Mega-Project 4

Diversification and Sustainable Improvement of Crop and Livestock Production Systems in Dry Areas

Introduction

Within developing-country dry areas, the majority of the rural population is involved in the agricultural sector, with crops and livestock both contributing significantly to the livelihoods of the poor. Mega-Project 4 focuses on enhancing income-generating options for the rural poor from crops and livestock, especially small ruminants; improving, intensifying and diversifying current agricultural production systems; increasing and diversifying outputs; improving the safety, quality and marketability of produce; and adding value through agri-processing of primary products, while sustaining the resource base. It aims to contribute to the development of productive and sustainable systems that enhance nutrition and livelihoods and generate opportunities for rural agri-business development and increased employment.

Greenhouses increase farmers' incomes in Yemen and Afghanistan

Increased income from high-quality cucumber crops in Yemen

Farmers in Yemen's rainfed terraces produce many food crops, but their returns are low. This has contributed to a rural exodus – particularly by men seeking other employment – and a decline in the maintenance and productivity of terraced lands. Attempts to encourage farmers to remain on the land have been successful only where irrigation water is available and cultivation of cash crops is possible.

A two-year project funded by the French-Yemen food aid program aims to introduce and promote affordable, sustainable systems of protected agriculture that use water efficiently to produce high-value crops in Yemen's mountain terraces. It involves installing simple greenhouse structures at 35 pilot sites.

Greenhouse production of cash crops is helping to increase farm incomes in Yemen.

By increasing water-use efficiency and therefore farmers' incomes, the project is helping to maintain terraced lands and conserve natural resources. This supports the Government of Yemen's rural development and food security policies.

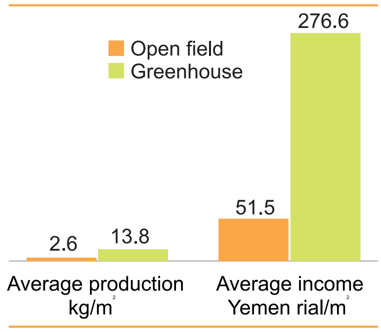

Fig. 4.1. Average cucumber yields and income per square meter in open fields versus greenhouses in Yemen, 2005. US$ 1 = YER 197 (approx)

Simple greenhouses have already been installed at 17 pilot sites and ICARDA has provided technical support for the participating farmers. Project staff carefully studied the farmers' socioeconomic profiles before installing the greenhouses, and production records were collected on a routine basis.

Training is a key component of this project. Using the train-the-trainer approach, ICARDA staff and consultants have improved knowledge among extension agents, agricultural engineers, and technicians. The project gave farmers on-the-job training and developed five handouts in Arabic on protected agriculture.

The first year yielded very promising results. Farmers using greenhouses to grow cucumber generated good income while increasing water and nutrient use efficiency and yields per unit of land (Fig. 4.1).

Producing high-quality cash crops in Afghanistan

To speed up rural development in Afghanistan, ICARDA developed a three-year project for transferring intensive cash-crop production systems to farmers. The project, which began in January 2004 and ended in March 2006, was supported by USAID.

The participants – 35 farmers in six provinces – increased their incomes by as much as 135% using the protected agriculture system to produce high-quality cash crops. Seeing the success of their neighbors, many more farmers have requested training from ICARDA in the greenhouse technology. In April 2006, 30 farmers in Kunduz agreed to pay 50% of the cost of the greenhouses in exchange for technical support from ICARDA and an on-the-job training course (21-27 April 2006).

An economic analysis showed that, compared with open-field production, cucumber production in greenhouses yields four times the outputs and five times the net income per unit of land. Equally important, it provides nine times the net return per unit of water.

By developing local capacity in protected agriculture techniques, the project sought to ensure that its outcomes were sustainable. By March 2006, 364 people had received training in Afghanistan. A series of eight training manuals were also published in the local language, covering greenhouse installation, climate control, drip irrigation, crop nutrient and management needs and vegetable production methods.

In 2005, a Protected Agriculture Center (PAC) was established in Kabul to conduct research and provide training, technical support and advisory services. Demonstration greenhouses at the center have helped to generate farmer interest and

Dr Ahmed Moustafa (left), Coordinator of ICARDA's Arabian Peninsula Regional Program, demonstrates protected agriculture technologies to Afghan farmers.

promote adoption. The first harvest – 1.7 tons of cucumber from one greenhouse – was produced in only 75 days, generating returns of U$1200.

