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LENTIL MECHANIZATION (ICARDA)

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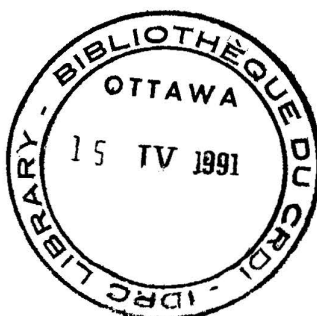
Final Report

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Food Legume Improvement Program

ICARDA, P.O. Box 5466

Aleppo, SYRIA



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1. Summary

The project with ICARDA aimed to design, field test and cost appropriate mechanized harvesting systems for small-to medium-sized lentil producers in Jordan, Syria and Turkey. The economic framework of harvest mechanization was investigated in Syria over the period 1985-1988 when the lentil grain price increased by 310%, the cost of hand harvest rose by 229% and the net benefit increased by 155% making lentil among the most profitable winter crops. Following a comparison of harvest machinery, tractor-mounted mowers (double-knife) were identified and field tested with national programs on farmers' fields. The importance of a flat seedbed and cultivars with reduced lodging has been highlighted as part of the harvest system. In large scale tests with the Syrian Ministry of Agriculture on farmers' fields during 1986/87 and 1987/88, the overall mean for grain yield following a hand harvest was 1579 kg/ha, as compared to 1455 kg/ha following harvest by the mower giving a loss of 124 kg/ha or 8% from mechanization. Comparable straw losses were 344 kg/ha or 16% from the hand harvest mean for straw of 2096 kg/ha. Losses were compensated by reduced harvest costs and the net benefit of mechanized harvest over hand harvest was 4%.

Two short courses on lentil harvest mechanization in 1986 and 1987, in cooperation with Jordan University, Amman, were organized for a total of 14 agronomists and engineers from six countries. In 1988 mechanics were trained in Syria. A seminar on harvest mechanization was held at ICARDA in 1987.

The General Organization of Agricultural Mechanization in Syria is now considering a bulk purchase of mowers to mechanize lentil harvest in 1989. In addition to the use of the double-knife mower by the national programs of Jordan and Syria, on-farm trials on lentil harvest mechanization have been catalyzed in both Algeria and Morocco.

2. Introduction and project aims

Lentil is the most important pulse crop in Jordan, Syria and Turkey. The major constraint to its production in these countries is its costly requirement for a hand harvest.

Accordingly, an IDRC project was formulated with ICARDA to identify, develop and test mechanized harvesting systems suitable for small-to medium-sized lentil producers in Jordan, Syria and Turkey. ICARDA, the implementing agency, has a world mandate for research on lentil improvement and has been undertaking research on lentil mechanization since its inception as a matter of priority. The IDRC grant initiated on April 24, 1985 specifically aims to:

1. Define the economic framework for harvest mechanization in Jordan, Syria and Turkey, to establish minimum performance criteria for lentil harvesting machinery.
2. Identify, design, test and optimize appropriate lentil harvesting machinery.
3. Define agronomic requirements for the harvesting machinery.
4. Design, test, and optimize gathering systems suitable for the selected harvest machinery.
5. Field test and cost appropriate machinery and agronomy harvest packages in collaboration with the national production programs of Jordan, Syria and Turkey.
6. Train personnel from these national programs in the agronomic requirements and operation of appropriate mechanical lentil harvesting systems; and
7. Initiate linkages with appropriate government agencies and machinery manufacturers in order to ensure expeditious machinery production and promotion.

The results of the first two years of the project have been reported in Progress Reports to IDRC: 1, April 24, 1985 to April 23, 1986 and 2, April 24, 1986 - April 23, 1987. The project was originally for a three years period starting on April 24, 1985, but an extension of six months was given until August 23, 1988. This final narrative report focuses predominantly on the period April 24, 1987 to August 23, 1988.

3. Definition of economic framework for harvest mechanization

Since 1985 mini-surveys of 20 farmers have been conducted annually to update the economic data on lentil harvest and to ask farmers specific questions on lentil harvest.

Dramatic changes have occurred in lentil prices over the period 1985-1988 to make lentil currently among the most profitable winter crops in Syria. The grain price increased by 310% from 1870 SL/t in 1985 to 7660 SL/t in 1988 (Table 1). Therefore, considering normal grain yield, as revealed by this year's mini-survey, of 1440 kg/ha the average grain revenue increased from 2690 to 11,030 SL/ha.

The cost of hand harvest also rose in this period from c. 1180 SL/ha in 1985 to 3880 SL/ha in 1988, but less rapidly than the grain price. Consequently, although the total production cost was 2360 SL/ha in 1985 and 7530 SL/ha in 1988, the net revenue or profit increased from 2260 SL/ha to 5756 SL/ha by 155%.

