Crop production technologies

Angás P., Cantero-Martínez C., Karrou M., Benbelkacem A., Avci M.

in

Cantero-Martínez C. (ed.), Gabiña D. (ed.).
Mediterranean rainfed agriculture: Strategies for sustainability

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 60

2004
pages 99-125

Crop production technologies

P. Angás*, C. Cantero-Martínez*,, M. Karrou***, A. Benbelkacem**** and M. Avci*****

*Mediterranean Agronomic Institute of Zaragoza (CIHEAM-IAMZ),
P.O. Box 202, 50080 Zaragoza, Spain
**Universitat de Lleida-IRTA, Rovira Roure 191, 25198 Lleida, Spain
***INRAM, B.P. 415, Rabat, Morocco
****ITGC, Station Expérimentale d'El-Khroub, 25100 Constantine, Algerie
*****CRIFC, P.O. Box 226, 06226 Ankara, Turkey

With the collaboration of: **A. Zeghida, R. Belkacem**, ITGC, Algeria; **M.Sh. Abd El-Maaboud, H.Kh. Hassan**, DRC, Egypt; **N. Di Bucchianico, G. Fecondo**, COTIR, Italy; **H. Benaouda**, INRA, Morocco; **T. Ameziane, S.B. Alaoui**, IAV, Morocco; **F. Vargas, J. Tous**, IRTA, Spain; **L. El-Mahdy**, ICARDA, Syria; **M. Mars, M. Loumeren**, IRA Medenine, Tunisia; **K. Meyveci**, CRIFC, Turkey

SUMMARY – The present paper summarises the results and conclusions of the evaluation of crop production technologies carried out in the MEDRATE project. Five technologies including soil test calibration and fertilisation recommendation, seed and planting techniques, use of improved plant material, weed control and alternative crops and cropping systems are analysed at three levels (research, on-farm trial experimentation and farmers' utilisation). Technological problems and alternatives are presented as introductory background and finally some positive and negative aspects for the integration of these technologies are discussed.

Key words: Mediterranean, rainfed agriculture, crop production, technologies.

***RÉSUMÉ –** "Technologies pour la production des cultures". Le présent article résume les résultats et les conclusions de l'évaluation des technologies de production des cultures menée dans le cadre du projet MEDRATE. Cinq technologies comprenant la corrélation et calibration des analyses de sols et les recommandations de fertilisation, les techniques de semis et de plantation, l'utilisation de matériel végétal amélioré, la lutte contre les mauvaises herbes, et les cultures et systèmes culturaux alternatifs sont analysées à trois niveaux (recherche, essais expérimentaux à la ferme et utilisation par les agriculteurs). Des problèmes technologiques et des alternatives sont présentés comme contexte d'introduction et finalement certains aspects positifs et négatifs pour l'intégration de ces technologies sont discutés.*

***Mots-clés :** Méditerranée, agriculture pluviale, production des cultures, technologies.*

Present technical problems and alternatives for the group of technologies

Winter cereals, orchard trees (olive, almond and carob) and vine are traditional species cultivated in Mediterranean conditions. These crops are the most adapted species to climatic and edaphic conditions of the Mediterranean area characterised by its aridity. Water availability to crops is the main limiting factor for yield stability and sustainability of the agricultural systems of the region. The growth period of these species matches available water accumulated in the soil during the rainy season.

Technology for these crops is well known in temperate agricultural system, but there is a need for more research and experimentation in arid and semiarid conditions (where marginal benefits avoid expenses on long-term projects. In fact, in some areas new varieties are not used, fertilisers are applied in quantities that do not match the requirements of the crops, weed control is done by hand or it is not practised, and possibilities for irrigation are low, even with supplementary amounts. Moreover, despite the crop being harvested mechanically, post-harvest losses are large and the quality of product remains low.

Development of crop production strategies and tactics is the best option to improve and stabilise the yield and economic margin of the farmer without compromising the sustainability of these agricultural systems. Some technological proposals for yield increase such as those applied in developed countries led to more economic margin for the farmer but they are not sustainable from the long-term point of view, because of their negative environmental impact. The compromise between short-term economic benefits and long-term sustainability has to be taken into consideration when technologies are developed.

Another challenge for development of the technologies is integration. Research and development are conducted most of the time under an individualistic conception. This has been the way of much research in the agricultural systems of developed and intensive agricultural areas. Only in a few areas can this multifactor and holistic research be found. This conception led to a very simplistic solution of problems with no guarantee of duration. Integration of these technologies is vital in these areas and can make the proposed solutions for sustainability more durable.

Social and economic aspects have to be taken into account as factors for development and adoption of technologies in these areas. Farmers often operate considering the high variability of the environmental conditions of these areas. Many times, they have to assume risk of failure in crop and livestock production. Diversification is a strategy followed by farmers of Mediterranean areas, but many times it is accompanied by high pressure on land and resources that accelerates their degradation and leads to loss of sustainability.

The development of technologies has to consider the adoption by users. Many times this adoption is not directly related with the fast economic benefit or other social aspects of the farmers (age, previous knowledge, education level, etc.).

In this work the most important crop production technologies that have been evaluated include soil test use and fertiliser recommendations, planting and seeding techniques, improved plant material, weed control and the options for new crops and cropping systems.

Technology 1: Soil test calibration and fertiliser recommendations

Description of the traditional/conventional technology

Conventional application of fertilisers was based only on crop species requirement or traditional receipt without taking into consideration soil type, soil nutrient content, plant test, previous crop and rotation, etc.

Objective of the alternative technology

(i) Adjustment of fertilisation based on the reduction of application to prevent pollution and improve the efficient use of water by crops.

(ii) Adjustment of fertilisation based on the increase of application to ensure yield improvement and the efficient use of water by crops.

Description of the alternative technology

Fertilisation is based on crop requirement, soil and plant tests and other factors affecting nutrient availability.

Summary of results

At research and experimental level. On-farm trials

Several short and medium term experiments have been carried out under different particular conditions of the selected areas. Most of them compare the crop performance under different treatments (rates) of N and P applications. In some experiments, alternative treatments promoted the reduction of fertiliser use (Italy and Spain selected areas). In the other selected areas, alternative treatment proposed the increase of fertiliser rates above zero or the present rate used by farmers.

All the experiments conducted refer to field crops and some of them included N x P interaction. Results are summarised in Tables 1 and 2.

Table 1. Range of differences (%) between *alternative* versus *conventional soil fertility* technologies in yield, yield stability, water use, water use efficiency (WUE) and economic results from the analysis in the selected areas[†]

Selected area	Crops[††]	Yield (%)	Yield stability (%)	Water use (%)	WUE	Quality[†††] (%)	Production cost (%)	Margin (%)
Algeria	FC	+60	–	–	–	GW +13	+3	+75
Italy 01	FC	Up to -11	–	–	–	=	–	–
Italy 02	FC	Up to -17	–	–	–	PC -14	–	–
Morocco 01	FC	+ 42	–	–	–	–	–	–
Morocco 02	FC	Up to +62	–	–	–	–	Up to +68	Up to 99
Spain 01	FC	+3	–	-3	-22	GW +13 PC -20	Up to -14	Up to +10
Syria 01	FC	–	–	–	–	–	–	–
Syria 02	FC	Up to 40 in N Up to 9 in P	–	–	–	–	–	–
Syria 03	FC	Up to 110	–	–	–	–	–	–
Egypt (3)	FC	–	–	–	–	–	–	–

[†]Algeria: Increase P and N.
Italy 01: Reduction of N in durum wheat.
Italy 02: Reduction of N in barley.
Morocco 01: Adjustment of NP based on soil test.
Morocco 02: Adjustment of NP based on soil test. Increase of P and N.
Spain 01: Adjustment of N based on soil test. Reduction of N applications in barley.
Syria 01: No comparison.
Syria 02: Increase NP.
Syria 03: Increase fertiliser application from 0.
[††]FC: field crops (winter cereals, chickpeas, legumes).
[†††]GW: grain weight; PC: protein content.

Table 2. Range of qualitative differences (from -3 to +3) between *alternative* versus *conventional soil fertility* technologies for different aspects from the analysis in the selected areas†. Qualitative estimation, positive or negative, compared to the control: -3 = high negative; -2 = medium negative; -1 = low negative; 0 = null; +1 = low positive; +2 = medium positive; +3 = high positive††

Selected area	Crops†††	BL	SL	CRA	CRC	L	AgU	SOM	PDI	TF	NT	GI	SA
Algeria	FC	–	+1	0	–	+2	–	–	–	+3	+3	0	+2
Italy 01	FC	–	–	–	–	+1 -1	+3 -1	0	-2	+2	+1	0	+2
Italy 02	TC	–	–	–	–	+2 -1	+3 -1	0	-2	+2	+1	0	+2
Morocco 01	FC	–											
Morocco 02	FC	-1	–	–	–	–	–	–	-2	+1	+2	0	+1
Spain 01	FC	–	–	–	–	+3	+3	-1	–	+3	+2	0	-2
Syria 01	FC	–	–	–	–	–	–	–	–	–	–	–	–
Syria 02	FC	–	–	–	–	–	–	–	–	+3	+2	–	+2
Syria 03	FC	–	–	–	–	–	–	–	–	+3	+2	–	+2
Egypt (3)	FC	–	–	–	–	–	–	–	–	–	–	–	–

†BL: biodiversity loss; SL: soil loss; CRA: crop residue amount; CRC: crop residue cover; L: leaching; AgU: agrochemical use; SOM: soil organic matter; PDI: pest and diseases impact; TF: technical feasibility; NT: need for training; GI: gender impact; SA: social acceptance.

††Algeria: Increase P and N.
Italy 01: Reduction of N in durum wheat.
Italy 02: Reduction of N in barley.
Morocco 01: Adjustment of NP based on soil test.
Morocco 02: Adjustment of NP based on soil test. Increase of P and N.
Spain 01: Adjustment of N based on soil test Reduction of N in barley.
Syria 01: No comparison.
Syria 02: Increase NP.
Syria 03: Increase Fertiliser application from 0.

