 has increased from Rs. 1247 billion (2014-15) to Rs. 1292 billion (2015-16), showing an increase of 3.63 percent over the same period last year (2015). There are about 29.8 and 70.3million heads of sheep and goats, respectively in Pakistan.

Sheep and goats are important contributors to meat production in Pakistan, producing 37,000 tons of meat annually. There are certain constraints of physiological and infectious origin which limited the growth of this industry in terms of poor production performance and reproductive efficacy. Balanced nutrition is an essential key for maintenance and growth of ruminants. the availability of livestock feed is becoming scarce due to poor quantity and quality of rangelands shrubs and grasses and its reduction in area due to urbanization

It has been well established that energy and total nutritive value is the major concern in composition of animal ration as it is responsible for maintenance of animal health and immune response. The fattening is mostly aimed to achieve maximum growth on the basis of feeding high protein levels (12-18%) within economical production costs on the basis of higher feed conversion efficiency. The productive performance of animals cannot be improved unless the numbers of grazing animals are adjusted according to the availability of nutrients from the rangelands along with strategic supplementary feeding interventions to increase output per animal. A number of interventions were tested to increase productivity of small ruminants in different ecologies of Pakistan in the AIP Project.

3.2 Technology/Intervention: Prevention and control of internal parasites in small ruminants

<u>Introduction</u>

Gastrointestinal nematodes are a main cause for production losses in terms of lower milk and meat production in affected animals. Heavy infestation with gastrointestinal parasites lead to retarded growth and to high mortality. In the past years the control of nematodes has relied on chemical treatments and has been quite effective but the development of anthelmintic resistance against parasites reported in various countries is threatening the effectiveness of anthelmintic drugs. At the same time studies in different parts of the world showed that there are many medicinal plants that have the potential to be used as anthelmintics. However, often the evidence reported in ethno-veterinary sources is based on observations, instead of proper experimentation. In our study the effectiveness of herbal medicine for the control of gastrointestinal parasitic infections in small ruminants was compared to synthetic drugs.

Methods

Synthetic and herbal anthelmintics were tested for prevention and control of internal parasites in sheep and goats with repetition in an interval of 3-4 months. The efficacy of two synthetic (Nilzan plus and Ivermectin) and three herbal medicines (Deedani, Atreefal Deedani and Kirmar) were tested against multiple parasitic infection in sheep and goats (Table 10)

Figure 25: Herbal Anthelmintics

Figure 26: Drenching anthelmintics

Table 10. Synthetic and herbal medicine against multiple parasitic infections in sheep and goats

Treatment	Dose applied
Nilzan plus	5 ml/10 body weight once
Ivrmectin	1 ml/50 kg body weight once
Deedani	5 g/head/day for 3 days
Atreefal Deedani	10 g/5 kg body weight once
Kirmar	3.5 g/head/day for two days

Benefits

The animals treated with Nilzan plus, Ivermectin and Atreefal Deedan showed the highest reduction (90-97%) in faecal parasitic egg counts, followed by Deedani (80-86%) and Kirmar (73-76%). These results indicate that the herbal anthelmintic Atreefal Deedan is as effective against internal parasites of sheep and goats as synthetic drugs and can be used to avoid drug resistance.

It is recommended to repeat treatment in an interval of 3-4 months to regularly eliminate the parasitic burden as preventive and control measure and alternate use of synthetic and herbal to avoid the drug resistance.

Major challenges

There is limited quality medicine available in rural areas for the control of internal parasites. Farmers were guided to purchase medicine from well reputed veterinary medical stores in adjacent big cities. Extension material in local language is required to widely distribute among the farming community for wider adoption of technology.

Partners

i. Animal Sciences Division, Pakistan Agricultural Research Council, Islamabad.
ii. Animal Health Program, Animal Sciences Institute, National Agricultural Research Centre, Islamabad.

3.3 Technology/Intervention: Supplemental Feeding of ewes and does

Introduction

One peak in sheep and goat mating occurs in September/October with lambing/kidding in March/April. Although supplemental feeding is recommended before mating, during late gestation and just after lambing/kidding for higher production, small ruminant production in the two fodder scarcity seasons depends entirely on grazing.

Methods

To enhance reproduction, supplemental feeding of ewes/does for 60 days in the fodder-scarce winter season (December/January) was tested. Three supplemental rations (Table 11) based on locally available feed were prepared and offered to sheep and goats (500 g/head/day for 60 days in combination with a green fodder mix of maize, alfalfa and oats (50:50 ratio).