The straw price increased in the period 1985-1988 by only 17% from 880 SL/ha to 1030 SL/ha and at a much lower rate than the grain price. The relative price change the seed versus straw suggests that harvesting solutions with straw losses are more acceptable than those with seed losses.

The mini-survey also revealed that all the farmers surveyed consider hand harvest as the largest production constraint in lentil. They would all accept new varieties which can be harvested mechanically. 94% of the farmers would use a heavy bar to level their land to facilitate harvesting and 75% of the farmers would use seed drills if available.

Table 1. Comparison of economic profitability of lentil production for farmers between 1985 and 1988 in Syria.

	1988	1985	% increase
Grain yield (kg/ha)	1440*	1440	-
Straw yield (kg/ha)	2190	2190	-
Grain revenue (SL/ha)	11,030	2,693	310
Straw revenue (SL/ha)	2,256	1,927	17
Total gross benefit (SL/ha)	13,286	4,620	188
Total cost of production (SL/ha)	7,530	2,360	219
Net revenue or profitability (SL/ha)	5,756	2,260	155

* Yield data are from 1988 mini-survey estimates from farmers for average lentil production over years.

4. Identification, design, testing and optimization of appropriate lentil harvesting machinery

The project focused on two types of harvesting equipment, namely angled blades and double-knife mower. A major effort was made in the first two years of the project (1984/85 and 1985/86 seasons) to optimize the angled blade system; but following field tests on farmers' fields in 1985/86 the work was discontinued because of the superior potential of the double-knife mower.

These mowers are available commercially and little further design is needed. However, the blades coat with soil in wet or damp conditions in a clay soil; small wheels or skids attached to both ends of the mower blade carry the cutting action above the ground avoiding clogging and reduce the speed at which the knives dull and require sharpening. A serrated bottom blade is preferable to a straight section in an unripe crop (plant moisture >50%).

5. Definition of agronomic requirements for harvesting machinery

Research on appropriate agronomic requirements was conducted in the first two seasons of the project (1984/85 and 1985/86) and has already been reported. Briefly, the angled blade system functioned best on a ridged crop. The double-knife mower gave unacceptably high seed and straw losses in a ridged field; it requires a flatter seed bed. Two systems to change the profile of the seed bed were tried namely: 1) Seeding with a locally-made tine drill and 2) dragging a heavy bar (40 kg) behind the cultivator covering previously broadcast seed. The performance of the double-knife mower on both systems of seed bed preparation was satisfactory.

In the final two seasons of the project (1986/87 and 1987/88) the mower was only used on farmers' fields on drilled crops.

Lodging affects the performance of the mower. In the 1984/85 season a non-lodging selection 78S26002 from ICARDA had a yield advantage over the lodged land race (ILL4401) of 9% with a hand harvest, the advantage increased to 39% with mowing. This emphasized the role of cultivar in the system. This particular selection 78S26002 has now been registered

as 'Idleb 1' in Syria for use on farmers' fields.

Another aspect of crop management investigated in the project is stubble grazing. The traditional method of harvest by hand pulling leaves a clean field, and after threshing the straw is bagged and sold as a livestock feed. Cutting by double-knife mower results in a lentil stubble, which is not a complete loss to the cropping system. The stubble can either be incorporated into the soil or grazed by sheep. Sheep were tested on lentil stubbles from a double-knife harvest, which they grazed without problem.

6. Gathering systems

The previous section described different harvest machinery which leave the crop on the ground to be gathered. Research in 1986 started on gathering systems with a comparison between two rakes, namely a dump rake and a finger-wheel rake. The latter had a more delicate raking action resulting in low additional harvest losses compared to hand gathering.

In the 1987 and 1988 harvest season we experimented with a simple collecting box behind the blade of the double-knife mower. The rear flap of the box could be periodically lifted by the tractor driver by lever to leave heaps of lentil on the field. The addition of the box to the double-knife mower did not result in a significant increase in harvest losses. Hence, it is a simple and appropriate system for gathering the crop. However, the most commonly available tractor in Syria, the Ebro had too low a clearance between the belt drive of the cutter bar and the ground to allow the lentil heaps to pass freely on the next pass around the field. The height of the walls of the collecting box and resulting heaps of lentil still require adjustment.

7. Field testing and costing

In Syria field testing of the double-knife mower was initiated on farmers' fields during the 1985/86 season. The testing continued in a cooperative program with the Agricultural Research Center of the Syrian Ministry of Agricultural Research and Agrarian Reform over the 1986/87 and 1987/88 seasons in which site selection, sowing and harvesting were

done jointly.