†††FC: field crops (winter cereals, chickpea, legumes); TC: tree crops (olive, almond and vineyard).

In all cases, a better crop performance was obtained when proposed alternative technology based on crop requirement, soil and plant tests and other factors affecting nutrient availability was used.

When alternative technology was used, such as the increase of N or P rates (all selected areas except Italy and Spain), yield was improved from 3 to 110%. Although water use was not much affected, water-use efficiency increased from 7 to 22%. A negative environmental effect was detected and more leaching, more pests and diseases were qualitatively detected. In wetter areas, more applications of pesticides were required. Increase of fertilisers was well accepted by farmers, but some training was necessary despite the high technical feasibility.

When alternative technology was the reduction of fertiliser applications (case for Italy and Spain), yield was stable or some increase of yield was obtained in drier years (this effect was estimated for about 70% of the years). Water use and water use efficiency were equal when half reduction of applied fertilisers was practised and lower when reduction reached zero. In these cases, less environmental impact was observed. However, social acceptance by the farmer was more controversial, and farmers are not completely convinced about the possibilities of this reduction, nor do they wish to lose opportunities for obtaining the highest possible yields.

At farmer level. On farm surveys

Farmers are interested in using the alternative technology which is based on the increase of fertiliser applications. The adoption level is up to 100% in Egypt and Algeria and 85% in Morocco. They observed an important increase in yield and quality of the product. Transfer of this technology has been easy through the Extension Services (91%), Research Services (58%) and other farmers (55%). They consider that the use and application of this technology is easy (70%), but the evaluation points out that some farmers could have difficulties in using the new technology. Consequently, there is a need for training according to 53% of the farmers. They consider that the negative aspects are: high cost of fertilisers, more labour, and more inputs (pesticides).

In Spain and Italy reduction of fertiliser use is highly appreciated but still the farmer is reluctant.

The positive environmental effects are appreciated not in terms of the increase or reduction of fertiliser application itself, but by the fact that using soil and plant tests could help to clarify fertiliser recommendation and adjust optimum rates.

Non-users of this technology are older than users, the size of their farms is smaller and their incomes are 50 % less. The main reasons to disregard the alternative technology are the high expense of fertilisers and the cost of soil and plant tests. In addition, they consider as a technological difficulty, the lack of response to fertiliser application in some years and also the lack of adequate fertiliser composition adjusted to the requirements.

Similarity and differences between sites

Response in all the selected areas is equal and technology is widely recognised. The differences are established by the different objective and strategy: in some selected areas fertiliser application is increasing and in others there is a reduction of fertiliser applications

Conclusions

Improvement

(i) When fertilisation (N-P) is increased: soil fertility, fertiliser availability and fertiliser use efficiency is improved. Water-use efficiency is maximised and the yield and the economic margin are improved.

(ii) When fertilisation (N) is reduced: reduced N fertilisation in adequate conditions produces more physiological efficiency of N and higher N fertilisation use efficiency. Equal protein content, more economic margin and less nitrate pollution is also obtained.

Disadvantages/limitations

When fertilisation (N-P) is increased the following negative aspects are observed:

(i) Increase in chemical contamination.

(ii) High expenses in equipment and fertilisers.

(iii) Fertiliser application may cause excessive vegetative growth that promotes an early soil water depletion affecting fruit development under low rainfall conditions. In addition, it must be adjusted when a decrease of available soil moisture is observed.

(iv) Fertiliser application may improve the growth of some weeds leading to herbicide application.

(v) Small farmers cannot afford to pay for soil analyses.

(vi) In some situations farmers and extension technicians are not well trained.

When fertilisation (N) is reduced the following negative aspects are noticed:

(i) Reduced N impedes a rise to maximum yield in the best years.

(ii) In wet years N fertilisation must be adjusted in order to have maximum yield**.**

Conditions of use

When fertilisation (N-P) is increased the following conditions of use have been proposed (depending on the situation):

(i) Fertiliser equipment is needed for a better and optimum application.

(ii) If the well-managed legume crop had been grown the previous year, N fertilisation is not necessary for the subsequent wheat crop. On the contrary, when winter cereals are grown as a previous crop, N fertilisation is essential if a reasonable and economic crop yield is expected.

(iii) Application of phosphorus when P values are lower than 5 ppm should be considered in all situations.

(iv) Application of N fertilisation should depend on the season's rainfall.

(v) N and P fertilisers should be incorporated into the soil before or during planting operations.

When fertilisation (N) is reduced, N fertilisers should be incorporated into the soil before or during planting operations.

Recommendations

(i) Both increased or reduced fertilisation can be widely used in wheat and barley system areas depending on the climatic and edaphic situation.

(ii) A judicious application of fertilisers in cereal crops may require realising their potential yields, especially when they were successively cultivated under limited rainfall conditions to make more efficient use of the limited soil moisture.

(iii) This technique needs to be accompanied by periodical soil analysis.

(iv) Local recommendation should be developed depending on the limiting factors of the cropping system.

(v) Banding, incorporating and splitting applications could help to adjust the efficiency of the fertiliser applications.

Technology 2: Seeding and planting techniques

Description of the traditional/conventional technology

Traditional or conventional technology is described differently in each selected area. Some data refers to sowing or planting date, other to sowing date or planting density in tree crops and other data refers to traditional broadcasting seeds by hand.

Objective of the alternative technology

The objective is the optimisation of seeding or planting technology (date, rate and form) to improve yields under limited availability of water for the crops.

Description of the alternative technology

The alternative systems depend on the traditional technology that require improvement.

Type: when seed is broadcasted by hand, the alternative technology is the use of a planter after an accurate seedbed preparation (Algeria and Syria).

Rate: in selected areas of Spain and Syria, reduction of seed rate is proposed as alternative technology in winter cereals and other field crops. In selected areas of Spain the proposed alternative technology was the increase of planting density in olive tree crops.

Date: early planting date is an alternative technology proposed in the selected area of Syria for winter cereals and in Turkey for chickpea.

Summary of results

Different experiments comparing the type, date and rate of sowing and planting were carried out at research and on farm trial levels. All of them were short term (3-4 year) experiments.

At research and experimental level. On farm trials

The summary of results for the main variables is presented in Tables 3 and 4.

Because of the high diversity of comparisons, results have been analysed by groups of technologies.

For Algeria and Syria, when planters are used instead of the broadcasting of seed by hand, up to 52% yield improvement is reached. In addition, although higher expenses of inputs and investment are also required, more economic margin is obtained. No environmental problems are detected and less impact of pest and diseases is recorded. Technical feasibility and social acceptance is high, but some training is needed.

Reduction of seed rate in Spain and Syria leads to lower yields when the reduction is disproportionate. However, reduction of 20% seed rate is optimum considering when conditions of the year are dry. Therefore, water use is lower and water-use efficiency increased slightly. The cost is less and the economic margin is lower and it is only equal to the conventional high rate when the reduction is only 20 to 25%. There are no problems of feasibility of the technology and there is no need for training. Environmental impact could be negative in long-term application of this alternative technology because less biomass is produced and less crop residues are left on the soil surface leading to the depletion of organic matter when intensive tillage is used.

The technology is completely accepted because farmers do not want to lose the opportunity to obtain the highest yields in wet years.

Table 3. Range of differences (%) between *alternative* versus *conventional plant and seeding* technologies in yield, yield stability, water use, water use efficiency (WUE) and economic results from the analysis in the selected areas†

Selected area	Crops††	Yield (%)	Yield stability (%)	Water use (%)	WUE	Quality††† (%)	Production cost (%)	Margin (%)
Algeria	FC	52	–	–	–	–	–	–
Spain 01	FC	Up to -25	–	=	Up to -26	=	Up to -17	Up to -25
Spain 02	TC	Up to +55	–	–	–	Parameter dependent	+75	+47
Syria 01	FC	Up to -8	–	–	–	–	–	–
Syria 02	FC	Up to +44	–	Up to +22	Up to +27	–	–	–
Turkey	FC	Up to 33	–	–	–	–	–	–

†Algeria: Use of planner. Winter cereals.
Spain 01: Reduction of sowing rate. Winter cereals.
Spain 02: Increase plant density. Olive tree.
Syria 01: Reduction of sowing rate.
Syria 02: Early planting date. Winter cereals.
Turkey: Early planting date. Chickpea.
††FC: field crops (winter cereals, chickpeas, legumes); TC: tree crops (olive, almond and vineyard).
†††GW: grain weight; PC: protein content; HR: high range between treatments.

Table 4. Range of qualitative differences (from -3 to +3) between *alternative* versus *conventional plant and seeding* technologies for different aspects from the analysis in the selected areas†. Qualitative estimation, positive or negative, compared to the control: -3 = high negative; -2 = medium negative; -1 = low negative; 0 = null; +1 = low positive; +2 = medium positive; +3 = high positive††

Selected area	Crops†††	BL	SL	CRA	CRC	L	AgU	SOM	PDI	TF	NT	GI	SA
Algeria	FC	–	+1	–	–	–	–	–	–	+3	+1	–	+1
Spain 01	FC	–	0	-1	-1	-1	–	-1	–	+1	+1	–	-2
Spain 02	TC	–	–	–	–	–	–	–	-1	+2	+1	0	+1 +2
Syria 01	FC	–	–	–	–	–	–	–	–	+3	+1	0	+2
Syria 02	FC	–	–	–	–	–	–	–	–	+3	+1	0	+2
Turkey	FC	–					+2		+3	+3	+1	0	+3

†BL: biodiversity loss; SL: soil loss; CRA: crop residue amount; CRC: crop residue cover; L: leaching; AgU: agrochemical use; SOM: soil organic matter; PDI: pest and diseases impact; TF: technical feasibility; NT: need for training; GI: gender impact; SA: social acceptance.
††Algeria: Use of planner. Winter cereals.
Spain 01: Reduction of sowing rate. Winter cereals.
Spain 02: Increase plant density. Olive tree.
Syria 01: Reduction of sowing rate.
Syria 02: Early planting date. Winter cereals.
Turkey: Early planting date. Chickpea.
†††FC: field crops (winter cereals, chickpea, legumes); TC: tree crops (olive, almond and vineyard).