Figure 27: Supplemental feeding to ewes **Figure 28:** Concentrate ration formulation

Table 11. Composition of supplemental feed

Ingredients	Ration Formulation		
	A	**B**	**C**
Cotton seed cake	10	20	1
Rape seed cake	10	0	10
Soybean meal	5	5	5
Maize grain	20	20	20
Wheat bran	23	23	20
Rice polish	20	15	18
Maize gluten 30%	5	10	5
Molasses	5	5	5
DCP	1	1	1
Salt	1	1	1
CP %	**16.5**	**17**	**17.5**
TDN %	**72-75**	**75-80**	**75-85**

Major benefits

Supplemental feeding of pregnant ewes/does in addition to grazing enhanced production; the ewes showed a liveweight gain of 3-5 kg, and lambs/kids survival reached 80-90%. The females grazing without supplement lost up to 2 kg liveweight and lambs/kids survival was only 70-75%. The small ruminant farmers who opted for improved technologies, achieved good economic returns. This technology would be most effective with controlled breeding to obtain the new born lambs/kids in the same season.

The extension material in local language is needed to widely distribute among the farming community for wider adoption of technology to obtained higher small ruminant productivity.

Major challenges

The farmers mostly follow uncontrolled breeding through keeping the males in the herds around the year which results in lambing/kidding. The management of supplemental feeding to whole flock linked with breeding cycle was found difficult.

Partners

- i. Animal Sciences Division, Pakistan Agricultural Research Council, Islamabad.
- ii. Animal Nutrition Program, Animal Sciences Institute, National Agricultural Research Centre, Islamabad.
- iii. Crop Sciences Program, National Agricultural Research Centre, Islamabad. Range Sciences Program, National Agricultural Research Centre, Islamabad.

3.4 Technology/intervention: Lambs/kids fattening targeting Eid-Ul-Azha marketing

Introduction

There are only a limited number of farmers who have adopted fattening with supplemental feed before marketing. So this study tested lamb/kid fattening in farmers' herds, and assessed fattening potential of native lambs/kids for increased mutton production to develop economic options for lamb/kid fattening.

Figure 29: Male kids/lambs fed with fattening ration for Eid ul Azha marketing

Methods

Different rations (Table 12) were tested for fattening male healthy lambs/kids for 90-120 days to be sold during Eid-ul Azha.

- Healthy male lambs/kids
- Age of lambs may be between 5-6 month and for kids between 9-10 month
- Castration of all the lambs/kids involving for fattening
- De-worming (with Nilzan plus 1 ml /kg liveweight orally) and vaccination (enterotoxaemia (ETV), Foot and Mouth disease (FMD), Peste des petits ruminants (PPR), Pox, Pneumonia (CCPP) as per animal health calendar
- Supplemental feeding for 90-120 days
- The supplemental feeding of 500 g/head for 7 days during adaptation period. Then 1 kg/head/day in combination with wheat straw (1:1 kg ratio) or green fodder like maize and Lucerne (1:2 kg ratios).

Table 12. Formulation of experimental rations

No	Ingredients	T1	T2	T3	T4	T5	T6	T7
1	Wheat	-	-	-	10	-	-	-
2	Wheat bran	13	16	15	27	15	20	15
3	Rice polish	-	-	-	8	-	5	5
4	Rape seed cake	-	-	-	3	-	3	5
5	Rape seed meal	-	-	-	1	-	-	-
6	Cotton seed cake	-	-	-	12	35	-	-
7	Cotton seed meal	-	-	-	1	-	12	10
8	Sun flower meal	-	-	-	1	-	-	-
9	Maize grain	40	40	40	25	24	30	35
10	Molasses	9	9	9	10	-	-	8
11	Common salt	1	1	1	1	1	1	1
12	Di-calcium phosphate	1	1	1	1	1	1	1
13	Barley grain	-	-	-	-	24	-	-
14	Soybean	12	10	0	-	-	-	-
15	Canola cake	9	8	9	-	-	8	5
16	Maize Gluten 30%	15	15	25	-	-	20	15
	CP %	**17.85**	**16.65**	**15.45**	**15.39**	**16.00**	**15**	**16.5**
	TDN %	**70**	**70**	**69**	**91**	**75**	**80**	**85**
	Energy (MJ/Kg)	**3200**	**3000**	**2800**	**2900**	**3100**	**2900**	**2800**

Benefits

Lambs/kids attained higher liveweight gains (2.4 to 8.5 kg; 96-188 g/head/day) with supplemental feeding compared to farmers' practice (0.7 to 2.8 kg; 23-62 g/head/day). The economic analysis showed that feeding lambs/kids with supplemental rations leads to higher profit margins which ranged from Rs. 5190 to Rs. 14730 per head compared with control groups (Rs. 5100 to Rs. 12900). Supplemental feeding resulted in higher profits of Rs. 90 to 1830 per head compared to farmers' practice. To enable the farmers to continue lambs/kids fattening in the future, they were linked with private and public feed mills to obtain feed.