A workshop at PAC on greenhouse manufacturing techniques helped to reduce greenhouse costs by 40% by promoting the use of locally available materials. Fifteen Afghan technicians received training at this workshop, supporting the sustainability of the project.
The project also organized six other workshops and seven farmer field schools. The final workshop, held on 19 March 2006, brought together 65 national and international experts, 17 farmers, and representatives of the Afghan government, the FAO, Kabul University, the French embassy, and many international development and agricultural research agencies. The participants requested support from ICARDA to continue the project and expand it to other provinces, and to support the formation of a protected agriculture growers' association in Afghanistan.

The greenhouse technology has had significant impact on growers' incomes, while enabling farners to use marginal land, and reduce labor and water requirements. This provides substantial evidence that the technology is economically viable in the context of Afghan agriculture. This is very important in light of the need to find suitable livelihood alternatives for poppy growers. While Afghanistan's ban on poppy cultivation is a positive development, it has serious implications for the rural economy. Poppy farmers and people who harvest poppy – a highly labor-intensive process – have lost a major source of income. According to interviews with farmers in poppy-growing areas, the net profits from greenhouse production of high-quality cash crops can easily replace – and surpass – the profits from poppy cultivation (Fig. 4.2).

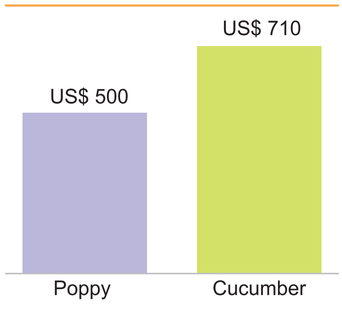

Fig. 4.2. Comparison of net income from poppy and greenhouse cucumber in Afghanistan, over one year of production. Figures are based on one jerib of poppy (2000 m^2) and one greenhouse (270 m^2) of cucumber, and were derived from interviews with farmers and a socio-economic study.

Effect of lower cost feed on the quality of meat from Awassi lambs

The high cost of feed reduces profits for small farmers fattening lambs in intensive production systems in Syria. Less expensive feeds of equal or better quality can boost farmers' incomes.

ICARDA researchers compared the effects of cheaper feeds (least-cost diets) and traditional costly feeds on meat quality. They conducted two fattening trials in 2003/04. In the first, on-station trial, they fed lambs two least-cost diets and a control diet of traditional feed. In the second, community-based participatory trial, they tested the most promising least-cost diet on three fattening farms in the Khanasser valley, northern Syria.

Weaned male Awassi lambs were used for both on-station and on-farm fattening trials. In the on-station trial, two least-cost diets and one traditional diet were fed to lambs for 90 days. In the on-farm trial, lambs were fed the best least-cost diet (as determined by the on-station trial) for 72 days and compared with lambs fed the traditional diet (Table 4.1). The least-cost diets included molasses and wheat straw treated with urea. These ingredients are available locally and are cheaper than traditional ingredients, but farmers are unfamiliar with them.

The fasting lambs (kept without feed, but given water) were slaughtered at the slaughterhouse in Aleppo, the carcasses kept at 2°C for 35 hours, and the *Longissimus dorsi* muscles extracted.

Table 4.1. Ingredients of diets in on-station and on-farm fattening trials.

Ingredients	On-station trial				On-station trial		
	Control	Diet 1	Diet 2	LCD	Control Farm 1	Control Farm 2	Control Farm 3
Broken corn	■		■	■			
Broken faba beans		■					
Cotton seed cake	■	■	■	■		■	■
Whole barley grain	■	■	■	■	■	■	■
Wheat bran	■	■	■	■	■	■	■
Wheat grain					■	■	■
Minerals, vitamins and salt	■	■	■	■			
Molasses			■	■			
Vetch grazing					■		
Barley/wheat straw	*ad lib*				*ad lib*	*ad lib*	*ad lib*
Urea treated wheat straw		*ad lib*	*ad lib*	*ad lib*			

Awassi ram lambs in the on-farm fattening trial in Khanasser Valley, northern Syria.

The pH of the meat was recorded at slaughter, and at 35 hours and 72 hours after slaughtering. One *Longissimus dorsi* muscle from each lamb was immediately stored at –20°C; the other was stored for 72 hours at 2°C after slaughtering, and then at –20°C until evaluation.

The pH of meat samples from on-station (average 5.99) and on-farm trials (average 6.05) did not differ significantly. Changes in the pH of meat samples from both trials were normal, and fell as the meat aged and the sugars were converted. In on-station trials, the pH was 6.17, 5.97, and 5.84, at 0, 35, and 72 hours, respectively, after slaughtering ($p<0.0001$) and in on-farm trials, 6.6, 5.8, and 5.76 ($p<0.0001$).