Increasing plant density in olive tree production in the selected area of Spain improved yield by 57%. Fruit weight increased, but some quality parameters such as fruit size and oil content decreased slightly. The cost was 74% higher, but the total economic margin increase was near 50%.

There are no technology development problems for farmers and social acceptance of the system is positive. Despite positive evaluation by farmers, they recognise that adoption level is variable and 50% of them accept the alternative technology well; however, few acceptances were observed in the case of 25% of them. The technology has been developed through research centres and 85% received training and information from these institutions.

Early planting techniques in Syria (winter cereals) and Turkey (chickpea) promoted an increase in yield up to 100%, depending on cultivars. In the Syrian experiments, yield stability was lower when early planting was adopted, making this alternative technique slightly riskier. No data on cost and economic margins were recorded. High technical feasibility and a low need for training make this technology well accepted by farmers. A reduction in agrochemical use is reported in Turkey.

At farmer level. On-farm surveys

For diverse seeding technologies (type, date and rate), social features such as age, education level, farm size and gross incomes are better in users than in non-users. The use of certain technologies such as the planter and early sowing was highly accepted and adopted and farmers gave it a very positive assessment. Actually, yield was higher and the quality of the product was better. However, the level of investment is high when the acquisition of machinery is included. Feasibility is high but it requires some training. Transfer of technology and access to technology has been through extension services and research centres (92%) and from farmer to farmer (62%). Many users believe that access of technology to other farmers will be easy. Only in Spain is the social acceptance for the reduction of seed rate by farmers not completely positive because they do not want to lose the opportunity of obtaining the highest yield in wet years and because seed price is still low.

For planting technology (increasing planting density) in olive trees in the selected area of Spain, social aspects between users and non-users are the same as are mentioned above. In the farmer's opinion, yield is 10% higher and an equal quality of product is obtained when the alternative technology is applied. Technical feasibility is very high and training is not needed. Investment, extra-inputs (9% more) and required labour are considered low. This technology was introduced at the farm level by research centres. Non-users of this technology allege a poor increase of yield and low stability, however, they recognise the low knowledge they have of proposed technique.

Conclusions

Improvement

(i) When seeding with a planter, improvement is due to the lower labour requirement. Yield and economic margin are increased and more stable production is obtained.

(ii) When increasing planting density: yield improvement and economic margin are increased.

(iii) When reducing seeding rate: there is more water conservation and water use by crop and WUE is improved. Grain yield increases and the production cost is reduced.

(iv) When planting early: there is a yield increase. Taller plants (50% taller) and high first pod formation of improved varieties are obtained. This enables mechanical harvest and less harvest losses (chickpea).

Disadvantages/limits

(i) When seeding with a planter: poor farmers cannot adopt the technique for economic reasons.

(ii) When reducing seeding rate: there is a lower yield potential in the best years.

(iii) When increasing planting density: there is a higher production cost in pruning and harvesting. Fruit size and oil content decrease. In mature trees, greater shade between rows and inside the canopy promotes a decrease in fruit set. Specific shaker machinery for harvesting is required.

(iv) When planting early: risk of crop failures in early sowing if rain ceased or short dry spells may occur after seedling emergence.

Conditions of use

(i) When seeding with a planter: farmers need to have the required equipment and good agronomic practices should be used.

(ii) When increasing planting density: in cultivars with a low or medium vigour, as Arbequina (olive), it is possible to increase planting density but it depends on mechanical and light requirements. Mechanical harvesting is one of the most important factors to consider when designing the layout for new intensive orchard production. During the first years of plantation, stakes should be used to protect young trees from the wind. Training for pruning with 2-3 main branches and about 1 m of trunk height is recommended to improve mechanical harvesting.

(iii) When planting early: sowing should be done after rain, when there is available soil water for germination, emergence and good establishment. Clean and new seed should be used. Seed must be treated with fungicide.

Recommendations

(i) When seeding with a planter: sowing with a planter is recommended everywhere in favourable semi-arid environments. Seed, fertilisers and herbicides should be available. A good seedbed preparation is required for the success of the operation.

(ii) Ridge planting, which is practised traditionally by Syrian farmers, should be replaced by seed drill planting in order to obtain higher grain yield.

(iii) Reducing seed rate when dry conditions become normal to extreme.

(iv) Increase planting density: this technique can be widely recommended in new olive orchards of these areas, however it should be experimented locally to determine the best plant density to be used for each cultivar. This technique can be considered for use in most scenarios in semiarid and irrigation supported agricultural systems.

Technology 3: Improved plant material

Description of the traditional/conventional technology

Use of local landraces or old varieties.

Objective of the alternative technology

Development and release of new improved plant material to increase yield potential and improve quality.

Description of the alternative technology

The alternative technology is variable depending on the selected areas and crops. Different strategies in the plant breeding programmes have been used:

(i) Use of new improved varieties of winter cereals (barley, bread and durum wheat) and legume crops, with several traits such as high yield, drought tolerance, short cycle, early heading and maturity, resistance to diseases and pest, high quality, etc.

(ii) Use of new improved material of orchard trees (olive, almond, carob) with better ecological, agronomic and commercial characteristics (as mechanical harvesting, late flowering, etc.).

Summary of results

Many short and long-term experiments at research and on-farm trial levels have been recorded in five countries. Also a set of surveys about the use and opinion of farmers have been obtained. This technology represents the most extended and widely used by farmers and is the most documented in all selected areas.

At research and experimental level. On-farm trials

Yield and yield stability (with high variability from 0 up to 82%) have been improved generally by introducing new varieties. However, some exceptions can be seen (Table 5) in some experiments of selected areas especially where extreme climatic conditions are prevalent. In those cases, local and more stable varieties performed better. Quality is also another characteristic that has been improved to a lesser extent than yield. This improvement helped to increase economic margin despite an increase in cost.

Results have been focused on yield and quality and there is a lack of information on other variables such as water use, water-use efficiency, nutrient uptake, efficient use of nutrients and other physiological and agronomic characteristics.

Measurements of environmental impact are also very weak (Table 6). Only some surveys reported positive impact on resistance to diseases and pests. All references showed negative aspects of the increase of use of agrochemicals (probably herbicides) when new varieties are used.

Social acceptance and technical feasibility are very high, but some training, specially informing about the characteristics of varieties and relations with agronomical technology, is needed.

At farmer level. On-farm surveys

The same characteristics as in the other technologies evaluated differ between users and non-users. Age, education level, gross income and farm size are among the most important reasons for non-adoption of use of new varieties by the non users that do not want to take the risk of practising an unknown technology.

Forty-four percent of users recognise the improvement of yield and the benefits from pest and disease control that can be obtained if the alternative technology is used. Quality is considered as an improved characteristic of the new varieties by 46% of farmers surveyed in the selected areas.

In farmers' opinion, investment and inputs have increased with the use of new varieties by 50% because they are coupled with intensification. Technical feasibility is high for 67% of farmers but some difficulties have been reported because of lack of knowledge by 37% of farmers in Turkey and Algeria and because of marketing problems in the case of 21.5% of farmers in Turkey.

Access to technology has been through extension services mainly (86%) and other farmers (52%). Extension services are the main technical assistance that the farmers have in these selected areas.

Farmers consider access to the use of new varieties easy. Its transfer to other farmers is also fast. However, there is a discrepancy in opinion about training needs. Fifty-seven percent consider that there is a high training requirement and 52% think that this need is low or very low.

Table 5. Range of differences (%) between *improved plant material technology* in yield, yield stability, water use, water use efficiency (WUE) and economic results from the analysis in the selected areas[†]

Selected area	Crops[††]	Yield (%)	Yield stability (%)	Water use (%)	WUE	Quality[†††] (%)	Production cost (%)	Margin (%)
Algeria 01	FC	Up to +32	Up to +27	–	–	GW: up to -13	Up to +21	–
Algeria 02	FC	Up to +71	–	–	–	GW: up to -12	Up to +32	–
Algeria 03	FC	Up to +62	–	–	–	GW: up to -14	–	–
Algeria 04	FC	Up to +32	Up to +66	–	–	GW: up to -20	–	–
Algeria 05	FC	Up to +82	–	–	–	GW: up to -14	Up to +21	–
Morocco 01	FC	+15	+50	+4.7	+11	GD: -5; PC: -11	–	–
Morocco 02	FC	Up to +46	–	–	–	–	Up to -7	Up to +75
Morocco 03	FC	Up to +36	–	–	–	–	Up to -6	Up to +26
Morocco 04	FC	Up to +68	–	–	–	–	Up to +6	Up to +123
Spain 01	FC	Up to -10	From -30 to +14	–	–	GD: up to +11	–	–
Spain 02	TC	Up to +73	–	–	–	Oil content: +6	+97	+62
Spain 03	TC	Up to -12	–	–	–	Gum quality: +	+11	+ 7
Syria 01	FC	From -6 to +33	–	–	–	GW: from -11 to +25 PC: from -12 to +12	–	–
Syria 02	FC	From 0 to +18	From 0 to +4.5	–	–	GW: from 0 to +18 PC: from 0 to -8	–	–
Syria 03	FC	From -20 to +21	–	–	–	GW: from -7 to +34 PC: from -6 to +14	–	–
Syria 04	FC	From 0 to +65	–	–	–	GW: from -12 to +15 PC: from -13 to +2	–	–
Syria 05	FC	From -13 to +30	–	–	–	GW: from 3.9 to 9.1	–	–
Syria 06	FC	From -5 to +70	–	–	–	GW: from -6 to +18 PC: from -10 to +15	–	–
Syria 07	FC	From -7 to +12	–	–	–	GW: from -6 to +5 PC: from 0 to -5.7	–	–
Turkey 01	FC	Up to +65	Up to +8	–	–	GW: up to -7 PC: up to +5	–	–
Turkey 02	FC	Up to +25	–	–	–	GW: up to -18 PC: up to +9	–	–
Turkey 03	FC	Up to +47	–	–	–	GW: up to +11 PC: up to +4.5	–	–
Turkey 04	FC	Up to +372	–	–	–	GW: up to -17	–	–
Turkey 05	FC	Up to +22	–	–	–	GW: from -14 to +7 PC: from -3 to 0	–	–
Turkey 06	FC	Up to +25	–	–	–	GW: from -10 to 0	–	–

[†]Algeria 01: durum wheat; Algeria 02: bread wheat; Algeria 03: barley; Algeria 04: chickpea; Algeria 05: experimental winter cereal trials.
Morocco 01: durum wheat; Morocco 02: bread wheat; Morocco 03: durum wheat; Morocco 04: barley.
Spain 01: barley; Spain 02: olive tree; Spain 03: carob tree.
Syria 01: durum wheat; Syria 02: durum wheat; Syria 03: bread wheat; Syria 04: barley; Syria 05: barley; Syria 06: durum wheat; Syria 07: bread wheat.
Turkey 01: barley; Turkey 02: barley; Turkey 03: barley; Turkey 04: chickpea; Turkey 05: wheat; Turkey 06: wheat.
[††]FC: field crops (winter cereals, chickpeas, legumes); TC: tree crops (olive, almond and vineyard).
[†††]GW: grain weight; GD: grain density; PC: protein content.