Hand harvest was compared with mechanical harvest by double-knife mower in three villages spread through the main lentil growing areas of Syria during the 1986/87 season and two villages in the 1987/88 season. At each site the local red-cotyledon, small-seeded land race 'Hurani 1' was compared to the ICARDA selection 78S26013 in large plots of 0.5 hectare/variety following seeding with a locally-made tine drill.

The yields of grain and straw were higher in the 1986/87 season than in the 1987/88 season. The overall mean for grain yield with a hand harvest was 1579 kg/ha, as compared to 1455 kg/ha following the harvest by mower representing a mean grain loss from mechanization of 124 kg/ha or 8% (Table 2). For straw yield, the overall mean with a hand harvest was 2096 kg/ha. The mower resulted in a mean straw yield of 1752 kg/ha, giving straw losses of 344 kg/ha or 16% compared to hand harvest. Losses from a mechanical harvest were lower for grain in the 1986/87 season, whereas for straw the losses were lower in the subsequent, 1987/88 season.

Table 2. Mean yield (kg/ha) of grain and straw from harvests by hand and by double - knife mower averaged over two cultivars and seasons with three locations in the 1986/87 season and two locations in the 1987/88 season.

	Season				Mean over	
	1986/87		1987/88		Seasons	
Harvest method	Grain	Straw	Grain	Straw	Grain	Straw
Hand	1809	2441	1349	1751	1579	2096
Mower	1724	1919	1185	1585	1455	1752
Loss (%)	4.7	21.4	12.1	9.5	7.9	16.4
S.E.+	79.9	105.0	76.5	110.1		

A partial budget analysis of the last two seasons yield data

revealed a 4% increase in net benefit from SL 12,034/ha with a hand harvest to SL 12,550/ha with the mower harvest (Table 3). This shows clearly the economic viability of the harvesting system proposed.

Table 3. Partial budget analysis of mean yield data from the 1986/87 and 1987/88 season.

	Harvest method		% change
	Hand	Mower	
Grain yield (kg/ha)	1579	1455	-7.9
Straw yield (kg/ha)	2096	1752	-16.4
Grain revenue (SL/ha)	12,095	11,145	-7.9
Straw revenue (SL/ha)	2,159	1,805	-16.4
Gross revenue (SL/ha)	14,254	12,950	-9.1
Harvest cost (SL/ha)	2220	400	-82.0
Net benefit	12034	12550	+4.3

In Jordan, following the purchase by the project of a double-knife mower for Jordan University, Amman, pilot plots of 1-2 ha. were harvested with the mower under the of the IDRC food legume project in Jordan.

8. Training

Training was a major focus of the project during the last two growing seasons. Activities can be divided into three broad categories to be individually discussed: 1) Short course on lentil harvest mechanization for agronomists and engineers holding university degrees; 2) Training of mechanics on double-knife mower maintenance; 3) Meeting of scientists on lentil harvest mechanization (the organisers may be also be considered amongst the trainees in this last activity).

8.1. Short course for engineers and agronomists

Formal training was initiated with a short course at ICARDA, Syria on Lentil Harvest Mechanization from May 11-22, 1986, reported earlier. A similar short course was run in 1987 from May 3-11 under the joint sponsorship of the University of Jordan and ICARDA. The lectures from outside ICARDA were Dr. B. Snobar (University of Jordan), Mr. T. Friedrich (Gottingen University) and Mr. H. Becker (Busatis Werke). We

covered all potential harvesting solutions from double-knife mower to both the lentil puller and modified combine harvester (see program in Appendix 1). On-farm trials, economics, seed bed preparation and both breeding and agronomy were also covered. The trainees assisted with the harvest of the on-farm trials and helped interview farmers.

The six trainees came from five countries namely Algeria, Jordan, Morocco, Syria and Turkey. All of them were already involved in either mechanization or lentil agronomy, so that they were in a position to make use of the course contents on their return. At the end of the course we formally asked the trainees what they planned to do on lentil harvest mechanization next year. Everyone wanted to try some of the techniques the course described. In order to look for improvements in the training for lentil harvest mechanization, we asked the trainees to assess the course contents. The need for more 'hands-on' harvesting and training in maintenance were expressed, but in general the trainees were very satisfied. Their name, job descriptions and addresses are given in Appendix 2.

A summary of the number of trainees by country and season is given below:

Number of Trainees

	1986	1987
West Asia		
Jordan	2	2
Syria	2	1
Turkey	2	1
North Africa		
Algeria	1	1
Morocco	-	1
Tunisia	1	-
Total	8	6

An audio-visual module consisting of a cassette tape integrated with slides has been prepared on lentil harvest mechanization and is being duplicated.