The meat was cooked for 70 minutes in a circulating water bath at 70°C core temperature of meat, then cut into small cubes, and evaluated by a panel of 27 men and women. They ranked the meat for tenderness, juiciness, taste, and smell on a scale of 1 (low) to 6 (high).

The panel detected no difference in smell, taste, and juiciness between the meat from lambs fed the two least-cost diets and the control diet in on-station trials. The panel rated the tenderness of meat from lambs fed least-cost diet 2 and the control diet the same. However, they rated meat from lambs fed least-cost diet 1 more tender than meat from lambs fed the control diet ($p=0.032$) (Fig. 4.3).

The evaluation of the meat from lambs in the on-farm trials produced very similar results to that from lambs in the on-station trials. The panel detected no difference in smell and taste between the meat from lambs fed the least-cost diet and the meat from lambs fed the control diet ($p>0.426$). Similarly, there was no difference in juiciness and tenderness between animals fed different diets on farms 1 and 2 ($p>0.381$). However, on farm 3, the meat from lambs fed the control diet was considered

Left to right: Evaluating the lamb carcasses; preparation; and evaluation of meat samples

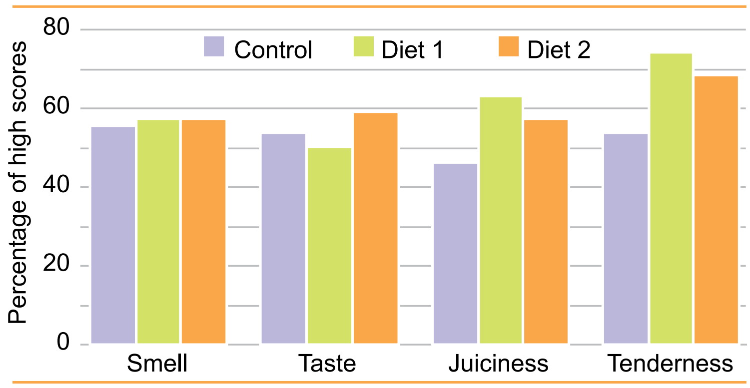

Fig. 4.3. Percentage of high scores (4 to 6) for meat quality of lambs fed two least-cost diets and a control diet in on-station trials. Control = traditional diet; diet 1 and diet 2 = least-cost diets.

more juicy and tender than meat from lambs fed the least-cost diet ($p<0.003$).

Researchers also measured the increase in weight of lambs fed different diets. Lambs fed the least-cost diets gained weight at the same rate or faster than those fed the traditional diets. The low-cost diets did not affect the aging or taste of the meat. This means farmers need not be concerned that least-cost feed will lower the quality of meat. By using lower-cost feeds they will raise their profits.

Farmers were enthusiastic about the low-cost feeds, in particular with the use of molasses. However, at present there is no system to deliver molasses to farmers, although it is readily available. ICARDA has encouraged farmers, the feed industry, and the government to look at ways to remove this constraint.

Simple changes to yogurt-making add value in northern Syria

Yogurt is widely consumed in West Asia, either by itself or in local dishes. In Syria, resource-poor farmers produce most of the yogurt. For example, sheep farmers in the El-Bab area of northern Syria derive 48% of their income from milk and yogurt.

To improve milk processing and yogurt production, ICARDA researchers used a participatory approach to test simple new technologies in two communities, Abu-Jabar and Bugaz, in El-Bab, Syria. Farmers here produce yogurt and cheese from flocks averaging 49 milking ewes in semi-intensive crop-livestock production systems.

Participatory workshops in both communities to identify problems in yogurt production involved both male and female farmers. Women were invited because it is the women who collect milk and process dairy products. A series of training workshops was then held for farmers on the basics of hygienic milk production and improving yogurt processing.

The traditional way of making yogurt is very prone to contamination. Farmers reported that the yogurt was often sour, had a poor texture, crumbled, and had a yeast flavor. All these lowered the quality and market value of the yogurt. Another problem was that the yogurt was not firm and collapsed when transported.

To overcome the problem of yogurt collapsing on the trip from farm to market, farmers tested three starters that produce firm yogurt and compared them with the starter they normally use. One of the new starters produces yogurt with a very mild flavor and high viscosity, the second, a yogurt with a mild flavor and medium viscosity, and the third, a yogurt with a strong flavor and medium-to-low viscosity.

Farmers identify problems in making yogurt and choose methods of improving processing at a participatory workshop.

Yogurt made by traditional methods and transported over bumpy roads loses its firm texture.