Table 6. Range of qualitative differences (from -3 to +3) between *improved plant material technology* and conventional use of cultivars for different aspects from the analysis in the selected areas†. Qualitative estimation, positive or negative, compared to the control: -3 = high negative; -2 = medium negative; -1 = low negative; 0 = null; +1 = low positive, +2 = medium positive; +3 = high positive††

Selected area	Crops†††	BL	SL	CRA	CRC	L	AgU	SOM	PDI	TF	NT	GI	SA
Algeria 01	FC	0	–	–	–	–	-1	–	+3	+3	+1	+2	+2
Algeria 02	FC	0	–	–	–	–	-1	–	+3	+3	+1	+2	+2
Algeria 03	FC	0	–	–	–	–	-1	–	+3	+3	+1	+2	+2
Algeria 04	FC	+1	–	–	–	–	–	–	+3	+3	+1	+3	+3
Algeria 05	FC	-1	–	–	–	–	-1	–	+2	+3	+2	-1	+2
Morocco 01	FC	0	–	–	–	–	0	–	–	+3	+1	+2	+2
Morocco 02	FC	0	–	–	–	–	-1	–	+1	+2	+1	–	+2
Morocco 03	FC	0	–	–	–	–	-1	–	+1	+2	+1	–	+2
Morocco 04	FC	0	–	–	–	–	-1	–	+1	+2	+1	–	+2
Spain 01	FC	+1	–	–	–	–	0	–	–	+3	+1	0	+2
Spain 02	TC	–	–	–	–	–	–	–	From 0 to -2	+2	+1	0	0 to +3
Spain 03	TC	–	–	–	–	–	–	–	From 0 to -1	+2	+2	0	0 to +3
Syria 01	FC	–	–	–	-	–	–	–	–	+3	+1	0	+3
Syria 02	FC	–	–	–	–	–	–	–	–	+3	+1	0	+3
Syria 03	FC	–	–	–	–	–	–	–	–	+3	+1	0	+3
Syria 04	FC	–	–	–	–	–	–	–	–	+3	+1	0	+3
Syria 05	FC	–	–	–	–	–	–	–	–	+3	+1	0	+3
Syria 06	FC	–	–	–	–	–	–	–	–	+3	+1	0	+3
Syria 07	FC	–	–	–	–	–	–	–	–	+3	+1	0	+3
Turkey 01	FC	-1	–	–	–	–	–	–	0	+3	+1	–	+3
Turkey 02	FC	-1	–	–	–	–	–	–	0	+3	+1	–	+3
Turkey 03	FC	-1	–	–	–	–	–	–	0	+3	+1	–	+3
Turkey 04	FC	-1	–	–	–	–	–	–	-1	+3	+1	–	+3
Turkey 05	FC	-1	–	–	–	–	–	–	0	+3	+1	–	+3
Turkey 06	FC	-1	–	–	–	–	–	–	-2	+3	+1	–	+3

†Algeria 01: durum wheat; Algeria 02: bread wheat; Algeria 03: barley; Algeria 04: chickpea; Algeria 05: experimental winter cereal trials.
Morocco 01: durum wheat; Morocco 02: bread wheat; Morocco 03: durum wheat; Morocco 04: barley.
Spain 01: barley; Spain 02: olive tree; Spain 03: carob tree.
Syria 01: durum wheat; Syria 02: durum wheat; Syria 03: bread wheat; Syria 04: barley; Syria 05: barley; Syria 06: durum wheat; Syria 07: bread wheat.
Turkey 01: barley; Turkey 02: barley; Turkey 03: barley; Turkey 04: chickpea; Turkey 05: wheat; Turkey 06: wheat.
††BL: biodiversity loss; SL: soil loss; CRA: crop residue amount; CRC: crop residue cover; L: leaching; AgU: agrochemical use; SOM: soil organic matter; PDI: pest and diseases impact; TF: technical feasibility; NT: need for training; GI: gender impact; SA: social acceptance.
†††FC: field crops (winter cereals, chickpeas, legumes); TC: tree crops (olive, almond and vineyard).

Adoption level is high or very high and is socially accepted with a very high positive effect on the well-being of the community.

Non-users of the new varieties complain of poor yields, low stability, seed price and low quality of the product.

Conclusions

Improvement

(i) Several aspects such as yield, net return/ha, disease resistance, seed and fruit quality are clearly improved. In some crops such as legumes and trees, mechanical harvest has also been improved.

(ii) In orchards, tree yield and productivity, early bearing, easy propagation and oil content have been improved. Much higher economic margins are obtained.

(iii) Other improved characteristics dependent of the breeding programme and of the objective in the selected area have been drought tolerance, tallest height, less lodging, resistance to scald.

Disadvantages/limits

Several disadvantages and limitations listed below have been reported when new improved varieties have been adopted:

(i) Risk of genetic erosion by loss of local landraces.

(ii) Difficulty to stabilise yield over years.

(iii) Low straw yield.

(iv) Increase the use of chemicals.

(v) Requirement of more inputs. Varieties need to be transferred within a full technological package such as adjusted fertilisation, sowing rate, etc.

(vi) Accurate weed control.

(vii) New diseases transported with seeds may arise.

(viii) New genotypes should test for diseases before sowing.

(ix) Price of certified seeds of new varieties is high.

(x) In some cases, lower seed weight and equal or less protein content are obtained.

(xi) Some varieties in Turkey have specific problems, low altitude limitations and in some areas they are sensitive to specific diseases.

In case of orchard trees specific limitations are:

(i) Incidence of specific disease.

(ii) Less vigour.

(iii) Less fruit weight and pulp/stone ratio.

(iv) Open-weeping growth habit.

(v) Higher harvesting cost and specific shaker machinery for harvesting.

Conditions of use

Several general and particular conditions as listed below should be taken into account when new varieties are used:

(i) Requires development of certified seed and availability of inputs.

(ii) Agronomic practices should be adjusted to the new improved material.

(iii) In some cases, improved material should be planted early (winter). In other cases conditions of use are late sowing.

(iv) On several occasions, fallow is the appropriate cropping system to be used with this technology.

(v) In orchards such as olive, when cultivars with a long ripening period are used, mechanical harvesting is better done in two times. Small trees should be planted in periods without frost risk. During first years of plantation stakes should be used to protect the young trees from the wind. Training pruning with 2-3 main branches and about 1 m of trunk height is recommended to improve mechanical harvesting.

(vi) In carob, small trees should be planted in periods without frost risk. In the first years of plantation stakes should be used to protect young trees from the wind. Training pruning with 2-3 main branches and about 0.8-1 m of trunk height is recommended to improve mechanical harvesting.

Recommendations

(i) New varieties could be not completely adapted to all conditions and should not be used everywhere. Some cultivars are adapted to dry conditions but others only to semiarid conditions.

(ii) For optimum development of the new improved plant material, it should be available and distributed at local and regional level.

(iii) Local high biomass production needs to be oriented for forage production.

(iv) It is required to be used with a whole technical package. Several agronomic aspects such as early or late sowing, specific plant density, extra N applications or others should be locally recommended.

Technology 4: Weed control

Description of the traditional/conventional technology

No chemical control or cultural practices, including hand weeding, is used.

Objective of the alternative technology

The main objective is the reduction of the weed population that competes with crops, especially for the available water and nutrients.

Description of the alternative technology

Weed population control based on chemical control.

Summary of results

At research and experimental level. On-farm trials

Not many results were recorded for this technology and most of them referred to a comparison between weeding and chemical control treatments. Particularities came from experiments of the Syrian selected area that include ICARDA experiments where interaction between herbicides and fertilisers were studied.

Tables 7 and 8 summarise the results from three countries. Yield increase from 15% to 65% is the major effect of weed control. Water use by crops, water-use efficiency and quality of the product are strongly improved. No data of cost and economic margin were calculated in research surveys. Negative environmental impact is attributed to a biodiversity loss, some leaching and increase of chemical products. However technical feasibility and social acceptance are high.

At farmer level. On-farm surveys

In previous technologies there was a coincidence between the social aspects that differentiated users and non-users. For weed control, it is surprising that this characteristic does not match in the same way. It is surprising that average age of non-users is lower than that of users and economic gross income is higher also from that of non-users.

Higher yields and quality of the product, medium to low investment, and higher product price are the main positive reasons for users to adopt this technology. They find it easy to apply, but some of them recognise that there is a lack of knowledge regarding which herbicides should be applied and how to use them. For these reasons, they think that training is strongly required.