Major challenges

There are challenges in procurement of lambs/kids and other inputs (feed, medicine etc.) but also in marketing fattened animals for a good price given the fluctuations in the lamb sale price in the market.

Partners

i. Animal Sciences Division, Pakistan Agricultural Research Council, Islamabad.
ii. Animal Nutrition Program, Animal Sciences Institute, National Agricultural Research Centre, Islamabad.
iii. Crop Sciences Program, National Agricultural Research Centre, Islamabad. Range Sciences Program, National Agricultural Research Centre, Islamabad.
iv. Pothwar Flour/feed Mill Private Ltd., Islamabad

3.5 Technology/intervention: Wintertime supplemental feeding of ewes and does including cactus (*Opuntia ficus-indica*)

Introduction

In dry areas, the drought-tolerant spineless cactus pear (Opuntia ficus indica) can be an alternative source of feed. It has a high production potential and is easy to establish under low rainfall and high temperatures. Cactus contains 101 g/kg of dry matter (DM), 77 g/kg of crude protein (CP) and 278 g/kg of neutral detergent fiber (NDF). Given the role of cactus in other dry regions of the world, spineless cactus was introduced as animal feed in dry areas of Pakistan. Because cactus as animal feed is not common in Pakistan, farmers needed to become convinced of this plant as animal feed, so the effect of cactus based feed formulation on sheep and goat production was demonstrated and capacity of farmers in cactus production and feeding was developed.

Methods

Supplemental feeding of pregnant ewes/does and weaned lambs/kids during winter season was tested with concentrate ration mixed with cactus or other available fodder to enhance the productivity.

Figure 30: Chopped cactus

Figure 31: Cactus-based supplemental feeding to sheep/goats

Three concentrate rations (Table 13) were formulated based on cactus cladodes, green oat and Alfalfa. The ingredients of the concentrate ration were grinded and mixed followed by addition of cactus or fodder at the time of feeding.

Table 13. Three supplemental feed formulations based on fodder and cactus

Items	A (Oat based)	B (Cactus based)	C (Lucerne based)
Maize grain	18	20	20
Barley grain	10	10	10
Wheat bran	26	27	27
Cotton seed cake	10	10	10
Canola meal	8	10	8
Ground net hay	8	5	8
Wheat straw	5	5	5
DCP	1	1	1
Common salt	1	1	1
Oat (fodder)	13	0	0
Cactus (Fresh)	0	11	0
Alfalfa (fodder)	0	0	10
Total	**100**	**100**	**100**
CP %	**14.25**	**14.10**	**14.3**
TDN	**67.24**	**67.25**	**67.3**

Pregnant ewes/does and weaned lambs/kids grazed for 5-6 hours daily on rangelands and received the 2 kg/head/day supplemental feed in the evening for two months (December 15, 2015 to February 16, 2016). Lambing/kidding (%), live weight at birth of lambs/kids and mortality of lambs/kids, and ewes/does mortality were recorded during the experimental period.

Benefits

The results showed that ewes fed on Alfalfa-based supplemental ration (group C) showed the highest weight gain (4.61 kg) followed by oat (4.78 kg) and cactus (3.39) compared to the control (1 kg) after 60 days. The does in group A and C fed on oat and Alfalfa-based supplement showed similar liveweight gain (3.33 Kg) followed by group B fed with the cactus based supplement (2.95 kg) compared to control (1.33 kg).

Lamb birth weights (4-4.3 kg) were highest in group B and C fed on cactus and Alfalfa-based ration followed by oat (3.46 kg) and smallest (2.7 kg) in the control group. Kid birth weights (3.15 Kg) was highest in group A fed on oat based ration, followed by Alfalfa (2.4 kg), cactus (2.3 kg) compared to the control (2 kg).

Cactus-based supplementation is still at an experimental stage and only recommended for Potwar area of Pakistan.

Major challenges

The farmers hesitated to feed the cactus to animals given that they had no previous experience.

Partners

i. Animal Sciences Division, Pakistan Agricultural Research Council, Islamabad.
ii. Animal Nutrition Program, Animal Sciences Institute, National Agricultural Research Centre, Islamabad.

iii. Crop Sciences Program, National Agricultural Research Centre, Islamabad. Range Sciences Program, National Agricultural Research Centre, Islamabad.

3.6 Technology/intervention: Development of Model cum Training farms for Small Ruminants

Introduction

Disease prevalence, shortage of feed, fodder, water and limited access to quality medicine/vaccine and lack in capacity of the farmers, alone or in combination result in an overall low farm productivity. Representative sites and champion farmers were selected to demonstrate best practices in animal husbandry integrated with feeding and health in a model farm concept.