The viscosity of the three types of yogurt was measured using a viscometer after mechanically shaking the yogurt for 15 minutes. Firmness was measured with a texture analyzer, using a 20-mm cylinder probe to penetrate 25 mm into the yogurt. Farmers then evaluated the yogurts and tested market reactions.

The new starters increased viscosity by 60-72% compared to yogurt made with traditional starters. The new starters also produced yogurt that was 20-30% firmer and could be transported without collapsing.

Adults preferred the strongly flavored yogurt made with the traditional starter. However, children preferred the mild and very mild yogurt produced with the new starters. The crucial test was how the yogurt sold in the market. Farmers' net incomes increased by 18% from yogurt made with the new starters. Strongly flavored, medium-to-low viscosity yogurt fetched the highest market price (30 Syrian pounds (SYP)/kg), followed by mild flavored medium viscosity yogurt (27 SYP/kg), and the traditional yogurt (25 SYP/kg). Yogurt with a very mild flavor and high viscosity fetched the lowest price (22 SYP/kg). Farmers could cover the cost of transporting yogurt to market (5 SYP per 2.5-kg bucket) by changing from the traditional starter to the starter that makes strongly flavored medium-low viscosity yogurt (Fig. 4.4).

Farmers opted to make yogurt with the new starters that produced a firm product and increased their income by 18%. The participatory approach and market evaluation were key to finding a solution and testing the new technology.

Farmers and their families test yogurt types made with a traditional starter and new starters.

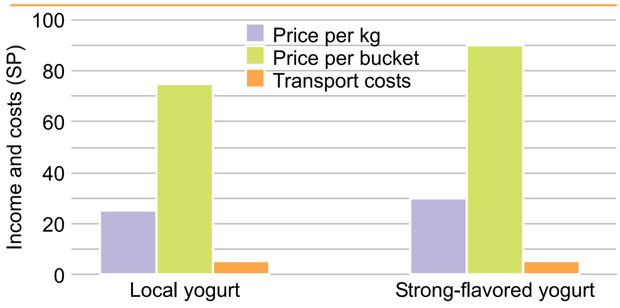

Fig. 4.4. Income and transport costs for local and strong flavored yogurt. A bucket contains 2.5 kg of yogurt (US$ 1 = SYP 50.5).

Zero-till direct sowing improves returns in cereal-legume rotations

Dryland farming systems in CWANA are becoming more intensive, which is threatening the region's soils and water supplies. However, zero-till systems have been developed that reduce soil erosion, boost soil fertility, and improve the water-holding capacity of soil. Likewise, conservation tillage practices aim to retain plant residues from previous crops for the same reasons. These systems can also give farmers higher yields and higher returns.

ICARDA researchers investigated zero-till and conservation tillage systems and compared them with conventional tillage systems in wheat-legume rotations. They conducted trials for five years on different systems: (1) conservation tillage with shallow tillage for wheat and deep tillage for lentil; (2) conventional tillage (deep for both wheat and lentil); (3) conservation tillage with shallow tillage for both wheat and lentil; (4) zero-till direct sowing leaving plant residues; and (5) zero-till direct sowing with plant residues removed.

Table 4.2 shows the average grain and straw yields for wheat and lentil for the five tillage systems over the five years 2002-2006. Conservation shallow tillage for wheat after lentil and deep tillage for lentil after wheat ('conservation shallow-deep' in Table 4.2) gave the highest wheat grain yields in most years, when compared to conventional tillage. This system also gave the highest mean straw yields for wheat.

Wheat also did well in the zero-till direct sowing system with the plant residue left, especially in the driest season (2005/06). In dry years the plant residue prevents moisture loss from the soil, but in wetter years it creates problems for the direct sowing drill machines.

Mean lentil straw yields were significantly higher under zero-till direct sowing. This was particularly the case under zero-till direct sowing with residue in the driest season (2005/06). There was very little difference in lentil grain yield between conservation and conventional tillage systems and zero-till direct sowing (Table 4.2).

These results show that in cereal-legume rotations in dryland farming systems, yields are higher for conservation tillage (when shallow tillage is used for the rotation's cereal crop and deep tillage is used for the legume crop) than for conventional systems (where deep tillage is used for both cereal and legume crops in the rotation). In fact, most farmers in Mediterranean lowlands are already using this 'shallow-deep' conservation tillage system in cereal-legume rotations.

Long-term field experiments have provided valuable information on zero-till systems, helping to devise practical recommendations for farmers.