The alternative technology was introduced by extension services and through other experienced farmers. This technology is one of the most accepted by farmers and 90 to 95% of farmers consider that it had a positive effect on the well-being of the community.

Reasons for the non-use of the alternative technology by non-user farmers are economic cost and lack of knowledge. Some of these farmers think that in extreme severe dry conditions there are no differences between application and non-application of herbicides.

Conclusions

Improvement

The use of the alternative promoted an improvement because:

(i) Higher yield and water-use efficiency is obtained.

(ii) Weed seed storage in the soil is reduced.

(iii) Weed infestation is reduced.

(iv) Clean seed for storage and selling is produced.

Disadvantages/limitations

Some disadvantages and limitations as listed below have been reported:

(i) Chemical contamination.

(ii) Less labour available for population.

(iii) Cost of the herbicide.

(iv) Reduction of biodiversity.

Table 7. Range of differences (%) between *alternative* versus *conventional weed control* technologies in yield, yield stability, water use, water use efficiency (WUE) and economic results from the analysis in the selected areas[†]

Selected area	Crops[††]	Yield (%)	Yield stability (%)	Water use (%)	WUE	Quality[†††]	Production cost (%)	Margin (%)
Algeria 01	FC	+65	–	+2	+130	GW: +18	–	–
Algeria 02	FC	+53	–	+13	+53	GW: +17	–	–
Morocco 01	FC	+18	–	-14	+250	–	–	–
Morocco 02	FC	+15	–	–	–	–	–	–
Syria 01	FC	+17	–	–	–	GW: =; PC: +10	–	–

[†]Algeria 01: application of herbicides compared with weedy fields; Algeria 02: application of herbicides compared with weedy fields.
Morocco 01: application of herbicides compared with weedy fields; Morocco 02: application of herbicides compared with weedy fields and hand weeded plots.
Syria 01: application of herbicides compared with weedy fields.
[††]FC: field crops (winter cereals, chickpeas, legumes).
[†††]GW: grain weight; PC: protein content.

Table 8. Range of qualitative differences (from -3 to +3) between *alternative* versus *conventional weed control* technologies for different aspects from the analysis in the selected areas[†]. Qualitative estimation, positive or negative, compared to the control: -3 = high negative; -2 = medium negative; -1 = low negative; 0 = null; +1 = low positive; +2 = medium positive; +3 = high positive[††]

Selected area	Crops[†††]	BL	SL	CRA	CRC	L	AgU	SOM	PDI	TF	NT	GI	SA
Algeria 01	FC	-1	0	–	–	-3	–	–	–	+3	+3	0	+2
Algeria 02	FC	-1	0	–	–	-3	–	–	–	+3	+3	0	+2
Morocco 01	FC	-2	–	–	–	0	+3	–	–	+3	+2	-1	–
Morocco 02	FC	–	–	–	–	–	–	–	–	–	–	–	–
Syria 01	FC	+2	–	–	–	–	–	–	–	+3	+2	0	+3

[†]Algeria 01: application of herbicides compared with weedy fields; Algeria 02: application of herbicides compared with weedy fields.
Morocco 01: application of herbicides compared with weedy fields; Morocco 02: application of herbicides compared with weedy fields and hand weeded plots.
Syria 01: application of herbicides compared with weedy fields.
[††]BL: biodiversity loss; SL: soil loss; CRA: crop residue amount; CRC: crop residue cover; L: leaching; AgU: agrochemical use; SOM: soil organic matter; PDI: pest and diseases impact; TF: technical feasibility; NT: need for training; GI: gender impact; SA: social acceptance.
[†††]FC: field crops (winter cereals, chickpeas, legumes).

Conditions of use

(i) Herbicide should be applied when weed infestation is important.

(ii) Weed control by the right herbicide at the right rate and time.

Recommendations

(i) Farmers need to identify all weeds and apply the herbicides safely. They need to be trained in weed identification in relation with herbicides.

(ii) Farmers require training in handling agrochemicals.

(iii) Equipment to spraying herbicides must be correctly used.

(iv) In some cases application of nitrogen can have a synergic effect on weed control and N has to be applied.

Technology 5: New crops and cropping systems

Description of the traditional/conventional technology

Monocropping, continuous cropping of winter cereals, or fallow-winter cereal crop rotation have been reported as the most common cropping systems in the selected areas.

Objective of the alternative technology

Introduction of alternative crops (legumes, other winter cereals) and cropping systems to improve yield and quality of the grain and forage production.

Description of the alternative technology

Several alternatives are proposed. They consist in the introduction of crops such as triticale, oats, vetch or canola (depending on the selected areas) in rotation with winter cereals.

Summary of results

At research and experimental levels. On-farm trials

Unfortunately not much information from research experiments were found in three selected areas.

Yield was generally improved, even up to 85% in the Egyptian selected area. In Spain, however, a reduction of yield was obtained because of difficulties for growing canola in the selected area (Table 9). The quality of the product was not generally improved. Cost and economic margin were very dependent on the crop and year conditions. No clear effect on water use and water-use efficiency was observed and high variation in the evaluated qualitative traits was found (Table 10). Despite the technical feasibility of the technology, social acceptance was not clear in all cases.

Generally, other winter cereals such as triticale and oats are well adapted and are successful options. However, legume crops and canola are riskier alternatives and have to be evaluated for other benefits apart from yield (i.e. weed, pest and diseases control, herbicide resistance, fertiliser application, etc.).

Table 9. Range of differences (%) between *alternative* and *conventional new crops* technologies in yield, yield stability, water use, water use efficiency (WUE) and economic results from the analysis in the selected areas†

Selected area	Crops††	Yield (%)	Yield stability (%)	Water use (%)	WUE	Quality††† (%)	Production cost (%)	Margin (%)
Algeria	FC	+5	–	–	–	Increase in several parameters	–	–
Egypt 01	FC	Up to 85	–	–	–	PC: up to 6	–	–
Egypt 02	FC	Up to 55	–	–	–	=	–	–
Spain 01	FC	Up to -17	–	Up to +20	Up to -31	GW: up to -14	Wheat-vetch -6 Wheat-canola +15	Wheat -vetch -50 Wheat-canola +6
Spain 02	FC	+8	–	+11	0	GW: -3	+5	+1

†Algeria: change from oats + vetch to triticale + peas.
Egypt 01: crop rotations barley and legumes compared with barley monocropping; Egypt 02: new cereals and legumes for forage compared with continuous barley.
Spain 01: crop rotations wheat and vetch or canola compared with barley monocropping; Spain 02: crop rotation including peas each 2-3 years with barley compared with barley monocropping.
††FC: field crops (winter cereals, chickpeas, legumes).
†††GW: grain weight; PC: protein content.

Table 10. Range of qualitative differences (from -3 to +3) between *alternative* and *conventional new crops* technologies for different aspects from the analysis in the selected areas†. Qualitative estimation, positive or negative, compared to the control: -3 = high negative; -2 = medium negative; -1 = low negative; 0 = null; +1 = low positive; +2 = medium positive; +3 = high positive††

Selected area	Crops†††	BL	SL	CRA	CRC	L	AgU	SOM	PDI	TF	NT	GI	SA
Algeria	FC	0	-1	0	–	–	–	–	–	+3	+2	0	+3
Egypt 01	FC	–	–	–	–	–	–	–	–	–	–	–	–
Egypt 02	FC	–	–	–	–	–	–	–	–	–	–	–	–
Spain 01	FC	0	0	-2	-2	-1	-1	–	-1	+3	+3	0	0
Spain 02	FC	–	0	-1	-1	+1	-1	–	-1	+1	+3	0	0

†Algeria: change from oats + vetch to triticale + peas.
Egypt 01: crop rotations barley and legumes compared with barley monocropping.; Egypt 02: new cereals and legumes for forage compared with continuous barley.
Spain 01: crop rotations wheat and vetch or canola compared with barley monocropping; Spain 02: crop rotation including peas each 2-3 years with barley compared with barley monocropping.
††BL: biodiversity loss; SL: soil loss; CRA: crop residue amount; CRC: crop residue cover; L: leaching; AgU: agrochemical use; SOM: soil organic matter; PDI: pest and diseases impact; TF: technical feasibility; NT: need for training; GI: gender impact; SA: social acceptance.
†††FC: field crops (winter cereals, chickpeas, legumes).

At farmer level. On-farm surveys

Users of the alternative technology consider that it has a positive effect because a better product is produced for a higher price. Variability of production is reduced and farmers positively assess it. Yield is generally lower.

Labour is reduced but inputs and investment are higher especially in the case of the introduction of forage crops.

Users found the technology technically feasible and only 31% of them think that training is required for the use of alternative crops. Technology transfer has been carried out by extension services that helped in production planning and marketing in some cases. Technology has a medium acceptance by users (54%) and is positively assessed for the well-being of the community.

Non-users think that alternative crops have very low yield and stability. Technological difficulty is also a reason against the introduction of these changes.

Conclusions

Improvement

The improvements listed below have been found in the surveys of evaluated technology:

(i) Higher yield and specific weight.

(ii) Increased net forage yield.

(iii) Improved quality of the forage.

(iv) Better weed control.

(v) Legumes improve soil N content.

(vi) Environment is more protected.

Disadvantages/limits

Canola is difficult to establish and aridity limits its introduction. Canola is a riskier crop in medium to extreme dry conditions. It should be recommended for sub-humid zones.

For legumes:

(i) Vetch has harvest problems and seed production is limited.

(ii) More specific technological knowledge for growing peas (pests, weeds, etc.) is required.

(iii) These species are riskier than winter cereals in semi-arid zones.

(iv) Low level of fertiliser application may increase weeds leading to more use of herbicides.

Conditions of use

(i) Crops as legumes and canola require earlier sowing compared to winter cereals. Early seasonal rainfall encourages the cultivation of leguminous species, whereas barley can be cultivated if rainfall was delayed.

(ii) In some cases, use of peas in rotation is limited to zones with rainfall in spring. In these areas sometimes spring is very dry and leguminous crops fail.