Method

The model farm was developed for 100 heads of small ruminants; proper housing would be integrated with capacity development in feed/fodder, disease prevention and control coverage, breeding and proper marketing

Figure 32: A view of Small Ruminant Model Farm at Chakwal

Sheep/goat shed for 100 heads

1. The **closed shed** is 1200 feet^2 (24 feet width, 50 feet length and 10 feet height) and within this room a separation of 10 x 24 feet^2 for pregnant animals with a net. The location of shed is from east to west. The space for each animal will be 12 feet^2. The wall is constructed with bricks coated with cement plaster on the inner side and outer side and cement plaster is put between bricks. One main door (4x7 feet) faces the open shed and four windows (8x6 feet each) are on each north-south wall. The floor is cemented and the roof is ready-made cement material. Four pillars are put at the distance of 10-12 feet in the middle of the room to support the roof.
2. The **open shed** is double the size of the closed shed (2400 feet$^{2)}$ (48 feet width and 50 feet length). Three sides of open shed are fenced with iron pipes fixed with a mesh net wire up to the height of 5 feet with a gate of 6 feet width.

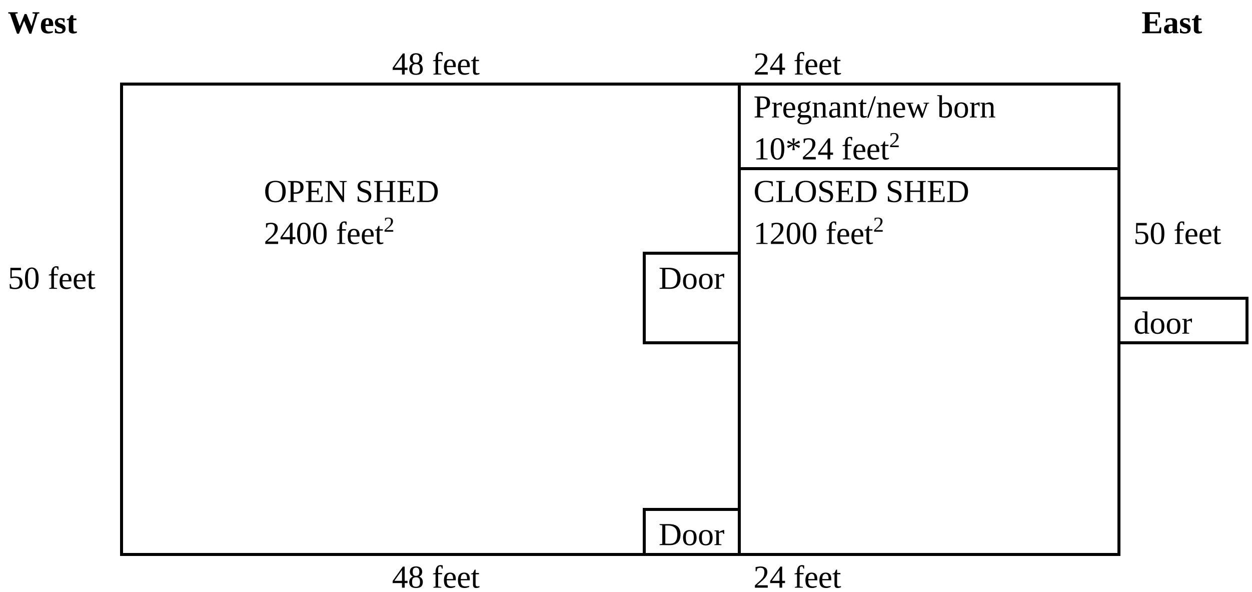

Figure 33: Diagram of Sheep/goat shed

Benefits

- 10 small ruminant farmers at three sites directly benefited from the model farm concept. An overall 20% increase in productivity of small ruminants was observed.
- The demonstration of the model farm concept benefited also other farmers indirectly by learning about improved production practices from the champion farmers.
- Proven technologies in feed, fodder and range can be disseminated through the model farms at the door step of neighboring farmers.

Major challenges

The farmers initially hesitated to invest their 50% share of the building costs, however after completion many farmers showed interest. Some are building by their own sheds copying the design of model the farm. NARC/PARC has engaged MSc./PhD students to further investigate the challenges farmers face in the already developed model farms as an excellent source of data. In addition, linkages of farmers with quality service providers need to be improved.

Partners

i. Animal Sciences Division, Pakistan Agricultural Research Council, Islamabad.
ii. Animal Nutrition Program, Animal Sciences Institute, National Agricultural Research Centre, Islamabad.
iii. Crop Sciences Program, National Agricultural Research Centre, Islamabad.
iv. Range Sciences Program, National Agricultural Research Centre, Islamabad.
v. Arid Zone Research Institute (AZRI), Umerkot