Table 4.2. Average grain yield of wheat and lentil in two conservation tillage, one conventional tillage, and two zero-till direct sowing tillage systems, Tel Hadya research station, Syria. The means are for the five-year period 2002-2006, for wheat-legume rotations.

Tillage system	Mean crop yield (t/ha)			
	Wheat		Lentil	
	Grain	Straw	Grain	Straw
1. Conservation (shallow-deep) tillage	3.96	6.73	1.15	1.48
2. Conventional (deep-deep) tillage	3.85	6.05	1.14	1.69
3. Conservation (shallow-shallow) tillage	3.58	5.61	1.10	1.48
4. Zero-till direct sowing (residue left)	3.29	5.13	1.07	1.81
5. Zero-till direct sowing (residue removed)	3.33	5.83	1.12	1.83
Standard error†	0.09	0.21	0.05	0.06

† Differences between tillage systems were significant for wheat grain yield, wheat straw yield and lentil straw yield at $p<0.01$, but were not significant for lentil grain yield

Zero-till direct sowing, however, may give farmers higher returns, particularly when residues are removed (Table 4.3). Lentil net returns were higher under zero-till direct sowing, with or without residues, than under conservation or conventional systems. Wheat net returns were also higher under zero-till direct sowing with the residue removed. So, zero-till direct sowing with the residue removed gave farmers the highest net returns. But whether or not farmers can use this system depends on whether zero-till drill equipment is available in their area for them to use.

In very dry seasons, for example the 2005/06 season, yields from zero-till direct sowing can be much better than from conventional tillage systems. During these particular trials, zero-till plots were sown at the same time as the other tillage-treatment plots, so as not to introduce another factor (sowing date) into the trial. Normally, sowing would be earlier in zero-till than in conventional tillage systems because seed is drilled directly and there is no need to prepare the land first. This means that the plants emerge early, covering the soil and reducing evaporation losses.

In the dry season of 2005/06, when rainfall from October to December was less than half the rainfall in the other years, the plants grown in the zero-till system did well even though they were sown at the same time as plants in the other systems. The plants grown in the conservation and conventional systems, however, did not do well. This means that sowing crops early with zero-tillage is likely to give higher yields. For every day gained by early planting with zero-tillage, yields are likely to increase by 20 kg/ha compared with conventional tillage.

The value of sowing early with zero-tillage was confirmed by zero-till direct sowing trials with chickpea and wheat at ICARDA's Tel Hadya research station in 2005/06. Chickpea yielded 78% more grain, and wheat 44% more grain, compared to conventional tillage systems. These directly-sown zero-till crops took advantage of the moisture available in the soil from winter rains in their early growth stages and developed deep root systems. Then, during the dry period later in the cropping season, they drew moisture

Table 4.3. Input costs and net returns (Syrian Pounds/ha) under two conservation, one conventional, and two zero-till direct-sowing tillage systems, at Tel Hadya research station. The means are for the five-year period 2002-2006.

	Wheat			Lentil			Wheat-lentil rotation
	Input cost	Income	Net return	Input cost	Income	Net return	Net return
1. Conservation (shallow-deep) tillage	12,205	44,573	32,368	15,569	22,308	6,739	19,554
2. Conventional (deep-deep) tillage	13,378	43,324	29,946	15,566	23,273	7,707	18,827
3. Conservation (shallow-shallow) tillage	13,065	40,253	27,188	14,240	21,676	7,436	17,312
4. Zero-till direct sowing (residue left)	11,430	36,968	25,538	14,226	23,004	8,778	17,158
5. Zero-till direct sowing (residue removed)	11,479	41,826	30,347	14,255	23,764	9,509	19,928

1US$ = 50.5 Syrian pounds

Direct-drilling equipment from India, originally designed for rice, is being adapted for use in wheat and intercropping systems.

from deep in the soil profile. When farmers do not have the equipment for zero-till direct sowing, then the next best option is to shallow till when planting cereals after legumes and deep till when planting legumes after cereals. Deep tillage after wheat turns the plant residues into the soil and makes sowing legume seed more successful. Yields are not as high with local implements for zero-till, such as 'ducks-foot' and local drills, as with modern machinery. Ideally, zero-till direct sowing drills should be manufactured by local workshops.

As well as saving time and fuel, zero-tillage improves soil structure, makes effective use of soil moisture, and gives higher yields, particularly in dry years. Zero-till also preserves precious topsoil. Studies show that for each ton of wheat produced under conventional tillage systems, 12 tons of topsoil is lost compared with about 0.5 tons under zero-till systems. In addition, zero-till gives farmers in dryland farming systems higher returns from cereal-legume rotations.