(iii) Blending seed of legumes and winter cereals is recommended for forage production in some regions.

Recommendations

(i) Sowing of canola and vetch when there is enough water to accept an early sowing.

(ii) Plant early with a planter and apply nutrients adjusting to requirements and soil conditions.

Summary. Integration of technologies

In the survey of technologies to be evaluated we found large differences in the amount of available data. Some technologies have been highly tested at research level (i.e. improved plant material) but some others have been tested in one or two selected areas only. Results on improved plant material from breeding programmes were mostly available at research level and this technology has also probably had the highest impact on the adoption by farmers. However, others like the soil test used for fertiliser recommendations, seeding and planting technologies and weed control has a lesser level of attention by researchers. Finally, the introduction of new crops and cropping systems is still in the first steps for most of the areas, probably because in Mediterranean conditions it is much more difficult to find new species economically interesting and easy to adopt by the farmers.

Evaluation of five technologies demonstrated a better performance of alternative options for each technology for yield improvement. Only in some cases, did yield stability and quality of the product increase. Evaluation at research and farmer levels also showed the perception of researchers and farmers of the positive or negative environmental effect that adoption of one determined technique can produce. In all technologies, transfer by Extension Services has been highly appreciated and it was revealed to be the most important way to take techniques to farmers. Researchers working in agronomic techniques seemed to be closer to the farmer than those working in breeding. All technologies seem to be well considered by the farmer, and they judge the positive impact on well being of the community that its adoption would represent.

The non-adoption of technologies is highly associated to older age, lower total incomes, high investment and lower educational levels of the non-users. From the farmer’s point of view, training is needed for development, optimisation and adoption of these technologies.

Negative aspects of the technology evaluation are the lack of quantitative information of many aspects of the technologies. Only a few data regarding water as the main limiting factor in these conditions are available (i.e. rainfall efficiency, water use by crops, water-use efficiency, etc.). There is also a limited amount of information on nutrient uptake by crops or about the efficient use of fertilisers. A more frustrating condition is that no data are available in relation to the impact of the technologies on the environment. Levels of soil organic matter and its evolution, leaching, biodiversity loss, or other phenomena are completely unknown.

A second negative aspect is the scarcity of integrated studies for several technologies. In most of the selected areas information is not available, and for instance, released new cultivars have not supplementary information for plant density or nitrogen fertilisation. Studies on weed control, in most cases, have not taken into account the level of nitrogen or phosphorus applications. Researchers mostly focus studies on a simple factor or technology and avoid the complexity of managing multiple technologies that are strongly dependent. This information would be very valuable for users of these technologies.

High effort and expenses have been used in obtaining new plant material and in releasing new varieties. Some great success has been achieved in obtaining higher yield and protection against attack from pests and diseases. However, most effort should be put into the development of other technologies. Adjustment of nutrient uptake through the identification of the fertilisers (form, time and type) that are adapted to these conditions is important to improve the optimisation of fertilisation. New seeding and planting techniques have to be associated with used cultivars and with nutrient application. Testing and development of new cropping systems (case of crop rotations) is important, but it is necessary to maintain experiments for a longer time evaluation. In those cases, not only short-time economic evaluations have to be considered, but also other aspects such as reduction of inputs, control of abiotic and biotic stresses and positive impact on the environment.

List of references from where data were obtained

Soil fertility and fertiliser recommendation technology

Abdel-Aleem, M.M., Hanna, N.S. and Sabry, S.R.S. (1992). Wheat research activities at the Northwest coast. II. Agronomy. In: *Annual Coordination Meeting*, Agricultural Research Center, Cairo (Egypt), pp. 27-37.

Abdel Monem, M., Azzaoui, A., El Gharous, M., Rayan, J. and Soltanpour, P. (1988). Response of dryland wheat to nitrogen and phosphorus in some Moroccan soils. In: *Soil Test Calibration in West Asia and North Africa, Proceedings of the Third Regional Workshop*, Rayan, J. and Matar, A. (eds), Amman (Jordan), 3-9 September 1988. ICARDA Publication No. 167, pp. 52-65.

Abdelmonem, M.A.S., Harmsen, K., Lindsay, W.L. and Vlek, P.G. (1987). Fate of nitrogen-tagged urea applied to wheat in the arid Mediterranean region. In: *Soil Test Calibration in West Asia and North Africa, Proceedings of the Second Regional Workshop*, Matar, A., Soltanpour, P.N. and Chouinard, A. (eds), Ankara (Turkey), 1-6 September 1987. ICARDA Publication No. 120, pp. 103-110.

Abou El-Enein, R.A., El-Sayed, A.A., Asaad, F.A., El-Sherbiny, A., Megahed, M., El-Moselhy, M. and Orabi, A. (1995). *Demonstration of the recommended barley cultivars in the North Coastal Region*, Nile Valley Regional Program Barley Annual Report.

Aït Challal and Zeghida, A. (1984-1990). ITGC Elkhroub Annual Reports.

Angás Pueyo, P. (2001). *Análisis de la influencia de las técnicas de laboreo y fertilización nitrogenada sobre la dinámica del agua y del nitrógeno del suelo en el cultivo de cebada* (Hordeum vulgare *L.*) *en las zonas áridas y semiáridas del Valle del Ebro. Agronomía y Modelización*. PhD Thesis, University of Lleida, 151 pp.

Cantero-Martínez, C., Villar, J.M., Romagosa, I. and Fereres, E. (1995). Nitrogen fertilization of barley under semi-arid rainfed conditions. *Eur. J. Agron.*, 4(3): 309-316.

El Hajj, K. and Saade, M. (1992). An economic analysis of fertilizer allocation strategies in the Syrian Arab Republic. In: *Fertilizer Use Efficiency Under Rain-fed Agriculture in West Asia and North Africa*, *Proceedings of the Fourth Regional Workshop*, Ryan, J. and Matar, A. (eds), Agadir (Morocco), 5-10 May 1991, pp. 227-245.

Hamblin, J., Al-Taweel, W., Yau, S.K., Walker, G., Michel, M. and Kashour, G. (1995). *The use of data from on-farm trials in planning breeding strategy*, ICARDA Cereals Program, Discussion Paper.

Harmsen, K. (2000). A modified Mitscherlich equation for rainfed crop production in semi-arid areas: 2. Case study of cereals in Syria. *Neth. J. Agr. Sci.*, 48: 251-272.

Hegazi, A.M. and Hassan, H.Kh. (1998). Wheat yield potentiality under rainfed agriculture conditions in Egypt. I. Response of yield and yield components to P and N fertilizers under intra- and inter-year rainfall variability conditions. In: *Proc. 8th Conf. Agron.*, Suez Canal Univ., Ismailia (Egypt), 28-29 November.

Jones, M.J. (1987). Interpreting data from on-farm fertilizers trials for use where soil-test values are not available. Prediction of barley response to fertilizers by means of soil nitrogen and phosphorus tests. In: *Soil Test Calibration in West Asia and North Africa, Proceedings of the Second Regional Workshop*, Matar, A., Soltanpour, P.N. and Chouinard, A. (eds), Ankara (Turkey), 1-6 September 1985. ICARDA Publication No. 120, pp. 23-35.

Jones, M.J. and Singh, M. (2000). Long-term yield patterns in barley-based cropping systems in northern Syria. 1. Comparison of rotations. *J. Agr. Sci.*, *Cambridge*, 135: 223-236.

Karrou, M. (1996). Variation génotypique de l'efficience d'utilisation de l'azote chez le blé tendre. *Al Awamia*, 95: 39-51.

Karrou, M. and ElMourid, M. (1996). Crop water use and water use efficiency under semi-arid conditions of Morocco. *Al Awamia*, 92: 113-125.

Mashreq Project Annual Report (1994). *Increased productivity of barley, pasture and sheep*, pp. 19-22.

Matar, A.E., Jabbour, E. and El Hajj, K. (1987). Prediction of barley response to fertilizers by means of soil nitrogen and phosphorus tests. In: *Soil Test Calibration in West Asia and North Africa, Proceedings of the Second Regional Workshop*, Matar, A., Soltanpour, P.N. and Chouinard, A. (eds), Ankara (Turkey), 1-6 September 1987. ICARDA Publication No. 120, pp. 12-22.

Matar, A.E., Saxena, M. and Silim, S.N. (1987). Soil test as a guide to phosphate fertilization of five legumes in Syria. In: *Soil Test Calibration in West Asia and North Africa, Proceedings of the*

Second Regional Workshop, Matar, A., Soltanpour, P.N. and Chouinard, A. (eds), Ankara (Turkey), 1-6 September 1987. ICARDA Publication No. 120, pp. 94-102.

Moshelhy, N.M.M. (2001). Some agronomic practices to enhance the productivity of interplanted barley and saltbush (*Atriplex nummularia* L.) shrubs under rainfed conditions on the North West Coast of Egypt. *Desert Inst. Bull., Egypt*, 51(2).

Pala, M. and Matar, A. (1987). Soil test calibration with N and P for wheat under dryland conditions in Syria. In: *Soil Test Calibration in West Asia and North Africa*, *Proceedings of the Second Regional Workshop*, Matar, A., Soltanpour, P.N. and Chouinard, A. (eds), Ankara (Turkey), 1-6 September 1987. ICARDA Publication No. 120, pp. 55-66.

Pala, M. and Matar, A. (1992). Wheat response to nitrogen and phosphorus fertilization under various environmental conditions of northern Syria. In: *Fertilizer Use Efficiency Under Rain-fed Agriculture in West Asia and North Africa, Proceedings of the Fourth Regional Workshop*, Ryan, J. and Matar, A. (eds), Agadir (Morocco), 5-10 May 1991, pp. 92-104.

Planting and seeding technologies

Acevedo, E. and Naji, I. (1989). *Cereal Program*, Annual Report. ICARDA, Aleppo, Syria, pp. 104-113.

Annonyme (1996). *Annalyse synthétique des acquis en matière d'itinéraire technique*. ITGC ElKhroub.