8.2. Training of mechanics

As part of the collaboration with the Syrian General Organization of Agricultural Mechanization (GOAM), we trained three mechanics from GOAM on the operation and maintenance of the double-knife mower in the ICARDA agricultural workshop from January 10-14, 1988. GOAM provided an old, broken double-knife mower and the joint refurbishment of this machine was one focus of the training. The GOAM trainees were key technicians in the GOAM workshops in three main lentil growing areas of Syria, namely Mr. Y. Najar from Aleppo, M.A. Eskan from Kameshly, and Mr. S. al Ghabit from Dera'a.

8.3. Seminar

A seminar was held on May 28, 1987 on the mechanization of lentil and chickpea harvest, following the conference of the International Association for Mechanization of Field Experiments at ICARDA, Syria. There were participants from Jordan, Lebanon, Syria and Turkey, in addition to ICARDA. The program is given in Appendix 3. The proceedings were published as part of the 'Mechanization of Field Experiments in Semi-Arid Areas.'

9. Linkages with appropriate government agencies and machinery manufactures in order to ensure expeditious machinery production and promotion

The project developed a system for lentil harvest mechanization involving cultivars with reduced lodging, a flattened seedbed and a double-knife mower. In Syria the testing and purchase of agricultural machinery is the responsibility of the General Organization of Agricultural Mechanization (GOAM), whereas the Agricultural Research Centre (ARC), Douma is responsible for the agronomy and breeding of annual food crops. Lentil harvest mechanization spans both institutes.

The experiments on farmers' fields in section 7 were all conducted jointly with ARC, Douma during the seasons 1985/86 - 1987/88. ARC, Douma released a lentil cultivar 'Idleb 1' from ICARDA with increased seed yield and reduced lodging compared with the land race in 1987. We have trained in lentil harvest mechanization those ARC staff working on

lentil. In 1988 a joint demonstration of lentil harvest mechanization at Izra'a was broadcast on television.

Links with GOAM developed strongly in the 1987/88 season following a planning meeting with M.N. Jaweesh (General Director of GOAM) on December 16, 1987, although we had earlier (1986) trained an engineer from GOAM and they had participated in field days. We trained three GOAM mechanics in 1988 and two engineers in a short course (not funded by IDRC). We purchased a double-knife mower as part of the project which we used with GOAM and ARC, Douma on farmers' fields during the 1988 season. After the harvest season the double-knife mower was handed over to GOAM.

Regarding linkage with manufacturers, we focused on the double-knife mower following the 1986 harvest. This mower is already available commercially from Busatis Werke in W. Germany. Staff from Busatis lectured and gave practicals on maintenance in both the 1986 and 1987 training courses.

Following the 1988 harvest GOAM is considering a bulk purchase of mowers to mechanize lentil harvest in 1989.

In both Jordan and Turkey our approach was to encourage the national staff of the IDRC sponsored food legume projects to develop the appropriate linkages, rather than the shorter term approach of forcing the linkages ourselves.

10. Spin - Off

The support contributed by IDRC to lentil harvest mechanization may be regarded as 'seed money' and it is important to record other activities catalyzed by the project, particularly in the area of training and application of the technology.

In training and arising from the cooperation with University of Jordan (UOJ), a MSc. student, Mr. N. Naneesh, is conducting a thesis project on 'The effect of lentil harvest methods and tillage practices on the response to nitrogen of a succeeding cereal crop' at ICARDA with supervision jointly by ICARDA and UOJ. Similarly, Mrs. Ghada Hanti has been seconded from GOAM to ICARDA to undertake a MSc. thesis registered at Aleppo University on 'The effect of genetic and agronomic variation on

lodging and losses from harvest mechanization in lentil'. The short training course established with IDRC support in 1986 and 1987 was repeated in 1988 with other financial support for two trainees from Turkey , three from Syria, and one from each of Jordan, Morocco and Tunisia.

In regard to the application of lentil harvest mechanization in areas outside the target area of Jordan, Syria and Turkey, the national legume programs of both Algeria and Morocco are both now using agronomic techniques, cultivars and the double-knife mower, tested and developed under the project in trials on farmers' fields.

11. Staffing

The IDRC contribution to the project provided for two positions: 1) Research assistant filled by Mr. M. Hamza on 31/7/1985 and 2) fabrication technician filled by Mr. S. Hayanni on 5/12/1985. On termination of the project on 24/8/1988 both staff members have continued to work with ICARDA.

During the period April 1987 - August 1988 the project staff included the following, in addition to Messrs Hamza and Hayani:

Project leader	Dr. W. Erskine
Leader, Food Legume Improvement Program	Dr. M.C. Saxena
Farm Manager	Dr. J. Diekmann
Agronomist	Dr. S. Silim
Economist	Mr. A. Salkini