Annonyme. ITGC Annual Reports 1990-1998.

Cantero-Martinez, C., Angas, P., Lampurlanes, J. and Santiveri, F. (2002). Data of conservation tillage for Spain were obtained from the different projects that have been carried out since 1986 by the group of Agronomy for dryland and irrigated agriculture. Unpublished data, University of Lleida, Dept. of Agronomy and Forestry Sciences.

Hamblin, J., Al-Taweel, W., Yau, S.K., Walker, G., Michel, M. and Kashour, G. (1995). *The use of data from on-farm trials in planning breeding strategy*, ICARDA Cereals Program, Discussion Paper.

Jones, M.J. (1987). Interpreting data from on-farm fertilizers trials for use where soil-test values are not available. Prediction of barley response to fertilizers by means of soil nitrogen and phosphorus tests. In: *Soil Test Calibration in West Asia and North Africa, Proceedings of the Second Regional Workshop*, Matar, A., Soltanpour, P.N. and Chouinard, A. (eds), Ankara (Turkey), 1-6 September 1985. ICARDA Publication No. 120, pp. 23-35.

Jones, M.J., and Singh, M. (2000). Long-term yield patterns in barley-based cropping system in northern Syria. 1. Comparison of rotations. *J. Agr. Sci.*, *Cambridge*, 135: 223-236.

Mahdi, L. (1996). *Agronomic assessment of variable sowing date, depth and seeding rate of wheat in a Mediterranean-type environment*. PhD Thesis, La Trobe University, School of Agriculture, Bundoora, Victoria, Australia.

Mahdi, L., Bell, C.J. and Ryan, J. (1996). Non-vitreousness or "Yellow-berry" in durum wheat as affected by both depth and date of planting. *Cereals Research Communications*, 24(3): 347-352.

Mahdi, L., Bell, C.J. and Ryan, J. (1998). Establishment and yield of wheat (*Triticum turgidum* L.) after early sowing at various depths in a semi-arid Mediterranean environment. *Field Crop. Res.*, 58: 187-196.

Mashreq Project Annual Report (1993). *Increased productivity of barley, pasture and sheep*, pp. 14-16.

Matar, A.E., Saxena, M. and Silim, S.N. (1987). Soil test as a guide to phosphate fertilization of five legumes in Syria. In: *Soil Test Calibration in West Asia and North Africa, Proceedings of the Second Regional Workshop*, Matar, A., Soltanpour, P.N. and Chouinard, A. (eds), Ankara (Turkey), 1-6 September 1987. ICARDA Publication No. 120, pp. 94-102.

Meyveci, K., Eyüpoğlu, H. and Karagüllü, E. (1993). Orta Anadolu Bölgesinde Bazı nohut çeşitleri için uygun ekim zamanlarının belirlenmesi. Tarla Bitkileri Merkez Araştırma Enstitüsü, Sonuç Raporu. (CRIFC, Project Final Report).

Pala, M. and Matar, A. (1987). Soil test calibration with N and P for wheat under dryland conditions in Syria. In: *Soil Test Calibration in West Asia and North Africa*, *Proceedings of the Second Regional Workshop*, Matar, A., Soltanpour, P.N. and Chouinard, A. (eds), Ankara (Turkey), 1-6 September 1987. ICARDA Publication No. 120, pp. 55-66.

Ryan, J., Abdel Monem, M. and El Gharous, M. (1992). Implications of spatial variability for soil testing and fertilizer use. In: *Fertilizer Use Efficiency under Rain-fed Agriculture in West Asia and North Africa, Proceedings of the Fourth Regional Workshop*, Ryan, A. and Matar, A. (eds), Agadir (Morocco), 5-10 May 1991, pp. 41-50.

Salem, M.O. (2000). *Development of rainfed agriculture and technology transfer*, Technical Report. Desert Research Center & ACSAD 2000.

Soltanpour, P.N., El Gharous, M., Azzaoui, A. and Abdelmonem, M. (1987). Nitrogen and phosphorus soil-test calibration studies in the Chaouia Region of Morocco. In: *Soil Test Calibration in West Asia and North Africa, Proceeding of the Second Regional Workshop*, Matar, A., Soltanpour, P.N. and Chouinard, A. (eds), Ankara (Turkey), 1-6 September 1987. ICARDA Publication No. 120, pp. 67-81.

Soltanpour, P.N., Matar, A. and Harmsen, K. (1987). Appendix. Program of work for the regional network of soil test calibration study sites in limited rainfed areas. In: *Soil Test Calibration in West Asia and North Africa*, *Proceedings of the Second Regional Workshop*, Matar, A., Soltanpour, P.N. and Chouinard, A. (eds), Ankara (Turkey), 1-6 September 1987. ICARDA Publication No. 120, pp. 111-116.

Sultan, M.Y., El-Bilassi, A.A., El-Sayed, A.A., Bedier, M.M. and Noaman, M.M. (1995). *Economic evaluation of the improved barley genotypes and the recommended package under farmers' field conditions in rainfed areas*. Nile Valley Regional Program Barley Annual Report.

Tous, J., Romero, A., Plana, J. and Baiges, F. (1999). Planting density trial with 'Arbequina' olive cultivar in Catalonia (Spain). *Acta Horticulturae*, 474: 177-180.

Improved plant material

Abd El-Gawad, A.A., Khalil, A.H., Abd El-Gawad, M.A. and Abd El-Mabood, M.Sh. (1998). Evaluation of certain wheat varieties under rainfed conditions. 1. Yield, yield attributes and some grain properties of certain varieties under rainfed and supplementary irrigation conditions. In: *Proc. 8th Conf. Agron.*, Suez Canal Univ., Ismailia (Egypt), 28-29 November, pp. 28-42.

Abou El-Enein, R.A., El-Sayed, A.A., Asaad, F.A., El-Sherbiny, A., Megahed, M., El-Moselhy, M. and Orabi, A. (1995). *Demonstration of the recommended barley cultivars in the North Coastal Region*. Nile Valley Regional Program Barley Annual Report.

Afiah, S.A.N. and Moselhy, N.M.M. (2001). Evaluation of selected barley genotypes under rainfed conditions of Ras El-Hekma, North Western Coast, Egypt. *Annals Agric. Sci.*, *Cairo*, 46(2): 619-629.

Aït Amer, O. (1999). Rôle du blé dur dans l'économie Algérienne. In: *Séminaire Wanaddin*, Alger, November 1999.

Akar, T., Avci, M., Düşünceli, F., Tosun, H., Ozan, A.N., Albustan, S., Yalvaç, K., Sayım, Î., Özen, D., Sipahi, H. and Ekiz, H. (2000). Orta Anadolu ve Geçit bölgelerinde Arpa (*H. Vulgare*) tarımının sorunları ve çözüm yollari. In: *Orta Anadolu'da Hububat tarımının Sorunları ve Çözüm Yolları*, *Proceeding*, Ekiz, H. (ed.), Konya (Turkey), 8-11 Haziran 1999, pp. 77-86.

Annonyme (1986-1992). *Synthèse des acquis en matière d'amélioration du potentiel génétique des orges*. ITGC Elkhroub.

Annonyme (1987-1997). *Synthèse des acquis en matière d'amélioration du blé dur*. ITGC Ann. Repport.

Annonyme (1990-1992). *Synthèse des acquis en matière d'amélioration des céréales*. ITGC Ann. Repport.

Avci, M. and Avçin, A. (1993). Baklagil-Bugday sisteminde azotun Cakmak 79 ve Kunduru 1149'un verim, protein, camsilik ve tane agirligina etkileri. In: *Makarnalik Bugday ve Mamulleri Simpozyumu*, 30 Kasim-3 Aralik 1993, Ankara (Turkiye). TOKB, TAGEM, TARM Yayınları, pp. 403-415.

Batlle, I. and Tous, J. (1997). The carob tree. *Ceratonia siliqua* L. In: *Promoting the Conservation and Use of Underutilized and Neglected Crops*. Institute of Plant Genetics and Crop Plant Research, Gatersleben/IPGRI, Publication No. 17, 92 pp.

Benbelkacem, A. (1990). The role of legumes in the farming systems of Algeria. In: *Proc. of a Workshop on the Role of Legumes in the Farming Systems of Mediterranean Areas*, UNDP/ICARDA, Osman, A.E., Ibrahim, M.M. and Jones, M.A. (eds), Tunis (Tunisia), 20-24 June 1988.

Benbelkacem, A. (1993). La recherche variétale sur les blés en Algérie. *Céréaliculture*, 26: 3-8.

Boucherika, S. (1990-1998). *Food legume development*. ITGC Elkhroub Annual Reports.

Bouissane, L. (2000). *Contribution à l'étude de l'effet de la fertilisation azotée sur la qualité technologique du blé dur*. Mémoire DESA, Université Hassan, 1er Faculté des Sciences et Techniques de Settat.

Bouzerzour, H. and Monneveux, P. (1992). Annalyse des facteurs de stabilité du rendement de l'orge dans les conditions des hauts plateaux de l'Est Algérien. In: *Sém. Tolérance à la Secheresse des Céréales en Zone Med*. Les Colloques INRA, No. 64, INRA, Paris, pp. 139-148.

CRIFC. Annual Reports 1998, 1999 and 2000.

Direction Provinciale d'Agriculture (DPA) de Settat (2000). Monographie agricole de la province de Settat.

Directorate of Agricultural Scientific Research, Douma Annual Report (1993). Regional Co-operation Program. Syrian Arab Republic, Ministry of Agriculture and Agrarian Reform and International Center for Agricultural Research in the Dry Areas (ICARDA).

Directorate of Agricultural Scientific Research, Douma Annual Report (1998). Regional Co-operation Program. Syrian Arab Republic, Ministry of Agriculture and Agrarian Reform and International Center for Agricultural Research in the Dry Areas (ICARDA) (Arabic version).

El Hafid, R. (1996). *Morphological and physiological traits associated with early-season drought resistance in durum wheat*. PhD Thesis, Colorado State University.

El Hasnaoui, A., Mazhar, M. and El Mzouri, E. (1989). *Evaluation des performances de la Saada dans les régions Chaouia et Abda*, Rapport d'Activité Année 1988-89. CRRA Settat, pp. 205-206.

El-Sayed, A.A. and Noaman, M.M. (1991). New released barley varieties for rainfed area in the northwestern coastal region of Egypt, In: *Annual Coordination Meeting*, Agriculture Research Center, Cairo (Egypt), pp. 2-17.

Gil, M. and Velilla, G. (1999). *Resultados de explotaciones del Bajo Aragón*. Informaciones Técnicas de la Diputación General de Aragón, No. 76. Dirección General de Tecnología Agraria, Centro de Técnicas Agrarias, Zaragoza, 7 pp.

Halak, Z. (2002a). *New released durum wheat variety (Douma 1105), suitable for rainfed areas in zone 1 and* 2, Report. Ministry of Agriculture and Agrarian Reform, Directorate of Agricultural Scientific Research (DASR), Douma, Damascus, Syria (Arabic version).

Halak, Z. (2002b). *New released durum wheat variety (Douma 18861), suitable for high rainfed in zone 1, and irrigation areas*, Report. Ministry of Agriculture and Agrarian Reform, Directorate of Agricultural Scientific Research (DASR), Douma, Damascus, Syria (Arabic version).

Hamblin, J., Al-Taweel, W., Yau, S.K., Walker, G., Michel, M. and Kashour, G. (1995). *The use of data from on-farm trials in planning breeding strategy*. ICARDA Cereals Program, Discussion Paper.

Hegazi, A.M. and Hassan, H.Kh. (1998). Wheat yield potentiality under rainfed agriculture conditions in Egypt. I. Response of yield and yield components to P and N fertilizers under intra- and inter-year rainfall variability conditions. In: *Proc. 8th Conf. Agron*., Suez Canal Univ., Ismailia (Egypt), 28-29 November.

ICARDA (1991). *Cereal Improvement Program*, Annual Report. ICARDA, Aleppo, 5 pp.

ICARDA (1992). *Cereal Improvement Program*, Annual Report. ICARDA, Aleppo, 11 pp.

ICARDA (1993). *Cereal Improvement Program*, Annual Report. ICARDA, Aleppo, 12 pp.

ICARDA (1994). *Cereal Improvement Program*, Annual Report. ICARDA, Aleppo, 27 pp.

ICARDA (1995). *Cereal Improvement Program*, Annual Report. ICARDA, Aleppo, 14 pp.

ICARDA (1996). *Cereal Improvement Program*, Annual Report. ICARDA, Aleppo, 23 pp.

ICARDA (1997). *Cereal Improvement Program*, Annual Report. ICARDA, Aleppo, 18 pp.

ICARDA (1998). *Cereal Improvement Program*, Annual Report. ICARDA, Aleppo, 19 pp.

ICARDA (2003). Natural Resource Management Program for 1996-2001. ICARDA, Aleppo.

Mazid, A., Tutwiler, R. and Al-Ahmad, H. (1998). Impact of modern technologies on durum wheat production in Syria. In: *Proceedings of the SEWANA (South Europe, West Asia and North Africa) Durum Research Network Workshop*, Nachit, M.M., Baum, M., Porceddu, E., Monneveaux, P. and Piccard, E. (eds), ICARDA, Aleppo (Syria), 20-23 March 1995. ICARDA, Aleppo, pp. 88-102.

Moshelhy, N.M.M. (2001). Some agronomic practices to enhance the productivity of interplanted barley and saltbush (*Atriplex nummularia* L.) shrubs under rainfed conditions on the North West Coast of Egypt. *Desert Inst. Bull.*, *Egypt*, 51(2).

Nachit, M.M. (1998). Durum breeding research to improve dryland productivity in the Mediterranean region. In: *SEWANA (South Europe, West Asia and North Africa) Durum Research Network, Proceedings of the SEWANA Durum Network Workshop*, Nachit, M.M., Baum, M., Porceddu, E., Monneveux, P. and Piccard, E. (eds), ICARDA, Aleppo (Syria), 20-23 March 1995. ICARDA, Aleppo, pp. 1-15.

Nasrellah, A. (1999). Variétés des céréales recommandées pour les zones du bour favorable au Maroc. Document interne, INRA, Rabat.

Noaman, M.M., El-Sayed, A.A. and Asaad, F.A. (1991). Developing drought tolerant barley genotypes for rainfed areas. In: *Annual Coordination Meeting*, Agriculture Research Center, Cairo (Egypt), pp. 18-31.

Pérez, M. (1998). *Orientaciones para las siembras de otoño-invierno*. Informaciones Técnicas de la Diputación General de Aragón. Numbers 26, 50, 70, 85 and 100. Dirección General de Tecnología Agraria, Centro de Técnicas Agrarias, Zaragoza.

Sabry, S.R.S., Hanna, N.S. and Abdel Aleem, M.M. (1992). Wheat research activities at the Northwest coast: 1. Breeding and variety testing. In: *Annual Coordination Meeting,* Agricultural Research Center, Cairo (Egypt), pp. 19-26.

Shehadeh, A. (1998). Durum wheat breeding strategy in Syria. In: *SEWANA (South Europe, West Asia and North Africa) Durum Research Network*, *Proceedings of the SEWANA Durum Network Workshop,* Nachit, M.M., Baum, M., Porceddu, E., Monneveux, P. and Piccard, E. (eds), ICARDA, Aleppo (Syria), 20-23 March 1995. ICARDA, Aleppo, pp. 23-32.

Sultan, M.Y., El-Bilassi, A.A., El-Sayed, A.A., Bedier, M.M. and Noaman, M.M. (1995). *Economic evaluation of the improved barley genotypes and the recommended package under farmers' field conditions in rainfed areas.* Nile Valley Regional Program Barley Annual Report.
Tous, J. (1990). *El Olivo. Situación y Perspectivas en Tarragona*. Diputació de Tarragona, 376 pp.
Tous, J. and Batlle, I. (1990). *El Algarrobo*. Ed. Mundi-Prensa, Madrid, 105 pp.
Tous, J., Plana, J., Romero, A. and Batlle, I. (1999). Situación actual del material vegetal de algarrobo. *Fruticultura Profesional*, 104(Especial frutos secos II): 26-30.
Tous, J. and Romero, A. (1993). *Variedades del Olivo. Especial Referencia a Cataluña*. La Caixa-AEDOS, Barcelona, 172 pp.
Tous, J., Romero, A. and Plana, J. (1998). Comportamiento agronómico y commercial de cinco variedades de olivo en Tarragona. *Investigación Agraria*, 13(1-2): 97-110.
Tous, J., Romero, A., Plana, J. and Batlle, I. (1996). Carob tree genetic resources. In: *3rd International Carob Symposium*, Tavira (Portugal), 19-23 May 1996.
Tous, J., Romero, A., Plana, J. and Hermoso, J.F. (2000). Red experimental de variedades de olivo en Cataluña. *ITEA*, Volumen Extra 21: 249-256.
Yalvaç, K., Atlı, A., Çetin, L., Düşünceli, F., Tuncer, T., Ozan, A.N., Albustan, S., Yazar, S., Zencirici, N., Eser, V. and Baran, I. (1999). Tarla Bitkileri Merkez Araştırma Enstitüsünün geliştirdiği Ekmeklik ve Makarnalık Buğday çeşitlerinin Orta Anadolu'daki verim, kalite ve hastalıklara dayanıklılık durumları. In: *Orta Anadolu'da Hububat tarımının Sorunları ve Çözüm Yolları, Proceeding,* Ekiz, H. (ed.), 8-11 Haziran 1999, Konya (Turkey).

Weed control

Bin Shuaib, O. (1987). *The effect of nitrogen, phosphorus and herbicides on weed infestation and wheat production*. MSc Thesis, Aleppo University, Faculty of Agriculture, pp. 56-62, 76, 83 (Arabic version).
Tanji, A. (1986). *On-farm evaluation of wheat production as affected by three weeding systems and top-dressed Nitrogen in Chaouia (Semi-Arid zone of Morocco)*. MSc Thesis, KSU, USA, 65 pp.
Tanji, A. (2002). Synthèse des essais de desherbage chimique du blé tendre réalisés au Maroc jusqu'en 2000. *Al Awamia* (in press).

New crops and cropping systems

Abdel-Aleem, M.M., Hanna, N.S. and Sabry, S.R.S. (1992). Wheat research activities at the Northwest coast. II. Agronomy. In: *Annual Coordination Meeting*, Agricultural Research Center, Cairo (Egypt), pp. 27-37.
Annonyme (1990-2000). *Bilans d'activités*, ITGC.
Benbelkacem, A. (1996). Development of triticale as a forage crop and grain feed in Algeria. In: *Triticale: Today and Tomorrow*, Guedes-Pinto, H., Darvey, N. and Carnide, V.P. (eds). Kluwer Academic Publishers, Dordrecht, pp. 859-865.
Cantero-Martinez, C., Angas, P., Lampurlanes, J. and Santiveri, F. (2002). Data of conservation tillage for Spain were obtained from the different projects that have been carried out since 1986 by the group of Agronomy for dryland and irrigated agriculture. Unpublished data, University of Lleida, Dept. of Agronomy and Forestry Sciences.
Dib, Y. (1992/1999). *Résultats d'analyses sur les associations fourragères*. ITEBO, Algeria.
El-Husseiny, N., Table, M.A., El-Shafei, Y.Z. and Abdel-Kader, F.H. (1990). Soil and water management for forage production under rainfed conditions of the Northwestern Coastal Region, Egypt. *J. Soil Sci.*, 30(1-2): 279-299.
Moselhy, N.M.M. (1999). Effect of rotation on sustainability of barley production under rainfed conditions in the NWC of Egypt. In: *Sixth International Conference on the Development of Dry Lands*, ICARDA, Cairo (Egypt), 22-27 August 1999.